NATIONAL ACADEMY OF NEUROPSYCHOLOGY

Bulletin

Vol. 27 No. 2

Free offer!
Act now and receive complimentary administrations
PearsonClinical.com/DREF

D·REF Delis Rating of Executive Functions

By Dean C. Delis

Easy. Efficient. Economical.

A quick online multi-rater measure of behavior-based executive function issues.

Introducing D-REF—a new online measure of executive function issues in children and adolescents ages 5-18. This cost-efficient tool lets you quickly administer, score, and report the frequency of observed behaviors. Comprehensive and balanced, this multi-rater measure includes:

- Parent and teacher rating forms for ages 5-18; self-rating forms for ages 11-18
- Single rater reports for the parent, teacher, or child
- Multi-rater forms that statistically compare teacher-parent, teacher-self, or parent-self-ratings

D-REF is easy to use!

As a fully digital instrument, D-REF streamlines your assessment process. Parent and teacher forms can be sent as links to their email addresses. Results are delivered on Q-global™, Pearson's new online administration, scoring and reporting platform. A range of indexes and scores help you pinpoint problems.

Try D-REF today!

Visit PsychCorp.com/DREF or call us today for more information about this efficient tool—and be sure to order your free trials!

888.627.7271 | PsychCorp | PearsonClinical.com

Contents

Editor's Corner

Michelle L. Mattingly, Ph.D., ABPP/CN
NAN Bulletin Editor

Eric Rinehardt, Ph.D., ABPP/CN
NAN Bulletin Associate Editor

We are pleased to introduce the fall edition of the NAN Bulletin series for 2013. We have decided to continue with the theme-based publication and have selected another topic which we find can be complex and controversial. Mild traumatic brain injury (mTBI) and concussion have drawn increased attention in the national media and medical community due to a variety of factors. Neuropsychologists frequently play a central role in the diagnosis and treatment of individuals with mTBI and concussion and must be capable of understanding a quickly developing and evolving body of knowledge in the area. The scope of this edition will include current views on diagnosis, treatment, and novel research approaches to mTBI and concussion. We hope that it will contribute to an advanced understanding of these issues for our readership.

Michelle L. Mattingly, Ph.D., ABPP/CN
NAN Bulletin Editor

Eric Rinehardt, Ph.D., ABPP/CN
NAN Bulletin Associate Editor

Patient Corner

A Patient Guide to Concussion: What It Is and What To Do About It

"Concussion" has become a household word in recent years, primarily as a result of new research both on sports and on war-related brain injuries. Nevertheless, the definition of concussion is not as well-known and in some situations the symptoms of concussion can be difficult to recognize. Here is the technical definition:

A clinical syndrome characterized by immediate and transient alteration in brain function, including alteration of mental status and level of consciousness, resulting from mechanical force or trauma (AANS, 2011).

Concussions are brain injuries. They are the mildest form of brain injury, as symptoms are temporary and recovery is usually excellent. Nonetheless, the symptoms can be significant and may require a visit to your doctor. It's important to remember that concussions can be caused by force alone; they do not have to involve physical contact with the head. Also, loss of consciousness is not necessary to be considered a concussion.

Immediate symptoms of concussion can include:

- Disorientation (confusion)
- Amnesia (change in memory)
- Nausea
- Dizziness
- Loss of consciousness
- Headache
- Blurred vision
- Loss of balance/stumbling

Symptoms that can occur within 24-48 hours include:

- Sleep problems
- Attention deficits
- Reading problems
- Irritability
- Being bothered by noise or light
- Feeling slowed down
- Persisting headache

What Do I Do If I Get A Concussion?

If you think you may have suffered a concussion or are experiencing any of the above symptoms, do not try to "tough it out." In most cases, rest is all you will need but there is an increased risk of re-injury in the days and weeks after the concussion. And exerting yourself (either physically or mentally) too soon after the concussion can worsen symptoms and could prolong recovery. If you experience any of the following symptoms, you should contact your physician immediately or if you cannot reach them right away then present to Urgent Care or an Emergency Room:

- Headaches that worsen
- Seizures
- Focal neurologic signs (such as unequal pupils)
- Looks very drowsy or can't be awakened
- Repeated vomiting
- Slurred speech
- Can't recognize people or places
- Increasing confusion or irritability
- Weakness or numbness in arms or legs
- Neck pain
- Unusual behavior change
- Significant irritability
- Any loss of consciousness lasting more than 30 seconds

You should be particularly careful to avoid activity that may cause another concussion (e.g. sports) until cleared by your physician. Also, many states now require that school-age children be removed from sports/play for at least 24 hours following a concussion, and many specify that the child needs to see a professional trained in concussion management before returning to organized recreational or sports activities.

How Long Will It Take For Me To Feel "Normal" Again?

Many people feel better the same day or within 24 hours, and most people feel completely better in under a week. Others take longer, especially if the concussion was on the more serious side or if they have had more than a couple of concussions. Some symptoms might warrant restrictions on activity (e.g., balance problems) or treatment (e.g., headache, sleep disruption, and mood) if they are severe or if they are significantly affecting everyday activity. Accommodations at school/work might also be warranted, especially if symptoms significantly compromise performance or if activities in those settings cause symptoms to get worse. Your physician can assist with guidelines and provide a letter to your school/employer if needed.

For more information:

AAN Position Statement
http://www.aan.com/uploadedFiles/Website_Library_Assets/Documents/6.Public_Policy/1.Stay_Informed/2.Position_Statements/3.PDFs_of_all_Position_Statements/sports.pdf

Centers for Disease Control (CDC) "ABCs"
www.cdc.gov/Concussion

Dr. Scott D. Bender is a board-certified clinical neuropsychologist and Director of Rehabilitation Neuropsychology at the University of Virginia. He specializes in rehabilitative and forensic issues involving traumatic brain injury, including concussion.

The content of this guide is not intended nor recommended as a substitute for medical advice, diagnosis, or treatment. Please consult your doctor for advice and individualized treatment.

Synopsis and Commentary on "Serial Measurement of Memory and Diffusion Tensor Imaging Changes Within the First Week Following Uncomplicated Mild Traumatic Brain Injury" from *Brain Imaging and Behavior*

Use of Diffusion Tensor Imaging to Measure Sub-Acute Alterations in the First Week following Mild Traumatic Brain Injury: Synopsis and Relevance to Clinical Neuropsychologists

Elisabeth A. Wilde[1-4], Stephen R. McCauley[1,3-5], Trevor C. Wu[1,3], and Erin D. Bigler[6-7]

[1]Physical Medicine and Rehabilitation Alliance, Baylor College of Medicine and the University of Texas-Houston Medical School, Houston, TX
[2]Department of Radiology, Baylor College of Medicine, Houston, TX
[3]Department of Neurology, Baylor College of Medicine, Houston, TX
[4]Michael E. DeBakey Veterans' Affairs Medical Center, Houston, TX
[5]Department of Pediatrics, Baylor College of Medicine, Houston, TX
[6]Departments of Psychology and 8Neuroscience, Brigham Young University, Provo, UT
[7]Department of Psychiatry and the Utah Brain Institute, University of Utah, Salt Lake City, UT

Introduction
An estimated 1.7 million new traumatic brain injuries (TBI) are reported annually in recent years in the United States, with approximately 75% of these classified as mild TBI (mTBI) (Faul, Xu, Wald, & Coronado, 2010). However, despite the prevalence of mTBI, the degree and persistence of physiological, psychiatric, and cognitive post-concussive symptoms has been controversial, as has the relation of these symptoms to underlying physiologic or structural brain change. Computed tomography (CT) and magnetic resonance imaging (MRI) have been moderately useful in acute diagnosis and prognosis of mTBI patients when findings are present (often termed "complicated mild" TBI); however, these imaging techniques have limited sensitivity in uncomplicated mTBI or concussion, and are frequently unrevealing regardless of clinical presentation. This article summarizes a study that we recently published in Brain Imaging and Behavior (Wilde et al., 2012) and discusses the implications for neuropsychological management of mild traumatic brain injury.

Recovery from mild TBI and Concussion
It is widely assumed that many patients with mTBI or concussion may exhibit transient symptoms that spontaneously and apparently completely resolve within 2-14 days post-injury from sports-related concussions (Covassin, Elbin, & Nakayama, 2010; Iverson, 2005; Iverson, Brooks, Collins, & Lovell, 2006; McCrea et al., 2003; Sim, Terryberry-Spohr, & Wilson, 2008; Thomas et al., 2011) and up to 3 months following other mechanisms of injury (Kwok, Lee, Leung, & Poon, 2008) though a subset of patients may exhibit persistent post-concussive symptoms beyond three months postinjury (King & Kirwilliam, 2011; Lannsjo, af Geijerstam, Johansson, Bring, & Borg, 2009; McCauley, Boake, Levin, Contant, & Song, 2001; McCauley et al., 2005, 2008; Ruff, Camenzuli, & Mueller, 1996; Sterr, Herron, Hayward, & Montaldi, 2006).

Diffusion Tensor Imaging
There has been significant recent interest in utilizing advanced imaging methods such as diffusion tensor imaging (DTI) which may be more sensitive to mTBI-related alterations in brain structure than CT and conventional MRI sequences. DTI has been used to probe white matter integrity via the diffusion properties of water through common DTI-derived metrics such as fractional anisotropy (FA) and apparent diffusion coefficient (ADC; also referred to as mean diffusivity), axial diffusivity (AD), and radial diffusivity (RD) (Alexander, Lee, Lazar, & Field, 2007; Huisman et al., 2004). FA is related to fiber directionality and anisotropic diffusion, or the tendency of water molecules to move preferentially in parallel (rather than perpendicular) to barriers to free diffusion such as fiber or axons. Higher anisotropic diffusion has been related to increased fiber density or axonal diameter and the ratio of intracellular/extracellular space. In the context of semi-acute mTBI, increased FA has also been implicated as a marker for inflammation or cytotoxic edema (Bazarian et al., 2007; Wilde et al., 2008; Mayer et al., 2010; Ling et al., 2012). FA is one of the most commonly reported metric in studies of TBI, though other metrics have also been utilized.

Memory Dysfunction in mTBI
Memory functioning has been generally considered a primary deficit in TBI (Bigler, 2008), but the results of studies in mTBI regarding persistent memory impairment have been mixed, with some studies suggesting persistent impairment (King & Kirwilliam, 2011; McCauley et al., 2005, 2008; Ponsford, Cameron, Fitzgerald, Grant, & Mikocka-Walus, 2011), and others finding no difference in comparison to a control cohort (Mayer et al., 2010; McCrea et al., 2009). While memory deficits have traditionally been ascribed to pathology in temporal lobe structures in more severe TBI, other brain regions, such as the cingulate, have also been implicated in verbal memory functioning (Kaneda & Osaka, 2008; Wu et al., 2010).

Study Design

Our previously published study (Wilde et al., 2012) examined uncomplicated mTBI in a small series (n=8) of adult patients recruited from the emergency department within 48 hours of injury who then underwent serial DTI and memory testing within 8 days post-injury. As indicated by conventionally used measures of injury severity, our cohort experienced relatively mild injury in that all patients had a Glasgow Coma Scale (GCS) score (Teasdale & Jennett, 1974) of 13-15 and no intracranial findings on initial CT scan. Patients did experience brief loss of consciousness (LOC; mean=14.1±12.6 minutes; range 1–30 minutes), and post-traumatic amnesia (mean PTA duration=55.0±46.8 minutes; range 0–150 minutes). DTI and memory testing were performed on four occasions over the first week for each patient using the following time intervals: 1) days 1-2 (0-48 hours), 2) days 3-4 (49-96 hours), 3) days 5-6 (97-144 hours) and 4) days 7-8 (145-192 hours). The Hopkins Verbal Learning Test-Revised (HVLT-R; Frey, 2003), a word list memory test with multiple equivalent forms, was also administered in a counterbalanced fashion, and total recall (age-corrected T-score) was used as the measure of interest.

Subacute Memory Changes

The individual results for each patient demonstrated that at the lowest point of memory performance, 7 of the 8 patients had age-corrected T-scores that fell to at least one standard deviation below either their initial assessment level, or that at the peak of their recovery. Five of the 8 patients had scores within normal limits at their initial assessment, and all but one patient rebounded to this average level of performance by the end of the week. When memory impairment was defined as a score of 1.5 standard deviations or more below the mean, 3 patients (38%) met this criterion at Day 1-2, 5 (63%) at Day 3-4, 3 (38%) at Day 5-6, and none at Day 7-8. As a more stringent test of the decrease in memory performance, the reliable change index (RCI; Jacobsen & Truax, 1991) was calculated based on normative data obtained from one week test-retest intervals (Benedict, Schretlen, Groninger, & Brandt, 1998). Using this procedure, 5 of 8 (63%) of the patients had differences in raw scores between Day 1-2 until their lowest performance that exceeded the RCI. Please see the original article for graphic representation of the results.

Subacute DTI Changes

Acute increases in left cingulum bundle FA occurred in each patient at varying time points during the first week, consistent with similarly reported increases in FA during the semi-acute phase post-mTBI (Bazarian et al., 2007; Ling et al., 2012; Mayer et al., 2010; Wilde et al., 2008). Variation in pattern of FA increases may reflect the heterogeneity of each patient's injury even though the general mechanism was similar across patients. Comparison of the trajectories of other DTI metrics such as ADC, AD, and RD further highlighted the complex nature of change as measured by DTI as there was considerable difference in the patterns between each metric, at least from a qualitative perspective. Some of these metrics indicated more prominent change within each individual, but the pattern of change was complicated and varied by metric.

Potential Relation between DTI-measured Brain Changes and Memory Performance

To illustrate the potential connection between alterations in DTI metrics and verbal memory performance in some patients, two patients were selected, both with significant LOC, PTA, and post-concussive symptoms; neither was involved in litigation. In the first example, the patient reached a local minimum on memory performance at about 65 hours postinjury and later recovered to within the normal range by 166 hours (see graphical representation in the original article). At these same time points, there was a local peak in the FA at about 65 hours, fllowed by a sharp decline. In contrast to this relatively "early" pattern of declining memory performance and a mirror pattern of increasing FA, the second patient demonstrated a "late" developing pattern. Here, memory performance reached a local minimum at about 124 hours while FA gradually increased, reaching a local peak at that same time point followed by some resolution on both measures. These examples document temporally consistent fluctuations within this semi-acute time frame in both performance on a memory task and FA in two cases, supporting a pathophysiological basis to short-term memory impairment in mTBI in these individuals.

Remaining Questions in the Use of DTI in mild TBI

We caution that, due to differences in scanner manufacturer and sequence parameters that preclude the creation of normative data (Hunter, Wilde, Tong, & Holshouser, 2012), the amount of alteration in FA or other DTI metric necessary to indicate clinically meaningful change is unknown. Our study did utilize the same scanner and imaging parameters for all imaging sessions in all patients, and our measurement of intra- and inter-rater reliability in the DTI metrics would suggest that the fluctations that we observed were not solely due to measurement error. There are also substantial gaps in what we currently know about the specificity of each DTI metric in measurement of underlying neuropathology in mTBI. However, it is possible that subacute fluctuations in both cognitive performance and DTI-derived metrics contribute to the seemingly conflicting results that have been found in other studies of mTBI. For example, some studies have failed to find differences between mTBI patient groups and controls using DTI, and those that do report differences have failed to reach a consensus regarding the direction of DTI-related changes and the degree to which these may be related to cognition. The patterns of memory performance and DTI metrics in our study may differ for patients with greater or lesser injury severity or with focal lesions. There may also be other injury- and host-related factors that must be considered in recovery from mTBI (e.g., age, gender, genetic contributors, pre-existing emotional disturbances, cognitive/brain reserve) and the interplay between injury and these factors remains a complex issue.

Conclusions

Our study represents the first prospective serial examination of DTI and memory utilizing four assessments over the first week post-injury in a small sample of uncomplicated mild TBI patients. Qualitative results suggest that performance on verbal list-learning was transiently affected in the majority of patients, with performance most negatively impacted on the second testing occasion (days 3-4 or 97-144 hours post-injury), and then returning to within normal limits. On the other hand, FA in the left cingulum bundle showed a more complex pattern, with the trajectory of changes in some patients changing more prominently than in others. Memory performance did appear to mirror changes in FA in the cases highlighted in two examples, but the pattern and the degree of symmetry between FA and memory did not necessarily correspond in all cases.

Detailed serial imaging over the semi-acute recovery period may be important in reconciling some of the conflicting findings in mTBI utilizing memory and/or DTI. The serial use of DTI may also allow a better understanding of the underlying pathophysiological changes in the semi-acute post-injury period. Should a consistent pattern emerge that allows identification of patients at-risk for acute and/or persistent symptoms, such knowledge would be critical in guiding development of therapeutic targets in mTBI and in understanding the time window when agents are likely to be most effective.

Acknowledgements

Findings from the study discussed above were originally published in Brain Imaging and Behavior. This work was supported by the National Institute of Neurological Disorders and Stroke grant 1R03NS069943-01 ("Diffusion Tensor Imaging of Acute and Subacute Mild TBI"; Wilde and McCauley, Co-PIs). The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health. Please note that EDB has provided expert opinions in forensic cases involving TBI.

Dr. Wilde earned her PhD from Brigham Young University and pursued fellowship training at the University of Michigan Medical Center. She is currently an Assistant Professor in the Department of Physical Medicine and Rehabilitation at Baylor College of Medicine. She has published extensively on neuroimaging correlates of traumatic brain injury.

References

Alexander, A. L., Lee, J. E., Lazar, M., & Field, A. S. (2007). Diffusion tensor imaging of the brain. Neurotherapeutics, 4(3), 316-329.

Bazarian, J. J., Zhong, J., Blyth, B., Zhu, T., Kavcic, V., & Peterson, D. (2007). Diffusion tensor imaging detects clinically important axonal damage after mild traumatic brain injury: a pilot study. [Research Support, N.I.H., Extramural Research Support, Non-U.S. Gov't]. J Neurotrauma, 24(9), 1447-1459. doi: 10.1089/neu.2007.0241

Benedict, R. H., Schretlen, D., Groninger, L., & Brandt, J. (1998). Hopkins Verbal Learning Test – Revised: Normative Data and Analysis of Inter-Form and Test-Retest Reliability. The Clinical Neuropsychologist, 12(1), 43-55.

Bigler, E. D. (2008). Neuropsychology and clinical neuroscience of persistent post-concussive syndrome. J Int Neuropsychol Soc, 14(1), 1-22. doi: S135561770808017X [pii] 10.1017/S135561770808017X

Covassin, T., Elbin, R. J., & Nakayama, Y. (2010). Tracking neurocognitive performance following concussion in high school athletes. [Research Support, Non-U.S. Gov't]. The Physician and sportsmedicine, 38(4), 87-93. doi: 10.3810/psm.2010.12.1830

Faul, M., Xu, L., Wald, M. M., & Coronado, V. G. (2010). Traumatic Brain Injury in the United States: Emergency Department Visits, Hospitalizations and Deaths 2002-2006. Atlanta, GA: Centers for Disease Control and Prevention, National Center for Injury Prevention and Control.

Frey, L. C. (2003). Epidemiology of posttraumatic epilepsy: a critical review. Epilepsia, 44 Suppl 10, 11-17. doi: 10004 [pii]

Huisman, T. A., Schwamm, L. H., Schaefer, P. W., Koroshetz, W. J., Shetty-Alva, N., Ozsunar, Y., . . . Sorensen, A. G. (2004). Diffusion tensor imaging as potential biomarker of white matter injury in diffuse axonal injury. [Research Support, U.S. Gov't, P.H.S.]. AJNR Am J Neuroradiol, 25(3), 370-376.

Hunter, J. V., Wilde, E. A., Tong, K. A., & Holshouser, B. A. (2012). Emerging imaging tools for use with traumatic brain injury research. [Research Support, N.I.H., Extramural Research Support, U.S. Gov't, Non-P.H.S.]. J Neurotrauma, 29(4), 654-671. doi: 10.1089/neu.2011.1906

Iverson, G. L. (2005). Outcome from mild traumatic brain injury. Current opinion in psychiatry, 18(3), 301-317. doi: 10.1097/01.yco.0000165601.29047.ae

Iverson, G. L., Brooks, B. L., Collins, M. W., & Lovell, M. R. (2006). Tracking neuropsychological recovery following concussion in sport. Brain injury : [BI], 20(3), 245-252. doi: 10.1080/02699050500487910

Jacobsen, N. S., & Truax, P. (1991). Clinical significance: A statistical approach to defining meaningful change in psychotherapy research. Journal of Consulting and Clinical Psychology, 59(1), 12-19.

Kaneda, M., & Osaka, N. (2008). Role of anterior cingulate cortex during semantic coding in verbal working memory. [Research Support, Non-U.S. Gov't]. Neurosci Lett, 436(1), 57-61. doi: 10.1016/j.neulet.2008.02.069

King, N. S., & Kirwilliam, S. (2011). Permanent post-concussion symptoms after mild head injury. Brain injury : [BI], 25(5), 462-470. doi: 10.3109/02699052.2011.558042

Kwok, F. Y., Lee, T. M., Leung, C. H., & Poon, W. S. (2008). Changes of cognitive functioning following mild traumatic brain injury over a 3-month period. [Multicenter Study Research Support, Non-U.S. Gov't]. Brain injury : [BI], 22(10), 740-751. doi: 10.1080/02699050802336989

Lannsjo, M., af Geijerstam, J. L., Johansson, U., Bring, J., & Borg, J. (2009). Prevalence and structure of symptoms at 3 months after mild traumatic brain injury in a national cohort. [Multicenter Study Research Support, Non-U.S. Gov't]. Brain injury : [BI], 23(3), 213-219. doi: 10.1080/02699050902748356

Ling, J. M., Pena, A., Yeo, R. A., Merideth, F. L., Klimaj, S., Gasparovic, C., & Mayer, A. R. (2012). Biomarkers of increased diffusion anisotropy in semi-acute mild traumatic brain injury: a longitudinal perspective. Brain, 135(Pt 4), 1281-1292. doi: 10.1093/brain/aws073

Mayer, A. R., Ling, J., Mannell, M. V., Gasparovic, C., Phillips, J. P., Doezema, D., . . . Yeo, R. A. (2010). A prospective diffusion tensor imaging study in mild traumatic brain injury. [Research Support, N.I.H., Extramural Research Support, Non-U.S. Gov't]. Neurology, 74(8), 643-650. doi: 10.1212/WNL.0b013e3181d0ccdd

References, cont.

McCauley, S. R., Boake, C., Levin, H. S., Contant, C. F., & Song, J. X. (2001). Postconcussional disorder following mild to moderate traumatic brain injury: anxiety, depression, and social support as risk factors and comorbidities. [Comparative Study Research Support, U.S. Gov't, P.H.S.]. J Clin Exp Neuropsychol, 23(6), 792-808.

McCauley, S. R., Boake, C., Pedroza, C., Brown, S. A., Levin, H. S., Goodman, H. S., & Merritt, S. G. (2005). Postconcussional disorder: Are the DSM-IV criteria an improvement over the ICD-10? [Comparative Study Research Support, U.S. Gov't, P.H.S.]. J Nerv Ment Dis, 193(8), 540-550.

McCauley, S. R., Boake, C., Pedroza, C., Brown, S. A., Levin, H. S., Goodman, H. S., & Merritt, S. G. (2008). Correlates of persistent postconcussional disorder: DSM-IV criteria versus ICD-10. [Comparative Study Research Support, Non-U.S. Gov't Research Support, U.S. Gov't, P.H.S.]. J Clin Exp Neuropsychol, 30(3), 360-379. doi: 10.1080/13803390701416635

McCrea, M., Guskiewicz, K. M., Marshall, S. W., Barr, W., Randolph, C., Cantu, R. C., . . . Kelly, J. P. (2003). Acute effects and recovery time following concussion in collegiate football players: the NCAA Concussion Study. [Research Support, Non-U.S. Gov't]. JAMA : the journal of the American Medical Association, 290(19), 2556-2563. doi: 10.1001/jama.290.19.2556

McCrea, M., Iverson, G. L., McAllister, T. W., Hammeke, T. A., Powell, M. R., Barr, W. B., & Kelly, J. P. (2009). An integrated review of recovery after mild traumatic brain injury (MTBI): implications for clinical management. [Review]. Clin Neuropsychol, 23(8), 1368-1390. doi: 10.1080/13854040903074652

Ponsford, J., Cameron, P., Fitzgerald, M., Grant, M., & Mikocka-Walus, A. (2011). Long term outcomes after uncomplicated mild traumatic brain injury: A comparison with trauma controls. Journal of neurotrauma. doi: 10.1089/neu.2010.1516

Ruff, R. M., Camenzuli, L., & Mueller, J. (1996). Miserable minority: emotional risk factors that influence the outcome of a mild traumatic brain injury. [Case Reports]. Brain Inj, 10(8), 551-565.

Sim, A., Terryberry-Spohr, L., & Wilson, K. R. (2008). Prolonged recovery of memory functioning after mild traumatic brain injury in adolescent athletes. [Research Support, Non-U.S. Gov't Research Support, U.S. Gov't, Non-P.H.S. Research Support, U.S. Gov't, P.H.S.]. Journal of neurosurgery, 108(3), 511-516. doi: 10.3171/JNS/2008/108/3/0511

Sterr, A., Herron, K. A., Hayward, C., & Montaldi, D. (2006). Are mild head injuries as mild as we think? Neurobehavioral concomitants of chronic post-concussion syndrome. [Research Support, Non-U.S. Gov't]. BMC neurology, 6, 7. doi: 10.1186/1471-2377-6-7

Teasdale, G., & Jennett, B. (1974). Assessment of coma and impaired consciousness. A pratical scale. Lancet, 13(7872), 81-84.

Thomas, D. G., Collins, M. W., Saladino, R. A., Frank, V., Raab, J., & Zuckerbraun, N. S. (2011). Identifying neurocognitive deficits in adolescents following concussion. Academic emergency medicine : official journal of the Society for Academic Emergency Medicine, 18(3), 246-254. doi: 10.1111/j.1553-2712.2011.01015.x

Wilde, E. A., McCauley, S. R., Barnes, A., Wu, T. C., Chu, Z., Hunter, J. V., & Bigler, E. D. (2012). Serial measurement of memory and diffusion tensor imaging changes within the first week following uncomplicated mild traumatic brain injury. [Case Reports Research Support, N.I.H., Extramural]. Brain Imaging Behav, 6(2), 319-328. doi: 10.1007/s11682-012-9174-3

Wilde, E. A., McCauley, S. R., Hunter, J. V., Bigler, E. D., Chu, Z., Wang, Z. J., . . . Levin, H. S. (2008). Diffusion tensor imaging of acute mild traumatic brain injury in adolescents. Neurology, 70(12), 948-955. doi: 70/12/948 [pii] 10.1212/01.wnl.0000305961.68029.54

Wu, T. C., Wilde, E. A., Bigler, E. D., Yallampalli, R., McCauley, S. R., Troyanskaya, M., . . . Levin, H. S. (2010). Evaluating the relationship between memory functioning and cingulum bundles in acute mild traumatic brain injury using diffusion tensor imaging. [Research Support, N.I.H., Extramural Research Support, Non-U.S. Gov't]. J Neurotrauma, 27(2), 303-307. doi: 10.1089/neu.2009.1110

Professional Issues

Mild Traumatic Brain Injury Diagnosis: Principles and Pitfalls

Dominic A. Carone, Ph.D., ABPP-CN
SUNY Upstate Medical University, Syracuse, NY

Mild traumatic brain (mTBI), also known as concussion, has been a topic at the forefront of scientific research and media coverage in recent years and particularly over the past decade. Reasons for this include but are not limited to increased media attention to sports concussion (particularly in the National Football League), injuries sustained by United States military personnel in the Middle East from 2003 to the present (particularly those caused by improvised explosive devices), and an increased number of personal injury lawsuits and disability applications filed by patients with known or alleged mTBI with related concerns regarding exaggeration and malingering (Carone & Bush, 2013). This increased attention to mTBI has positive aspects such as increasing awareness among the public and healthcare providers so that it is recognized (resulting in reduced false negative diagnoses) and patients are not placed at risk of suffering another concussion in the first 7 to 10 days post-injury (McCrea et al., 2009). However, the increased attention to mTBI has also had negative consequences such as failing to use evidence-based diagnostic (and treatment) guidelines, which results in false positive diagnoses and prolongation of symptoms due to iatrogenesis. This article reviews core diagnostic criteria for mTBI along with guidance for avoiding diagnostic pitfalls (i.e., false positives and false negatives).

For students or clinicians beginning their study of mild TBI, perusal of the existing operational diagnostic systems can initially be overwhelming because there are so many of them. Some have been developed by professional associations such the American Academy of Neurology (American Academy of Neurology, 1997); some have been developed by special committees (Mild Traumatic Brain Injury Committee of the Head Injury Interdisciplinary Special Interest Group of the American Congress of Rehabilitation Medicine, 1993); some have been developed by the federal government (Centers for Disease Control and Prevention, 2003; Defense and Veterans Brain Injury Center, 2006; Holm, Cassidy, Carroll, & Borg, 2005, the latter of which is the reference for the World Health Organization [WHO]); and some have been developed by individual researchers (Ommaya & Gennarelli, 1974; Stein, 1996). These various diagnostic systems differ in many respects such as whether specific cut-off scores employing proxy indicators of brain injury are used (e.g., loss of consciousness [LOC] length, length of post-traumatic amnesia, Glasgow Coma Scale scores in Stein's system) and if and how the presence of seizures, intracranial lesions not requiring surgery, and focal neurological deficits are considered. Specifically, some diagnostic criteria include seizures as a way that mTBI can manifest (WHO criteria) whereas others (Centers for Disease Control and Prevention criteria) only list it as a supportive but non-diagnostic feature. This is likely because of the fact that a seizure can cause someone to fall and hit their head but not be the result of a mTBI. In additions, seizures are sometimes caused by factors other than head trauma but which are often associated with a resulting head trauma (e.g., drug and/or alcohol overdose).

Non-emergent (and generally small) traumatically induced intracranial lesions are generally present on conventional neuroimaging (i.e., computerized axial tomography, magnetic resonance imaging) in a minority of mTBI cases (Doezema, King, Tandberg, Espinosa, & Orrison, 1991; Hughes et al., 2004; Iverson, Lovell, Smith, & Franzen, 2000; Kurca, Sivak, & Kucera, 2006) and make the diagnosis of mTBI obvious in an emergency room setting. Such cases are typically referred to as "complicated" mTBIs (Williams, 1990). Although one study (Hofman et al., 2001) reported that a majority (57%) of mTBI subjects had abnormal MRI findings, the percentage is misleading due to a very small number of subjects studied (21). Non-conventional diagnostic methods such as fluid biomarkers for neuronal injury (e.g., S-100B) and imaging techniques (e.g., diffusion tensor imaging, SPECT scans) should not be used in isolation from core diagnostic criteria (see below) to diagnose mTBI due to specificity problems, methodological limitations, and low levels of recommended clinical appropriateness (American College of Radiology, 2012; Choi, Jeong, Rohan, Polcari, & Teicher, 2009; Iverson et al., 2011; Lange, Iverson, Brubacher, Madler, & Heran, 2012; Zetterberg, Smith, & Blennow, 2013).

In most cases that clinicians will encounter in regular clinical and forensic practice, patients with known or suspected mTBI will have negative neuroimaging results and will not have suffered a seizure or a focal neurological deficit. It is important to remember that a focal neurological deficit is so named because it reliably indicates a focal area of neuropathology and dysfunction, such as a motor cortex lesion causing hemiparesis, an orbital frontal lesion causing anosmia, or a visual cortex lesion causing temporary vision loss. Focal neurological signs such as these are rarely encountered in acute concussion and are much better indicators of moderate to severe traumatic brain injuries. In fact, a recent study showed that cranial nerve findings and other neurological abnormalities offered no diagnostic value in differentiating concussion patients from patients with somatoform disorders, major depressive disorder, generalized anxiety disorder, and post-traumatic stress disorder (Silva, Donnell, Kim, & Vanderploeg, 2012).

Most symptoms that concussion patients report are non-specific (e.g., headaches, memory difficulties, concentration problems, blurry vision). In other words, they can be caused by a wide variety of factors and are thus non-focal. Such symptoms should not be used for mTBI diagnosis, a point that is explicitly noted in the CDC criteria. Specifically, the CDC criteria states that headaches, dizziness, irritability, or fatigue, when identified soon after the injury, can be used to support the diagnosis of mTBI but cannot be used to make the diagnosis in the absence of LOC or altered mental status.

The lack of application of the aforementioned exclusionary criteria by emergency room physicians, primary care physicians, pediatricians, nurse practitioners, psychologists, and other outpatient health care providers is one of the primary reasons for false positive mTBI diagnoses. The emphasis on an alteration of mental status by the CDC is an important one because it is the one criterion that all commonly used mTBI operational diagnostic criteria share. It is important to remember that alteration of mental status does not require LOC. In fact, requiring LOC to be present to diagnose mTBI is perhaps the primary reason for a false negative mTBI diagnosis. Even well-regarded authorities in neurology have made this diagnostic error (Ropper & Gorson, 2007). It is currently recognized that alteration of mental status can take many forms besides LOC, such as post-traumatic amnesia, retrograde amnesia, disorientation, slowed verbal responsiveness, and perseverative responding.

The mTBI criteria discussed up to this point are all operational definitions. That is, they require the presence of a specific feature(s) to make the diagnosis. These operational definitions differ from a frequently cited definition of mTBI created by the Concussion in Sports (CIS) Group. This definition first appeared as part of the published proceedings from the first International Symposium on Concussion in Sport in Vienna, Austria (Aubry et al., 2002). The definition provided was as follows: *"Concussion is defined as a complex pathophysiological process affecting the brain, induced by traumatic biomechanical forces."(p.7)*. This definition has remained the same in the published summary and agreement statements from the second, third, and fourth iterations of the CIS symposiums (McCrory et al., 2005; McCrory et al., 2013; McCrory et al., 2009). The definition is followed by a list of statements about concussions such as that they may be caused by a blow to head, that resulting impairment is typically short-lived, and that acute symptoms largely reflect a functional disturbance rather than a structural one. While the definition provided by the CIS group is accurate, the problem with it is that it is non-operational and thus cannot be used in clinical settings to determine whether a particular patient suffered a mTBI. That is, there are no specific criteria in the definition (e.g., alteration of mental status, focal neurological deficits) that must be met to allow the clinician to rule the diagnosis in or out. The most that is said near the mTBI definition by the CIS group regarding specific signs or symptoms is that LOC is not required. The danger in trying to apply this non-operational definition of mTBI to patients in a clinical setting is that it will result in very high false positive diagnoses. This is because any reported symptom (e.g., headache, light sensitivity), however non-specific, can be theoretically conceptualized as the result of a *complex pathophysiological process affecting the brain, induced by traumatic biomechanical forces* when this is actually not the case.

In clinical and research settings, health care providers must utilize operational definitions to make diagnoses and the same hold true for mTBI. With the few exceptions discussed above, this means that there needs to be evidence of altered mental status at the time of the injury or shortly thereafter. However, the confidence that one can place as to whether a patient meets the altered mental status criteria will vary from case to case depending on the level of evidence present to support it (see Table 1). The best level of evidence for a mTBI diagnosis based on the altered mental status criteria is if medical records on the day of injury (or within 24 hours of the injury) document a witnessed alteration of mental status by a health care provider or emergency responder. This will typically be the paramedics, emergency room staff, or personal physician which is why it is essential to try to obtain the early medical records. Observations in a police report would also suffice as evidence of altered mental status (e.g., witnessed LOC when arriving to the scene) which is why it is also important to try and access the accident report if available. It should be noted that some health care providers may document an alteration of mental status near the time of injury but not list a diagnosis of concussion. This can be because the health care provider used an alternative term that is insufficient (e.g., head injury, head contusion) or neglected to mention it due to a focus on other medical problems at the time (e.g., bone fractures and orthopedic surgeries). This does not mean that a mTBI did not occur. Likewise, a diagnosis of mTBI in the early ER record that is not accompanied by documented alteration of mental status (or does not meet the exceptions to this discussed above) should not be taken as evidence that a mTBI has occurred. An example would be a patient diagnosed in the ER with mTBI solely based on reporting a headache despite negative neuroimaging, no focal neurological signs, and no alteration mental status in the early medical records (confirmed upon interview). Such diagnoses should not be uncritically accepted by subsequent health care providers reviewing the case file.

Table 1. Levels of Evidence that Alteration of Mental Status Criteria has Been Met

Level of Evidence	Description
I. Strong	Medical records on the day of injury (or within 24 hours of the injury) clearly document a witnessed alteration of mental status. Documentation in a police report would also suffice.
II. Moderate	Observation of altered mental status by a reliable collateral observer who is a not an emergency responder or health care provider.
III. Weakest	Self-report from the injured person.

Note: The level of evidence classification for level II assumes there is no level I evidence. The level of evidence classification for level III assumes there is no level I or II evidence. In many clinical situations there will be more than one level of evidence.

In an ideal world, patients with suspected concussions would all go for medical care on the day of injury. In reality, however, there are people who suffer concussions who do not seek immediate medical care for a variety of reasons. These reasons can include but are not limited to not wanting to be inconvenienced by an ER visit, believing that the symptoms will improve in 24 hours, not being close to an emergency medical facility, lack of health insurance, or telephone advice from a pediatrician or primary care physician to observe the patient and not come for an evaluation unless there is evidence of clinical deterioration. Eventually, the patient will have seen a health care provider regarding the injury if they are being referred for a neuropsychological evaluation, but this may not occur for days, weeks, or months post-injury. In such cases, the neuropsychologist will find that another health care provider has typically retrospectively diagnosed a concussion but since there are no acute medical records to review (and presumably no video of the event), the diagnosis would have to stem from one of two (or both) sources: observations of the injury from an observer or self-report of symptoms at the time of injury by the injured person. However, since both of these levels of evidence do not involve observations from an objective trained health care provider or emergency responder, the level of evidence is weaker due to inherent limitations involved with retrospective recall. For example, in a classic study, McCrory (2001) found that athletes consistently over-reported recalled episodes of major (associated with LOC) and minor (no LOC) concussion in their teammates when compared with self-reported and video-documented episodes.

The degree of confidence that one places in the observations of a collateral informant (typically a family member who was present at the time of the injury) or injured patient requires the evaluator to take certain clinical and contextual variables into account. For example, information provided regarding an altered mental status claim is less reliable if the informant or patient has demonstrated repeatedly that they are a poor historian during the course of an interview, if information has been provided inconsistently to other health care providers via a comprehensive medical file review (e.g., reporting no LOC, possible LOC, and definite LOC to three different health care providers), or if there is evidence that the observer (e.g., a spouse) stands to benefit significantly from a personal injury compensation claim (e.g., litigation, disability). To this point, it is important to remember another inherent limitation regarding altered mental status reports – it can easily be fabricated or embellished. That is, anyone can say that they observed someone in a disoriented state or claim LOC when this was actually not the case. This is an important factor to consider since patients with known or suspected mTBI have the highest rates of exaggeration and malingering on neuropsychological evaluations. (Mittenberg, Patton, Canyock, & Condit, 2002). Thus, if a patient reports that the first place he/she drove to after a car accident was to a personal injury attorney's office (as happened in one case of mine), did not seek acute medical care, and claims an alteration of mental status on an outpatient basis in the context of a litigation or other compensation seeking claim, the self-report needs to be viewed as suspect, particularly if the patient goes on to fail symptom validity testing. Self-report of altered mental status can be viewed as more reliable when it is accompanied by the observations of a reliable third party, and/or by observations of trained medical professionals and emergency responders, and does not take place in a compensation seeking context.

Health care providers also need to be mindful of other limitations regarding self-reported or observed mental status alteration that do not involve nefarious motives. First, it is not at all uncommon for people experiencing traumatic events or injuries not involving the brain to report altered mental status, leading to specificity concerns when relying on self-report data in isolation (Lees-Haley, Fox, & Courtney, 2001). Second, and as the WHO criteria for mTBI explicitly states, the alteration of mental status criteria cannot be used to diagnose mTBI if it is caused by the effects of drugs, alcohol, or medication; injuries or treatments for other injuries; or other problems (e.g., psychological trauma, language barrier, or co-existing medical conditions). Third, health care providers must avoid relying on non-scientific phrases used by patients or observers as the basis for meeting the alteration of mental status criteria. Common examples from clinical practice include the words "dazed," "loopy," and "foggy." None of these vague terms are listed in Stedman's Medical Dictionary (Stedman, 2006) whereas the terms disorientation, consciousness, anterograde amnesia, and retrograde amnesia are listed. Thus, health care providers should ask questions to elicit more clearly whether an alteration of mental status may have taken place. An example highlighting the importance of this is a middle-aged man who was diagnosed with mTBI purely based on him saying that he felt "dazed" when a small piece of hard snow fell on his head from above. However, when queried as to what he meant by the word "dazed," he only meant that he was surprised because he did not expect it and denied any actual alteration of mental status. Lastly, health care providers must be mindful of highly atypical alteration mental status claims (e.g., two years of retrograde amnesia and two minutes of anterograde amnesia) that are contradictory to empirical base rate data after mTBI (Paniak, MacDonald, Toller-Lobe, Durand, & Nagy, 1998).

In summary, the best objective scientific evidence for mTBI is a traumatically induced lesion on conventional neuroimaging. Absent rare exceptions such as acute focal neurological deficits, the second best evidence of mTBI comes from observed altered mental status by health care responders and/or emergency responders within 24 hours of the injury. In some cases, the evidence will be clear that there was or was not an alteration of mental status but in other cases the evidence will not be clear and clinicians should have no qualms in formally documenting the diagnostic limitations that result from such ambiguity. Relatedly, reliance on self or collateral report to meet the alteration of mental status criteria has inherent limitations that health care providers must be aware of before definitively diagnosing mTBI, particularly due to the risk of worsening patient outcomes via iatrogenesis.

With regards to the latter point, Roth and Spencer (2013) recently documented a case study of iatrogenically induced disability in a veteran with a history of mTBI. Lessons from the case yielded several suggestions for reducing iatrogenic risk and unnecessary disability in patients with known or suspected mTBI. First, the authors recommended more fully and broadly educating health care providers about the nature, course, and morbidity associated with mTBI. Such education should obviously be evidence-based and focused on the mild end of the TBI spectrum rather than confounding such education with information that best pertains to moderate and severe traumatic brain injury. As McCrea (2008) has correctly documented, traumatic brain injury is not a unitary concept. Second, and related to the latter suggestion, Roth and Spencer (2013) also recommend (while citing military guidelines) that health care providers use the word "concussion" during patient interactions rather than the terms "traumatic brain injury" or "brain damage." This helps reduce the implications of permanent brain damage, which carries with it false implications of chronic disability and greater neurological severity than is actually the case. Once health care providers are properly educated, they can implement the third suggestion, which is to provide evidence-based education to patients in the acute post-injury phase that is consistent across disciplines and emphasizes expectations for a normal and full recovery along with therapeutic suggestions for more adaptive attributions of cognitive symptoms during the recovery process. This is particularly important when considering that numerous research studies have shown that modifying post-injury expectations has a strong influence on recovery after concussion (Miller & Mittenberg, 1998; Mittenberg, Canyock, Condit, & Patton, 2001; Mittenberg, Tremont, Zielinski, Fichera, & Rayls, 1996; Ponsford et al., 2001; Ponsford et al., 2002).

Fourth, the authors also suggested using caution when making casual and repeat referrals to specialists where a presumption of head injury is entertained because this can unnecessarily reinforce the self-perception of suffering and disability. The details of the case study also highlighted the need for clinicians to integrate the results of neuropsychological evaluations that show evidence of poor effort, symptom exaggeration, and objective test performance that is discrepant from self-report into case conceptualization and treatment planning rather than repeatedly ignoring it. All of these suggestions and lessons are particularly important for healthcare providers without formal training in neurology and neuropsychology (e.g., primary care physicians, nurses, social workers, other psychologists) because it is with such providers that the iatrogenic ball typically begins its proverbial roll.

Dominic A. Carone, PhD, ABPP-CN is the co-editor of the book, Mild Traumatic Brain injury: Symptom Validity Assessment and Malingering. He served as President of the New York State Association of Neuropsychology for 3.5 years and of the Central New York Psychological Association (one year). He is currently employed as a neuropsychologist and clinical associate professor at SUNY Upstate Medical University where he coordinates the Neuropsychology Assessment Program.

References

American Academy of Neurology. (1997). Practice parameter: the management of concussion in sports (summary statement). Report of the Quality Standards Subcommittee. Neurology, 48, 581-585.

American College of Radiology. (2012). ACR appropriateness criteria: Head trauma. Retrieved 8/8/2013, from http://www.acr.org/~/media/ACR/Documents/AppCriteria/Diagnostic/HeadTrauma.pdf

Aubry, M., Cantu, R., Dvorak, J., Graf-Baumann, T., Johnston, K. M., Kelly, J., . . . Schamasch, P. (2002). Summary and agreement statement of the 1st International Symposium on Concussion in Sport, Vienna 2001. Clinical Journal of Sport Medicine, 12, 6-11.

Carone, D. A., & Bush, S. (2013). Introduction: Historical Perspectives of Mild Traumatic Brain Injury, Symptom Validity Assessment, and Malingering. In D. A. Carone & S. Bush (Eds.), Mild traumatic brain injury: Symptom validity assessment and malingering (pp. 1-29). New York: Springer Publishing Company.

Centers for Disease Control and Prevention. (2003). Report to Congress on Mild Traumatic Brain Injury in the United States: Steps to Prevent a Serious Public Health Problem. . Washington, DC: Centers for Disease Control and Prevention

Choi, J., Jeong, B., Rohan, M. L., Polcari, A. M., & Teicher, M. H. (2009). Preliminary evidence for white matter tract abnormalities in young adults exposed to parental verbal abuse. Biological Psychiatry, 65, 227-234.

Defense and Veterans Brain Injury Center. (2006). Defense and Veterans Brain Injury Center Working Group on the Acute Management of Mild Traumatic Brain Injury in Military Operational Settings: Clinical Practice Guidelines and Recommendations. Washington DC: Defense and Veterans Brain Injury Center.

Doezema, D., King, J. N., Tandberg, D., Espinosa, M. C., & Orrison, W. W. (1991). Magnetic resonance imaging in minor head injury. Annals of Emergency Medicine, 20, 1281-1285.

Hofman, P. A., Stapert, S. Z., van Kroonenburgh, M. J., Jolles, J., de Kruijk, J., & Wilmink, J. T. (2001). MR imaging, single-photon emission CT, and neurocognitive performance after mild traumatic brain injury. American Journal of Neuroradiology, 22, 441-449.

Holm, L., Cassidy, J. D., Carroll, L. J., & Borg, J. (2005). Summary of the WHO Collaborating Centre for Neurotrauma Task Force on Mild Traumatic Brain Injury. Journal of Rehabilitation Medicine, 37, 137-141.

Hughes, D. G., Jackson, A., Mason, D. L., Berry, E., Hollis, S., & Yates, D. W. (2004). Abnormalities on magnetic resonance imaging seen acutely following mild traumatic brain injury: correlation with neuropsychological tests and delayed recovery. Neuroradiology, 46, 550-558.

Iverson, G. L., Hakulinen, U., Waljas, M., Dastidar, P., Lange, R. T., Soimakallio, S., & Ohman, J. (2011). To exclude or not to exclude: white matter hyperintensities in diffusion tensor imaging research. Brain Injury, 25, 1325-1332.

Iverson, G. L., Lovell, M. R., Smith, S., & Franzen, M. D. (2000). Prevalence of abnormal CT-scans following mild head injury. Brain Injury, 14, 1057-1061.

Kurca, E., Sivak, S., & Kucera, P. (2006). Impaired cognitive functions in mild traumatic brain injury patients with normal and pathologic magnetic resonance imaging. Neuroradiology, 48, 661-669.

References, cont.

Lange, R. T., Iverson, G. L., Brubacher, J. R., Madler, B., & Heran, M. K. (2012). Diffusion tensor imaging findings are not strongly associated with postconcussional disorder 2 months following mild traumatic brain injury. Journal of Head Trauma Rehabilitation, 27, 188-198.

Lees-Haley, P. R., Fox, D. D., & Courtney, J. C. (2001). A comparison of complaints by mild brain injury claimants and other claimants describing subjective experiences immediately following their injury. Archives of Clinical Neuropsychology, 16, 689-695.

McCrea, M. (2008). Mild traumatic brain injury and postconcussion syndrome: The new evidence base for diagnosis and treatment New York: Oxford University Press.

McCrea, M., Guskiewicz, K., Randolph, C., Barr, W. B., Hammeke, T. A., Marshall, S. W., & Kelly, J. P. (2009). Effects of a symptom-free waiting period on clinical outcome and risk of reinjury after sport-related concussion. Neurosurgery, 65, 876-882; discussion 882-873.

McCrory, P. (2001). Does second impact syndrome exist? Clinical Journal of Sport Medicine, 11, 144-149.

McCrory, P., Johnston, K., Meeuwisse, W., Aubry, M., Cantu, R., Dvorak, J., . . . Schamasch, P. (2005). Summary and agreement statement of the 2nd International Conference on Concussion in Sport, Prague 2004. British Journal of Sports Medicine, 39, 196-204.

McCrory, P., Meeuwisse, W. H., Aubry, M., Cantu, B., Dvorak, J., Echemendia, R. J., . . . Turner, M. (2013). Consensus statement on concussion in sport: the 4th International Conference on Concussion in Sport held in Zurich, November 2012. Journal of the American College of Surgeons, 216, e55-71.

McCrory, P., Meeuwisse, W., Johnston, K., Dvorak, J., Aubry, M., Molloy, M., & Cantu, R. (2009). Consensus statement on concussion in sport - the Third International Conference on Concussion in Sport held in Zurich, November 2008. Physician and Sportsmedicine, 37, 141-159.

Mild Traumatic Brain Injury Committee of the Head Injury Interdisciplinary Special Interest Group of the American Congress of Rehabilitation Medicine. (1993). Definition of mild traumatic brain injury. Journal of Head Trauma Rehabilitation, 8, 86-87.

Miller, L. J., & Mittenberg, W. (1998). Brief cognitive behavioral interventions in mild traumatic brain injury. Applied Neuropsychology, 5, 172-183.

Mittenberg, W., Canyock, E. M., Condit, D., & Patton, C. (2001). Treatment of post-concussion syndrome following mild head injury. Journal of Clinical and Experimental Neuropsychology, 23, 829-836.

Mittenberg, W., Patton, C., Canyock, E. M., & Condit, D. C. (2002). Base rates of malingering and symptom exaggeration. Journal of Clinical and Experimental Neuropsychology, 24, 1094-1102.

Mittenberg, W., Tremont, G., Zielinski, R. E., Fichera, S., & Rayls, K. R. (1996). Cognitive-behavioral prevention of postconcussion syndrome. Archives of Clinical Neuropsychology, 11, 139-145.

Ommaya, A. K., & Gennarelli, T. A. (1974). Cerebral concussion and traumatic unconsciousness. Correlation of experimental and clinical observations of blunt head injuries. Brain, 97, 633-654.

Paniak, C., MacDonald, J., Toller-Lobe, G., Durand, A., & Nagy, J. (1998). A preliminary normative profile of mild traumatic brain injury diagnostic criteria. Journal of Clinical and Experimental Neuropsychology, 20, 852-855.

Ponsford, J., Willmott, C., Rothwell, A., Cameron, P., Ayton, G., Nelms, R., . . . Ng, K. (2001). Impact of early intervention on outcome after mild traumatic brain injury in children. Pediatrics, 108, 1297-1303.

Ponsford, J., Willmott, C., Rothwell, A., Cameron, P., Kelly, A. M., Nelms, R., & Curran, C. (2002). Impact of early intervention on outcome following mild head injury in adults. Journal of Neurology, Neurosurgery, and Psychiatry, 73, 330-332.

Ropper, A. H., & Gorson, K. C. (2007). Clinical practice. Concussion. New England Journal of Medicine, 356, 166-172.

Roth, R. S., & Spencer, R. J. (2013). Iatrogenic risk in the management of mild traumatic brain injury among combat veterans: A case illustration and commentary. International Journal of Physical Medicine and Rehabilitation, 1, 1-7.

Silva, M. A., Donnell, A. J., Kim, M. S., & Vanderploeg, R. D. (2012). Abnormal neurological exam findings in individuals with mild traumatic brain injury (mTBI) versus psychiatric and healthy controls. Clin Neuropsychol, 26, 1102-1116.

Stedman. (2006). Stedman’s medical dictionary (28th ed.). Baltimore: Lippincott Williams & Wilkins.

Stein, S. C. (1996). Classification of head injury. In R. K. Narayan, J. T. Povlishock & W. J. E. Jr. (Eds.), Neurotrauma (pp. 31-42). New York: McGraw-Hill.

Zetterberg, H., Smith, D. H., & Blennow, K. (2013). Biomarkers of mild traumatic brain injury in cerebrospinal fluid and blood. Nat Rev Neurol, 9, 201-210.

TBI Population Screening: The Road to Medical Iatrogenesis is Paved with Good Intentions

Heather G. Belanger, Ph.D.
Department of Mental Health and Behavioral Sciences, James A. Haley VA, Tampa, FL
Departments of Psychology & Psychiatry, University of South Florida, Tampa, FL

Rodney D. Vanderploeg, Ph.D.
Department of Mental Health and Behavioral Sciences, James A. Haley VA, Tampa, FL
Departments of Psychology & Psychiatry, University of South Florida, Tampa, FL
Defense and Veterans Brain Injury Center

Acknowledgements

The views expressed herein are those of the authors and do not necessarily reflect the views or the official policy of the Department of Veterans Affairs, Department of Defense, or U.S. Government. This article is based on material from a prior publication (Vanderploeg & Belanger, 2013). The second author of this commentary was part of the workgroup that developed the screening questions and procedures for VHA TBI screening.

Medical Screening

Medical screening is designed to identify disease early in an 'at risk' population, thus enabling earlier intervention and management to reduce mortality and suffering. For this goal to be realized, a number of criteria should be met. Although screening may lead to an earlier diagnosis, not all screening tests have been shown to benefit the population being screened. Over-diagnosis, misdiagnosis, additional unnecessary procedures and resulting costs, and iatrogenic effects are some potential adverse effects of screening.

VHA Screening Practices for Mild TBI

The Department of Defense and the Veterans Health Administration (VHA), in order to ensure identification of service members potentially needing medical services following deployment to Iraq or Afghanistan, implemented a series of clinical reminders or screeners including a screen for a possible deployment-related TBI. Within the VHA the TBI Clinical Reminder is completed if the patient served in Iraq or Afghanistan after September 11, 2001. The screen consists of four questions: (1) Injury event, (2) Immediate loss or alteration of consciousness, (3) Immediate/acute postconcussive symptoms, and (4) Current (past week) postconcussive symptoms. A positive response to all four questions constitutes a positive screen. The goal of the screen was to identify individuals who <u>may have experienced a deployment-related TBI</u> and who <u>currently are reporting symptoms that may be related to that historically remote injury event</u>. Positive screens result in referrals for follow-up evaluations.

These TBI screens are positive between 15-23% of the time (Evans et al., 2013; Hoge et al., 2008; Sayer, Nelson, & Nugent, 2011; Terrio et al., 2009). Within the VHA, clinicians have completed a subsequent Comprehensive TBI Evaluation on 75% of the positive screens (the rest fail to return for scheduled appointments or cannot be contacted). Of these, a TBI is confirmed 56% of the time (i.e., 44% false positives). The VHA's TBI screen, as used in typical clinical care nationally, is 87% sensitive but only 15% specific (Belanger, Vanderploeg, Soble, Richardson, & Groer, 2012). Under the best of circumstances using carefully trained examiners (i.e., not clinical practice), 94% sensitivity and 59% specificity rates have been demonstrated (Donnelly et al., 2011).

Model and Core Principles of Medical Screening

Screens should be used if a number of criteria are met (Grimes & Schulz, 2002). Medical screenings are designed for progressive disorders (e.g., cancer, hypertension, early heart disease, etc.) or disorders with very poor potential outcomes that are preventable (e.g., blood screens during pregnancy to check for red cell antibodies) (Streiner, 2003; Wilson & Jungner, 1968). For example, if a cancerous tumor in the breast is diagnosed early or an enlarged prostate gland is detected before it becomes cancerous, the hope is that appropriate early treatment will prevent problems from developing later. In addition to the ***progressive nature of the disorder***, for screening to be worthwhile there must be a valid test for the disorder and an ***effective treatment available***.

Why Screening for Mild TBI is a Potentially Bad Idea

1. TBI is not a Progressive Disorder. TBI reflects an acute injury that typically improves with time. Deficits from a TBI may not completely resolve, but they are not expected to worsen over time with the exception of acute medical complications such as subdural or epidural hematomas or subarachnoid bleeding. Neither of these are relevant to DoD or VA post-deployment screenings for TBI.

2. Reliable Confirmation of a TBI Diagnosis after a Positive Screen is Currently not Possible. There is no definitive way to diagnose mild TBI in the postacute or chronic setting. Reliance on self-report via a structured interview is the gold standard but is fraught with difficulty. Potential monetary and psychological "rewards," as well as reliance on subjective reports and memory, complicate matters. Unlike physical diseases that have biological markers (e.g., tumor cells, blood pathogens, etc), mild TBI, though clearly a physical injury, must be witnessed for verification and even then may be misdiagnosed. Neuroimaging in the Emergency Department is frequently normal (Borg et al., 2004) and in fact some definitions of mild TBI preclude neuroimaging abnormalities. Screening for a condition that inspires disagreement about its definition and for which reliable diagnosis is virtually impossible is ill-advised.

3. Effective Treatment should exist for Screened Disorders, but No Treatment Exists for Chronic Mild TBI. Another major requirement for screening is that if a disorder or condition is identified, appropriate and effective treatment should exist for that condition (Wilson & Jungner, 1968). Given the natural history of mild TBI, if postconcussive-like symptoms exist in the chronic phase then they are most likely unrelated to mild TBI/concussion and far more likely to be related to other factors(e.g. mental health conditions) (Donnell, Kim, Silva, & Vanderploeg, 2012; Meares et al., 2011). The only demonstrated effective treatment for mild TIB is during the acute state and involves psychoeducational and supportive interventions (Belanger, Donnell, & Vanderploeg, in press). These educational interventions in the acute phase have been shown to result in significantly shorter symptom duration and fewer symptoms at follow-up in civilians (Mittenberg, Canyock, Condit, & Patton, 2001; Mittenberg, Tremont, Zielinski, Fichera, & Rayls, 1996; Ponsford et al., 2002). Expectation management is key, utilizing appropriate support, education, early symptom management and a clear and consistent positive message of recovery over time.

Harm and Costs Outweigh Benefits of Mild TBI Screening

Harm. A growing body of literature demonstrates the role of expectation in both cognitive performance and rate of symptom complaint. Simply drawing attention to the label "TBI" can cause increased symptom reporting and result in poorer cognitive performance (Ferguson, Mittenberg, Barone, & Schneider, 1999; Mittenberg, DiGiulio, Perrin, & Bass, 1992; Pavawalla, Salazar, Cimino, Belanger, & Vanderploeg, 2013; Suhr & Gunstad, 2005). If there is an expectation of post-injury problems, then in at least some individuals, such symptoms are more likely to be reported (Mittenberg, et al., 1992; Whittaker, Kemp, & House, 2007). In addition, since virtually everyone with a mild TBI experiences acute symptoms for minutes to hours post-injury, the mere presence of these symptoms can reinforce preexisting negative expectations and beliefs. Given the current political climate and the emphasis on TBI as the "signature injury" of the war on terror, research regarding patient self-expectations is particularly pertinent. Screening individuals within the context of increased media attention on TBI sets the stage for expectancies to exert an influence on the patient's belief system to attribute many or all difficulties to TBI. Also, with recent media attention on multiple concussions in the sports arena and their purported association with dementia, suicide, and other adverse long-term outcomes, it is understandable that both patients and providers may have a more catastrophic reaction to a diagnosis of mild TBI than perhaps may be warranted. In addition, there may be an inclination by the patient to attribute symptoms to TBI, rather than psychological diagnoses such as PTSD.

In addition to the effects of expectation, the presence of external incentives also clouds interpretation of post-screening neuropsychological findings of patients with a history of mild TBI. Meta-analytic studies of mild TBI have demonstrated the adverse effect of external incentives on cognitive performance. (Belanger, Curtiss, Demery, Lebowitz, & Vanderploeg, 2005; Binder & Rohling, 1996). In a system such as the VHA, where compensation is provided for service-connected injuries, financial incentives should always be considered as a potentially complicating factor. Given the denigration experienced by many returning Vietnam era veterans, there has been a very strong desire to "do the right thing" for the OEF/OIF war-injured veteran. If there is any indication of exposure to or injury from blasts, or having sustained even a mild TBI, there is political pressure to assume that current symptoms and complaints are valid and related to those deployment events. In that context, even if there is evidence for symptom exaggeration or overt malingering, there is pressure to base treatment decisions on patient's self-report and preference in order to enhance customer satisfaction and avoid "bad press."

Costs. TBI screening also has financial costs. While the screen itself is embedded in a variety of other post-deployment screens and therefore is of minimal additional cost, the subsequent evaluation and treatment process adds considerable cost. Due to the high sensitivity and low specificity of the screen, significant clinical resources are spent evaluating numerous false positives. In addition, extra 'cost' is likely created by TBI screening and medical evaluation-induced iatrogenesis in the form of unnecessary treatments, healthcare visits, and lost work for patients. Since only 38.6% of those who screen positive for mild TBI receive a definitive diagnosis of TBI, screening for mild TBI is arguably quite a wasteful process.

In addition, there is the cost to the larger Veterans Affairs system and to society in terms of disability compensation. In 2008, the VA created a disability category for residuals of TBI that allows for assignment of up to 40% disability to those who report three or more subjective symptoms that interfere at least moderately with work, instrumental activities of daily living, or important social relationships. Based on our analyses of the VHA national data, approximately 70% of veterans screening positive for mild TBI report at least three symptoms at a level indicating moderate day-to-day functional impairment or worse during the Comprehensive TBI Evaluation following a positive screen. If disability benefits were provided based on the level of medical symptom reporting during the Comprehensive TBI Evaluation, this would be a substantial cost to the system, given the high endorsement rate of symptoms.

Benefits. The DoD and VHA are to be commended for attempting to make sure that Service Members and Veterans returning from deployment are offered whatever medical care they require. The benefit of postdeployment screening (TBI and other health and mental health screens) is to identify and treat problems (regardless of etiology, one might argue). Given that the primary focus of the TBI screen is on nonspecific symptoms and given the unknown etiology of these symptoms, a problem-centric, symptom-based approach is likely most prudent. Such an approach is laid out in the VA/DoD Clinical Practice Guidelines for concussion/mild TBI (Department of Veterans Affairs and Department of Defense, April, 2009). Primary care or postdeployment clinics are well suited and equipped to identify and treat or triage such troubling symptoms of unknown etiology.

In reviewing potential benefits and costs/harms of screening for mild TBI, it becomes clear that the potential costs/harms outnumber the potential benefits (see Table 1). Furthermore, some of the benefits assume that the assumptions underlying useful medical screening, as reviewed above, have been met (e.g., that mild TBI is a progressive condition, and that proactive treatment is a good thing because effective treatment exists). Unfortunately, as has already been illustrated, these assumptions for screening are not met with regard to screening for mild TBI.

Table 1. Benefits versus Costs and Harms to TBI Screening

Benefits	Costs/Harms
Reassurance in those who screen negative (80%)	Anxiety in those who screen positive (20%)
More proactive treatment	Iatrogenic symptom magnification
Identification of important clinical concerns, even if not related to mild TBI	Extra diagnostic expenses and possible morbidity in false positives
Political sensitivity – screen everyone. No one is left behind and not offered care for their symptoms regardless of etiology	“Over-diagnosis” and misattribution of symptoms to mild TBI
Possible enhanced patient care/ satisfaction	Personal expenditure in attending follow-up evaluations
Possible increased productivity via symptom reduction	Lost productivity due to iatrogenesis and participating in screening and evaluation process
	Mistreatment or failure to obtain correct treatment for a comorbid condition because of symptom misattribution
	Contribute to public misperception of mild TBI (i.e., that there is likely sequelae years post-injury)
	VA Disability compensation for symptoms that are unrelated to mild TBI and impossible to verify objectively
	Over-reporting of “symptoms” that are not really problematic

Summary and Recommendations

Based on generally accepted medical screening principles and assumptions, screening for mild TBI is unnecessary at best and potentially harmful at worst. The conditions for beneficial medical screening are simply not met. Because nonspecific symptoms can be effectively treated in a symptom-specific manner, tying them to mild TBI (which in the chronic phase is highly unlikely) through a screening and evaluation process is wasteful and potentially harmful. Identification of health-related problems and non-specific symptoms should be based on the patient’s concerns in discussions with their health care provider as part of their ongoing regular healthcare, as is typically done in primary care. This is not to say that screening for other high probability postdeployment conditions such as depression, PTSD, or other disorders may not be beneficial. However, the same type of medical screening criteria and harm/cost/benefit analysis should be undertaken to ensure that such screening programs are likely to improve patient outcomes. As was recently done with prostate and other screening programs, it may be time to revisit the necessity of screening for mild TBI.

Heather Belanger, PhD, ABPP is a Clinical Neuropsychologist in the TBI/ Polytrauma Center at the James A. Haley Veterans Hospital, and faculty in the Departments of Psychology and Psychiatry and Behavioral Neurosciences at the University of South Florida. Her funded research includes a web-based intervention trial following mild TBI, a smart phone-based intervention trial, and a study examining the VA’s TBI screening and evaluation process.

Rodney Vanderploeg, Ph.D., ABPP-CN is the supervisory clinical neuropsychologist in the Brain Injury and Polytrauma Rehabilitation programs at the James A. Haley Veterans Hospital in Tampa where he has worked since 1987. He is a Clinical Professor in the Department of Psychiatry and Neurosciences and Department of Psychology at the University of South Florida. Dr. Vanderploeg has been an investigator in the Defense and Veterans Brain Injury Center (DVBIC) since 1992 and is the Tampa site Co-Principal Investigator. In his more than 30 years as a clinical neuropsychologist, he has published over 100 articles and 115 abstracts, and co-authored 25 books or book chapters. He has been funded on 9 research grants in the area of brain injury and has served on 7 journal editorial boards.

References

Belanger, H. G., Curtiss, G., Demery, J. A., Lebowitz, B. K., & Vanderploeg, R. D. (2005). Factors moderating neuropsychological outcome following mild traumatic brain injury: A meta-analysis. Journal of the International Neuropsychological Society, 11(3), 215-227.

Belanger, H. G., Donnell, A. J., & Vanderploeg, R. D. (in press). Special Issues with Mild TBI in Veterans and Active Duty Service Members. In M. S. Sherer, A. (Ed.), Handbook on the Neuropsychology of Traumatic Brain Injury. New York: Springer Press.

Belanger, H. G., Vanderploeg, R. D., Soble, J. R., Richardson, M., & Groer, S. (2012). Validity of the Veterans Health Administration's traumatic brain injury screen. Archives of Physical Medicine & Rehabilitation, 93(7), 1234-1239.

Binder, L. M., & Rohling, M. L. (1996). Money matters: a meta-analytic review of the effects of financial incentives on recovery after closed-head injury. American Journal of Psychiatry, 153(1), 7-10.

Borg, J., Holm, L., Cassidy, J. D., Peloso, P. M., Carroll, L. J., von Holst, H., & Ericson, K. (2004). Diagnostic procedures in mild traumatic brain injury: results of the WHO Collaborating Centre Task Force on Mild Traumatic Brain Injury. Journal of Rehabilitation Medicine, 43 Suppl, 61-75.

Department of Veterans Affairs and Department of Defense. (April, 2009). VA/DOD clinical practice guideline for management of concussion/mild traumatic brain injury Retrieved November, 2012, 2009, from http://www.healthquality.va.gov/mtbi/concussion_mtbi_full_1_0.pdf

Donnell, A. J., Kim, M. S., Silva, M. A., & Vanderploeg, R. D. (2012). Incidence of postconcussion symptoms in psychiatric diagnostic groups, mild traumatic brain injury, and comorbid conditions. Clinical Neuropsychologist, 26(7), 1092-1101.

Donnelly, K. T., Donnelly, J. P., Dunnam, M., Warner, G. C., Kittleson, C. J., Constance, J. E., . . . Alt, M. (2011). Reliability, sensitivity, and specificity of the VA traumatic brain injury screening tool. Journal of Head Trauma Rehabilitation, 26(6), 439-453.

Evans, C. T., St Andre, J. R., Pape, T. L., Steiner, M. L., Stroupe, K. T., Hogan, T. P., . . . Smith, B. M. (2013). An evaluation of the Veterans Affairs traumatic brain injury screening process among Operation Enduring Freedom and/or Operation Iraqi Freedom veterans. PM&R, 5(3), 210-220; quiz 220. doi: 10.1016/j.pmrj.2012.12.004
S1934-1482(12)01773-X [pii]

Ferguson, R. J., Mittenberg, W., Barone, D. F., & Schneider, B. (1999). Postconcussion syndrome following sports-related head injury: expectation as etiology. Neuropsychology, 13(4), 582-589.

Grimes, D. A., & Schulz, K. F. (2002). Uses and abuses of screening tests. Lancet, 359(9309), 881-884. doi: S0140-6736(02)07948-5 [pii]
10.1016/S0140-6736(02)07948-5

Hoge, C. W., McGurk, D., Thomas, J. L., Cox, A. L., Engel, C. C., & Castro, C. A. (2008). Mild traumatic brain injury in U.S. Soldiers returning from Iraq. New England Journal of Medicine, 358(5), 453-463.

Meares, S., Shores, E. A., Taylor, A. J., Batchelor, J., Bryant, R. A., Baguley, I. J., . . . Marosszeky, J. E. (2011). The prospective course of postconcussion syndrome: The role of mild traumatic brain injury. Neuropsychology, 25(4), 454-465.

Mittenberg, W., Canyock, E. M., Condit, D., & Patton, C. (2001). Treatment of post-concussion syndrome following mild head injury. Journal of Clinical and Experimental Neuropsychology, 23(6), 829-836.

Mittenberg, W., DiGiulio, D. V., Perrin, S., & Bass, A. E. (1992). Symptoms following mild head injury: expectation as aetiology. Journal of Neurology, Neurosurgery & Psychiatry, 55(3), 200-204.

Mittenberg, W., Tremont, G., Zielinski, R. E., Fichera, S., & Rayls, K. R. (1996). Cognitive-behavioral prevention of postconcussion syndrome. Archives of Clinical Neuropsychology, 11(2), 139-145.

Pavawalla, S. P., Salazar, R., Cimino, C., Belanger, H. G., & Vanderploeg, R. D. (2013). An exploration of diagnosis threat and group identification following concussion injury. Journal of the International Neuropsychological Society, 19(3), 305-313.

Ponsford, J., Willmott, C., Rothwell, A., Cameron, P., Kelly, A. M., Nelms, R., & Curran, C. (2002). Impact of early intervention on outcome following mild head injury in adults. Journal of Neurology, Neurosurgery and Psychiatry, 73(3), 330-332.

Sayer, N. A., Nelson, D., & Nugent, S. (2011). Evaluation of the Veterans Health Administration traumatic brain injury screening program in the upper Midwest. Journal of Head Trauma Rehabilitation, 26(6), 454-467.

Streiner, D. L. (2003). Diagnosing tests: using and misusing diagnostic and screening tests. Journal of Personality Assessment, 81(3), 209-219.

Suhr, J. A., & Gunstad, J. (2005). Further exploration of the effect of "diagnosis threat" on cognitive performance in individuals with mild head injury. Journal of the International Neuropsychological Society, 11(1), 23-29.

Terrio, H., Brenner, L. A., Ivins, B. J., Cho, J. M., Helmick, K., Schwab, K., . . . Warden, D. (2009). Traumatic brain injury screening: preliminary findings in a US Army Brigade Combat Team. Journal of Head Trauma Rehabilitation, 24(1), 14-23.

Vanderploeg, R. D., & Belanger, H. G. (2013). Screening for a remote history of mild traumatic brain injury: when a good idea is bad. Journal of Head Trauma Rehabilitation, 28(3), 211-218. doi: 10.1097/HTR.0b013e31828b50db
00001199-201305000-00008 [pii]

Whittaker, R., Kemp, S., & House, A. (2007). Illness perceptions and outcome in mild head injury: a longitudinal study. Journal of Neurology, Neurosurgery & Psychiatry, 78(6), 644-646.

Wilson, J. M. & Jungner, G. (Eds.). (1968). Principles and practice of screening for disease. Geneva: WHO.

Intervening to Mitigate Chronic Post Concussive Symptoms among Veterans

Lisa A. Brenner, Ph.D., ABPP (Rp)
Veteran Integrated Service Network (VISN) 19 Mental Illness Research Education and Clinical Center (MIRECC), Denver, CO
Departments of Psychiatry, Neurology, and Physical Medicine and Rehabilitation, University of Colorado, School of Medicine, Aurora, CO

Nazanin H. Bahraini, Ph.D.
Veteran Integrated Service Network (VISN) 19 Mental Illness Research Education and Clinical Center (MIRECC), Denver, CO
Department of Psychiatry, University of Colorado, School of Medicine, Aurora, CO

Introduction

Military personnel who served in Iraq and Afghanistan (Operation Iraqi Freedom [OIF]; Operation Enduring Freedom [OEF], and Operation New Dawn [OND]) are being exposed to both physical and psychological stressors. Traumatic brain injury (TBI), and in particular mild TBI (mTBI), has been discussed as a "signature injury" of the current conflicts. Immediately post-injury, the majority of individuals with a history of mTBI experience post-concussive symptoms (PCS). For most people, recovery, as measured by self-reported symptoms, is rapid. However, a small group of individuals (e.g., 7.5%)[1] report persistent symptoms including headaches, dizziness, balance problems, difficulty with memory and cognitive functioning, fatigue, and depressed/anxious mood. Evidence-based or informed treatments for PCS are limited, particularly those aimed at addressing symptoms long-post injury. Findings regarding post-acute PCS among those who have served in the military, as well as a summary of selected evidence-informed intervention strategies to address such symptoms, will be presented below.

TBI and PCS among Veterans from Recent Conflicts

When comparing number of injuries sustained by OEF/OIF combat Veterans to those from previous conflicts, military personnel who served most recently have sustained higher numbers of both explosion-related injuries (OEF/OIF 81%, Vietnam 65%, World War II 73%) and injuries to the head and neck regions (OEF/OIF 30.0%, Vietnam 16.0%, World War II 21.0%).[2] Nevertheless, estimates of mTBI among those who have served in Iraq and Afghanistan are variable and dependent upon a wide range of factors including time of service, military occupational specialty (MOS), and method used to assess history of TBI.

Terrio et al.[1] found that 22.8% of Soldiers in a Brigade Combat Team returning from Iraq had a history of clinician confirmed TBI. Their findings also indicated that although 33.4% of soldiers with TBI reported 3 or more common PCS (i.e., headaches, dizziness, balance problems, irritability, and/or memory problems) immediately post-injury, only 7.5% endorsed such symptoms post-deployment. Interestingly, although many of the soldiers with a history of mTBI interviewed denied memory problems or irritability in the acute period post-injury, 52.3% and 48.6% endorsed such symptoms post-deployment respectively, calling into question the etiology of these symptoms.

In a follow up study using data from the same cohort, Brenner et al.[3] explored the unique and shared contribution(s) of mTBI and/or posttraumatic stress disorder (PTSD) to the endorsement of PCS. Findings suggested that among soldiers with histories of physical injury, mTBI and PTSD were independently associated with PC symptom reporting. Moreover, those with both conditions were at greater risk of reporting PC symptoms (adjusted prevalence ratio 6.27; 95% CI: 4.13–9.43) than those with either PTSD (adjusted prevalence ratio = 2.74; 95% CI: 1.58–4.74), mTBI (adjusted prevalence ratio = 4.03; 95% CI: 2.67–6.07), or neither condition. These findings suggest that co-occurring psychiatric conditions, such as PTSD, contribute to the reporting of PCS. To complicate matters, studies have also demonstrated that a history of TBI increases risk for developing PTSD.[4,5]

Specific Treatment for PCS

Among civilians, research supports the benefits of early education regarding the expectation for recovery.[6,7] For example, to evaluate the impact of education on symptom reporting, cognitive performance and psychological outcomes, Ponsford and colleagues7 assigned 202 adults seeking care post-injury at two Emergency Departments (EDs) to one of two treatment conditions. The 79 participants in the intervention group were contacted within 48 hours of ED admission and seen five to seven days post-discharge. During this visit, a history was taken and neuropsychological measures were administered. These individuals also received an informational booklet regarding common symptoms associated with mTBI, time course for recovery, and suggestions regarding coping. Participants in the non-intervention group were give standard ED treatment and no informational booklet. At three months post-injury, those in the no-intervention group reported more symptoms including those related to anxiety and sleep disturbance.

What remains unknown is whether such interventions are effective long-post injury. To begin the process of answering this question, King et al.[8] conducted a pilot study in which 25 Active Duty (n=10), Veteran (n=9) and civilian participants (n=6) engaged in a self-administered psychoeducational computer-based treatment. Time since injury varied significantly between the groups (mean number of days since injury (SD) – Active Duty 138.30 (194); VA – 987.78 (737); civilian .17 (.41)). The computer program was based on an evidence-based treatment by Mittenberg et al.[6,9] (*Recovering from Head Injury: A Guide for Patients*) and focused on information regarding TBI severity, expected symptom profiles, general strategies for symptom management, typical recovery patterns, and expectations for recovery" (p. 275).[8] Preliminary findings suggested that both acute and chronic groups benefited from the intervention as evidenced by significantly reduced physical, emotional and cognitive complaints.

Treatment for Specific Symptoms

Current best practices also include identifying and addressing symptoms (e.g., headaches) regardless of etiology.[10] A helpful resource for clinicians is the Department of Defense (DoD)/ Department of Veterans Affairs (VA) Clinical Practice Guidelines (CPGs) for Management of Concussion/Mild Traumatic Injury (http://www.healthquality.va.gov/mtbi/concussion_mtbi_full_1_0.pdf).[11] The intent of the CPGs is to: 1) "reduce current practice variation and provide [DoD/VA] facilities with a structured framework to help improve patient outcomes"; 2) "provide evidence-based recommendations to assist providers and their patients in the decision-making process related to the patient health care problems"; and 3) "identify outcome measures to support the development of practice-based evidence that can ultimately be used to improve clinical guidelines" (p.1).[11] Algorithms regarding Initial Presentation, Management of Symptoms, and Follow-up of Persistent Symptoms are also provided to assist with clinical decision making.

Treating PTSD Symptoms as a Means of Decreasing PCS

Further support for addressing symptoms regardless of etiology is provided by findings from a recent study which suggested that a "trauma-focused treatment approach" resulted in decreases in PTSD symptoms as well as PCS. In specific, Walter and colleagues[12] explored outcomes of interest among 28 male veterans participating in an eight week PTSD/TBI residential treatment program. All of the veterans met criteria for PTSD and had a history of TBI (24 mild, 4 moderate). Post-treatment measures suggested significant decreases in clinician-assessed PTSD severity, self-reported PTSD severity, and PCS severity. These findings further highlight the complex relationship between PTSD and PC symptoms among returned Veterans.

Conclusion

As demonstrated by the studies noted above, the body of research regarding strategies to mitigate PCS among military personnel is limited. However, work to date supports several important treatment strategies that are focused on education and symptom management. When delivering these interventions, providers may also want to consider using a stepped care approach. With this stepwise progression, providers may proceed to the next step or level if symptoms are not adequately managed at the current level.

- **Step 1**: Providing patients with education about mTBI symptoms and recovery as soon as possible after the injury. Information provided should include:[11]
    - Overview of common symptoms following mTBI and expected outcomes
    - Normalization of symptoms
    - Reassurance that a positive recovery is expected
    - Importance of self-care (sleep, nutrition, stress management) to improve outcomes
    - Risk reduction strategies to prevent harm and re-injury (e.g., limiting consumption of alcohol)

- **Step 2**: Implementing evidence-based interventions to address specific symptoms (e.g., poor sleep, headaches)[11]

- **Step 3**: Implementing evidence-based interventions to address MH complaints and monitoring both MH and PCS post-treatment outcomes[11]

Lisa A. Brenner, Ph.D. is a Board Certified Rehabilitation Psychologist, and an Associate Professor of Psychiatry, Neurology, and Physical Medicine and Rehabilitation at the University of Colorado Denver School of Medicine. Dr. Brenner is the Director of the VISN 19 Mental Illness Research, Education, and Clinical Center (MIRECC). She is also the Director of Training for the MIRECC Psychology Post-Doctoral Fellowship program. Her primary area of research interest is TBI, co-morbid psychiatric disorders, and negative psychiatric outcomes including suicide. Dr. Brenner serves as the Secretary for APA Division 22.

Nazanin Bahraini, Ph.D. is a Licensed Psychologist and Assistant Professor of Psychiatry at the University of Colorado Denver School of Medicine. Dr. Bahraini is also the Director of Education for the VISN 19 Mental Illness Research, Education, and Clinical Center (MIRECC). Her primary area of research interest is focused on the interplay between traumatic brain injury and posttraumatic stress disorder and their cumulative impact on suicide risk. Other areas of interest include upstream interventions to mitigate suicide risk in the Veteran population, and implementation of evidence based suicide prevention practices in routine care settings.

References

1. Terrio, H., Brenner, I.A., Ivins, B.J., Cho, J.M., Helmick, K., Schwab, K. et al. (2009). Traumatic brain injury screening: Preliminary findings in a US Army Brigade Combat Team. Journal of Head Trauma Rehabilitation, 24, 14-23.

2. Owens, B. D., Kragh, J. F., Wenke, J. C., Macaitis, J., Wade, C. E., & Holcomb, J. B. (2008). Combat wounds in Operation Iraqi Freedom and Operation Enduring Freedom. Journal of Trauma, 64, 295-299.

3. Brenner, L.A., Ivins, B.J., Schwab, K., Warden, D., Nelson, L.A., & Jaffee, M. (2010). Traumatic brain injury, posttraumatic stress disorder, and postconcussive symptom reporting among troops returning from Iraq. Journal of Head Trauma Rehabilitation, 25(5),307-312.

4. Bryant,R.A., O'Donnell, M.L., Creamer, M., McFarlane, A.C., Clark, C.R., Silove, D. (2010).The psychiatric sequelae of traumatic injury. American Journal of Psychiatry, 167(3),312–320.

5. Hoge, C. W., McGurk, D., Thomas, J. l., Cox, A. l., Engel, C. C., & Castro, C. A. (2008). Mild traumatic brain injury in U.S. soldiers returning from Iraq. New England Journal of Medicine, 358, 453-463.

6. Mittenberg, W., Tremont, G., Zielinski, R. E., Fichera, S., & Rayls, K. R. (1996). Cognitive-behavioral prevention of postconcussion syndrome. Archives of Clinical Neuropsychology, 11, 139–145.

7. Ponsford,J., Willmott,C., Rothwell,A., Cameron, P., Kelly, A.M., Nelms, R., et al. (2002). Impact of early intervention on outcome following mild head injury in adults. Journal of Neurology & Neurosurgery Psychiatry, 73, 330–332

8. King, E.G., Kretzmer, T.S.Vanderploeg, R.D., Asmussen, S.B., Clement,V.L., & Belanger, H.G. (2013). Pilot of a novel intervention for postconcussive symptoms in active duty, veterans, and civilians. Rehabilitation Psychology, 58(3),272-279.

9. Mittenberg, W., Zielinski,R.E., & Fichera, A. (1993). Recovery from mild head injury: A treatment manual for patients. Psychotherapy in Private Practice ,12,37-52.

10. Brenner, I. A., Vanderploeg, R. D., & Terrio, H. (2009). Assessment and diagnosis of mild traumatic brain injury, posttraumatic stress disorder, and other polytrauma conditions: Burden of adversity hypothesis. Rehabilitation Psychology, 54, 239-246.

11. Management of Concussion/mTBI Working Group (2009). VA/DoD Clinical Practice Guideline for Management of Concussion/ Mild Traumatic Brain Injury. Journal of Rehabilitation Research and Development, 46, CP1-CP68.

12. Walter,K.H., Kiefer, S.L., & Chard, K.M. (2012). Relationship between posttraumatic stress disorder and postconcussive symptom improvement after completion of a posttraumatic stress disorder/traumatic brain injury residential treatment program. Rehabilitation Psychology57(1),13–17.

NAN would like to congratulate the 2013 award recipients for their contributions to the field over the past year and throughout their careers.

Distinguished Lifetime Contribution to Neuropsychology Award
Dean C. Delis, Ph.D.

Distinguished Service Award
Robert W. Elliott, Ph.D.

Early Career Award
Thomas D. Parsons, Ph.D.

Early Career Service Award
Karin J M McCoy, Ph.D.

Outstanding Dissertation Award
Yakeel T. Quiroz-Gaviria, Ph.D.

Nelson Butters Award for Research Contributions to Clinical Neuropsychology
Erin E. Morgan, Ph.D.
Steven Paul Woods, Psy.D.
Igor Grant, M.D.

Tony Wong Diversity Award for Outstanding Mentorship
S. Walden Miller, Ph.D.

Tony Wong Diversity Award for Outstanding Work Related to Diversity as a Graduate Student
Nicholas S. Thaler, Ph.D.

Tony Wong Diversity Award for Outstanding Work Related to Diversity as a Post Doc or Early Career Professional
Maiko Sakamoto, Ph.D.

It's Not Just White Male Adults Playing Football and Hockey: Concussion Management with Diverse Athlete Populations

Frank M. Webbe, Ph.D.
Florida Institute of Technology

Christine M. Salinas, Psy.D.
Comprehensive Epilepsy Center, Florida Hospital for Children

Although the contemporary sport neuropsychology literature includes studies of many sports played by men and women, children and adolescents, many races and ethnicities, the observers of the modern sport scene – including many neuropsychologists – might be functionally unaware that sport-related concussions are prevalent and of importance outside of American football and professional ice hockey.

Barth and colleagues (1989) seminal work on concussions in college football primed the pump for future studies, and established football as the showpiece domain of sport neuropsychology. Professional ice hockey has joined football not only as an epidemiologically related venue for sport concussions, but also as a magnet for media attention. The predominant focus on concussions in these sports has created the appearance of a gendered phenomenon, since male participation dominates in these arenas. The cultural diversity of football players has at least made it clear that sport concussions are an 'equal opportunity' injury.

Accumulating evidence regarding the epidemiology of concussion supports that athletes of other sports, women, and those from other cultural groups may have equivalent or greater risk than in football (Dick, 2009; Gessel, Fields, Collins, Dick, & Comstock, 2007). Moreover, a significant proportion of the world's youth play sports such as soccer where the concussion risk is moderate to high (Webbe and Salinas, 2010).

The goal of this article is to provide an overview of sport-related concussions within the context of age, gender, sport, pre-morbid conditions, language and culture. These factors, singly or in combination, may influence concussion incidence, severity, and recovery, as well as management approaches. We have provided a more complete development of these issues elsewhere (Salinas and Webbe, 2012).

Younger Athletes Are at Greater Risk

Youth athletes may be particularly vulnerable to sport-related concussions. However, most of the data have been collected with high-school aged youth. This is not surprising since high school programs are better structured and may follow concussion management guidelines compared to youth organizations. Children may have more risk since the incidence rate is greater in high school than in collegiate sports (Guskiewicz, Weaver, Padua, & Garrett, 2000). High school athletes also exhibit protracted recovery following concussion compared to collegiate and professional athletes (Field, Collins, Lovell, & Maroon, 2003; Meehan, d'Hemecourt, & Comstock, 2010). Unfortunately, there are sparse comprehensive data on concussion outcomes in youth, due in part to the lack of assessment tools that have been developed specifically for this purpose. Pediatric ImPACT shows promise in evaluating processing speed post-injury (Newman, Reesman, Vaughan, & Gioia, 2013). It is not entirely clear whether concussion or repeat injury could alter the cognitive developmental trajectory. Moser, Schatz, and Jordan (2005) reported that adolescents with a history of multiple concussions performed similarly on the RBANS and Trail Making Test to athletes who sustained a concussion within 1 week of evaluation. Persistent post-concussive symptoms are also frequently observed in children beyond the typical 7-10 day 'norm' for adults (Mittenberg, Wittner, & Miller, 1997). Several factors may be contributory: time to evaluation and education received regarding physical and cognitive rest; poor compliance; premorbid conditions; sociocultural factors (Yeates et al., 2012); and family adjustment (McNally et al., 2013). Unfortunately, only limited data are available regarding the reliability and reliable change indices of concussion symptom scales used with children younger than 12 (i.e., Graded Symptom Checklist, Post Concussion Symptom Inventory/Acute Concussion Evaluation, Rivermead Post Concussion Symptom Questionnaire, Health Behavioral Inventory; Gioia, Schneider, Vaughan, & Isquith, 2009). Careful evaluation is needed since children may report more somatic symptoms, whereas parents endorse increased cognitive problems (Hajek et al., 2011).

These findings suggest that the risk and associated consequences of concussion in children is high but the likelihood of having appropriate resources and trained professionals available is low. Comparative differences between adolescents and adults make extrapolation of these trends to youth reasonable. Giza and Hovda's (2001) work using animal models would support this interpretation.

Sex and Concussion: No Respect for Women

The burgeoning feminist movement that arose in the 1960's, congressional passage in 1972 of Title IX, and continuing broad demands to eliminate gender barriers have resulted in a rapid growth in women's sport participation. More than 40% of females play high school and college sports (Cheslock, 2007). With greater equality, however, came unforeseen consequences. Comprehensive reviews and meta-analytic studies indicate that females have a higher risk of concussion at all levels of competition (Covassin & Elbin, 2010; Dick 2009; Farace & Alves, 2000; Gessell, Fields, Collins, Dick, & Comstock, 2007). Collegiate women's soccer and basketball players sustain more concussions than males (Agel, Evans, Dick, Putukian, & Marshall, 2007). Professional female soccer players have more than twice the risk (22%) compared to men (8%; Dvorak, McCrory, and Kirkendall, 2007). Hootman, Dick, and Agel (2007) found that women had more concussions than men in sports played by both sexes (i.e., soccer, basketball, lacrosse), and concussions represented a greater percentage of all injuries. Regrettably, insufficient data are available in youth to draw gender-based conclusions on concussion incidence or recovery.

Concussion effects are evaluated through symptom ratings, traditional and computerized neurocognitive tests, balance and gait measures, and sophisticated electrophysiological or neuroimaging tools. Using only symptom measures can result in interpretive difficulties when comparing post-concussive consequences across sexes. For example, Covassin and colleagues (2006) showed that females report more baseline symptoms, which complicates post-concussion analyses. Despite symptom differences, females and males perform similarly on baseline neurocognitive tests (Covassin, Schatz, & Swanik, 2007). When studies have controlled for that enhanced reporting phenomenon (e.g., Colvin et al., 2009), it was found that women (aged 8-24) did nonetheless report more symptoms than men following concussion. Neurocognitive tools have also showed consistent impairments in women following even one concussion, and more persistent cognitive decline (Broshek et al., 2009).

Understanding women's potential vulnerability to concussion and its associated consequences provokes the obvious question of why this should be so. It appears that an almost algebraic summation of positive and negative risk factors produce the answer. From the positive risk perspective, adult females show weaker musculoskeletal support for the head, which exacerbates the acceleration of the head and brain induced by an externally applied force (Dvorak et al., 2007).

Physiological and metabolic factors might argue theoretically for negative risk. Studies with mice, rabbits, and cats indicate rather conclusively that progesterone is neuroprotective following brain injury (Bramlett & Dietrich, 2005; Stein, 2008). Regrettably, animal studies have not translated into reliable protective effects in humans, and it appears that the naturally occurring progesterone levels may be insufficient to convey this effect (Coimbra, Hoyt, Potenza, Fortlage, & Hollingsworth-Fridlund, 2003).

Premorbid Conditions: ADHD, LD, Psychological Distress

Although many articles, guidelines, and consensus statements warn about ADHD and LD as premorbid conditions that might influence baseline and post-concussive evaluations in youth (McCrory et al., 2009, McCrory et al., 2013), little data have been reported that support or refute the suggestion in practice (Salinas, Webbe, and Devore, 2009). This is surprising, since attention is a good predictor of physical injury in university students (Bergandi & Witting, 1988), and children who sustain mild traumatic brain injuries (Gerring et al., 1998). Often times, concussed athletes have a history of ADHD or LD. In these cases, their cognitive and/or emotional difficulties (Pritchard, Nigro, Jacobson, & Mahone, 2012) may overlap with or be exacerbated by concussion.

ADHD and LD. With college players, Collins et al. (1999) reported that an LD history resulted in lower baseline neuropsychological performance, and interacted with concussion to produce lower scores on some aspects of executive function (including processing speed). Iverson, Collins, and Lovell (2004) reported that adolescents with ADHD performed worse on baseline ImPACT testing, particularly in the areas of visual memory, processing speed, and inhibition. In a small sample of youth soccer players aged 9-14, children with an ADHD diagnosis, or who satisfied ADHD criteria based upon parent ratings, performed more poorly than same aged peers on computerized cognitive measures (e.g., Concussion Resolution Index for Children, CRI-C; Salinas, Webbe, & Devore, 2009). In both high school and collegiate athletes, Elbin and colleagues (2013) determined that self-reported ADHD, LD, or the combination was related to significantly poorer baseline computerized neurocognitive performance and higher symptom endorsement compared to a randomly selected control group.

The majority of the sports concussion literature has excluded those with LD and/or ADHD, since inclusion might confound or increase error variance. Because athletes with these conditions have been routinely excluded from empirical research, inaccurate interpretations of neurocognitive performance and symptom reporting may be a common occurrence in these populations, leading to less than optimal management.

Psychological distress. The role of pre-morbid psychological distress in the management of sport-related concussions is in its infancy. In one of the few empirical papers, Bailey, Samples, Broshek, Freeman, and Barth (2010) showed that higher baseline Personality Assessment Inventory (PAI) symptom endorsement by freshman collegiate football players predicted poorer performance on the Concussion Resolution Index (CRI), with significantly slower simple and complex reaction time. This relationship was most pronounced when the various elevated scales were considered as a block, versus the individual scales. The authors caution that in the context of concussion management, it is important to identify those athletes who exhibit high overall psychological distress rather than single scale elevations. The concern, of course, is that reduced baseline performance secondary to distress might result in poor sensitivity following concussion. Moreover, because emotional changes post-concussion are prevalent, the management of concussed athletes is enhanced if pre-morbid emotional factors have been considered (Mainwaring, Hutchison, Camper, and Richards, 2012).

The Role of Culture and Language in Concussion Management

Sports participation has led to cultural paradigm shifts in the status quo, such as through the impact of Jesse Owens' dominating Olympics performance and Jackie Robinson's breaking of the color barrier in Major League Baseball. The diverse representation of athletes at all levels makes the issue of cultural competence in concussion management important. Mounting evidence suggests that culture and education influence neuropsychological performance (Manly, Jacobs, Small, & Stern, 2002; Puente & Puente, 2009). Unfortunately, empirical data regarding the cultural equivalence of cognitive and symptom measures used for baseline and post-concussion evaluations are sparse. Although computerized batteries such as ImPACT and traditional neuropsychological tests are available in several languages, linguistic and cultural variables have often been overlooked in studies. At NAN's symposium on Concussion in Sport, Echemendia and Comper (2008) reported significant testing differences between athletes in the National Hockey League based upon cultural and linguistic background. Description of symptoms, ostensibly a straightforward task, was highly variable across languages and national groups.

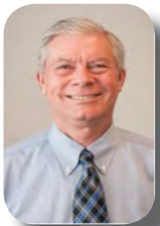
The issue of whether culture may influence baseline or even post-concussive performance remains an open question. Nonverbal and 'culture free' tests such as reaction time might be impacted, particularly when evaluating international, professional athletes, given recent evidence that suggests culture may mitigate performance on timed tasks (Agranovich, Panter, Puente, & Touradji, 2011).

Few studies have assessed equivalence of outcomes in sport-related concussion. Shuttleworth-Edwards, Whitefield-Alexander, Radloff, Taylor, and Lovell (2009) showed that 11-21 year old South African rugby players endorsed more symptoms than age-matched U.S. football players; no significant differences in cognitive performance emerged. The authors concluded that ImPACT was equivalent for South African athletes whose native language was English and who came from economically advantaged backgrounds. They cautioned against extending this interpretation to educationally disadvantaged populations.
In a slight contrast, Tsushima and Oshiro (2008) compared ImPACT data for more than 700 Hawaiian adolescent athletes to the U.S. normative set. A trend toward mildly reduced performance among Hawaiians was found, leading to a lower cut off for the impaired classification. This difference is not trivial, as utilization of U.S. Mainland norms in this population may result in a high number of false positives, leading to prolonged return-to-play decisions.

Kontos, Elbin, Covassin, and Larson (2010) compared pre-and post-concussion ImPACT performance between African American and Caucasian high-school and collegiate athletes, most of whom played football. Findings indicated equivalent baseline performance, but African American athletes evidenced poorer processing speed and were 2.4 times more likely to have an impaired domain 1 week post-concussion. This data should be considered preliminary in nature. More research is needed to delineate any underlying bases for post-concussion differences, including sociocultural factors associated with race (Yeates et al., 2002).

Summary and Take Home Messages

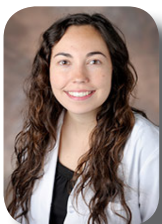
- Youth sustain more concussions than adults with generally worse outcomes such as more persistent cognitive changes and symptoms. Surveillance and pediatric sport-related concussion management remain in their infancy.
- Females have a higher concussion incidence compared to males, and they experience more severe and persistent symptoms. The interaction of anatomical features with applied biomechanical forces describes a mechanism for a true sex difference that goes beyond symptom endorsement.
- Preexisting ADHD, LD, and psychological distress are important factors to consider when interpreting baseline and post-injury assessments, and may complicate recovery and management decisions.
- Symptom manifestation as well as baseline and post-injury data may be influenced by athletes' cultural and linguistic background, including on nonverbal tasks. These variables should be factored into neuropsychological interpretation and return-to-play decisions.



Frank Webbe earned his Ph.D. in psychology at the University of Florida and is professor of psychology at Florida Institute of Technology, research director of the East Central Florida Memory Disorder Clinic, and co-director of the Florida Tech Sport-Related Concussion Project. For many years he has studied the risk factors for concussion in sport, as well as best practices for assessing and managing sport-related concussions.

He is a fellow of the American Psychological Association and the National Academy of Neuropsychology, treasurer of the NAN Foundation Board of Trustees, and Chair of the Technology Professional Interest Area of the International Society to Advance Alzheimer Research and Treatment. Dr. Webbe is a former president of the Division of Sport and Exercise Psychology of the American Psychological Association, and also of the national group, Running Psychologists.

Dr. Webbe is the NCAA Faculty Athletics Representative at Florida Tech, and is the president-elect of the national Faculty Athletics Representatives Association. As FAR for Florida Tech, Webbe assists in assuring the quality of the student-athlete experience and in the University's compliance with NCAA by-laws.



Christine M. Salinas, PsyD is a clinical neuropsychologist at Florida Hospital for Children with specialty training in lifespan neuropsychology (pediatric focus). Her primary responsibilities include providing inpatient and outpatient neuropsychological services for children and adults with intractable epilepsy. Dr. Salinas completed a Doctorate of Psychology, with a concentration in Neuropsychology, at the Florida Institute of Technology. She completed a Pre-Doctoral Internship in Clinical Neuropsychology at Emory University School of Medicine and a Post-Doctoral Fellowship in Pediatric Neuropsychology at the Florida Hospital for Children. She has significant training and experience in conducting bilingual Spanish/English assessments.

Professionally, Dr. Salinas has been active in clinical research with several peer-reviewed articles and book chapters, as well as national presentations. Her research interests broadly include the neurobehavioral consequences of sports related concussion and epilepsy. Dr. Salinas is primary or co-author of manuscripts related to sports concussion in specialty populations, sports neuropsychology in children, concussion management, subconcussive head impacts in soccer, cognitive performance in athletes with ADHD, and sports injuries. She currently has projects underway related to cognitive outcomes in epilepsy surgery; language mapping in children, and youth concussion. She is interested in integrating advanced technologies such as fMRI, DTI and MEG in her research. Dr. Salinas is active in several professional organizations and she currently serves as Member-At-Large for the Hispanic Neuropsychological Society.

References

Agel, J., Evans, T. A., Dick, R., Putukian, M., & Marshall, S. W. (2007). Descriptive epidemiology of collegiate men's soccer injuries: National Collegiate Athletic Association Injury Surveillance System, 1988-1989 through 2002-2003. Journal of Athletic Training, 42, 270-277.

Agranovich, A. V., Panter, A. T., Puente, A. E., & Touradji, P. (2011). The culture of time in neuropsychological assessment: Exploring the effects of culture-specific time attitudes on timed test performance in Russian and American samples. Journal of International Neuropsychological Society, 17 (4), 692-701.

Bailey, C., Samples, H., Broshek, D. K., Freeman, J. R., Barth, J. T. (2010). The Relationship Between Psychological Distress and Baseline Sports-Related Concussion Testing. Clinical Journal of Sport Medicine, 20, 272-277.

Barth, J. T., Alves, W. M., Ryan, T. V., Macciocchi, S. N., Rimel, R. W., Jane, J. A., & Nelson, W. E. (1989). Mild head injury in sports: Neuropsychological sequelae and recovery of function. In H. S. Levin, H. M. Eisenberg, & A. L. Benton (Eds.), Mild head injury (pp. 257-275). New York: Oxford University Press.

Bergandi, T. A., & Witting, A. F. (1988). Attentional style as a predictor of athletic injury. International Journal of Sport Psychology, 19, 226-235.

Bramlett, H. M., & Dietrich, W. D. (2001). Neuropathological protection after traumatic brain injury in intact female rats versus males or ovariectomized females. Journal of Neurotrauma, 18, 891-900.

Broshek, D. K., Kaushik, T., Freeman, J. R., Erlanger, D., Webbe, F. M., & Barth, J. T. (2005). Sex differences in outcome following sports-related concussion. Journal of Neurosurgery, 105, 856-863.

Cheslock, J. (2007). Who's playing college sports? Trends in participation. East Meadow, NY: Women's Sports Foundation.

Coimbra, R., Hoyt, D., Potenza, B., Fortlage, D., & Hollingsworth-Fridlund, P. (2003). Does sexual dimorphism influence outcome of traumatic brain injury patients? The answer is no! Journal of Trauma-Injury Infection & Critical Care, 54, 689-700.

Collins, M. W., Grindel, S. H., Lovell, M. R., Dede, D. E., Moser, D. J., Phalin, B. R., ...McKeag, D. B. (1999). Relationship between concussion and neuropsychological performance in college football players. Journal of American Medical Association, 282, 964-970.

Colvin, A. C., Mullen, J., Lovell, M. R., West, R. V., Collins, M. V., & Groh, M. (2009). The role of concussion history and gender in recovery from soccer-related concussion. American Journal of Sports Medicine, 37, 1699-1704.

Covassin, T., Swanik, C. B., Sachs, M., Kendrick, Z., Schatz, P., Zillmer, E., & Kaminaris, C. (2006). Sex differences in baseline neuropsychological function and concussion symptoms of collegiate athletes. British Journal of Sports Medicine, 40, 923-927.

Covassin, T., Schatz, P., & Swanik, C. B. (2007). Sex differences in neuropsychological function and post-concussion symptoms of concussed collegiate athletes. Neurosurgery, 61, 345-351.

Covassin, T., & Elbin, R. J. (2010). History and epidemiology of concussion in sport. In F. M. Webbe (Ed.), Foundations of sport neuropsychology (pp. 53-74). New York: Springer Publishing.

Dick, R. W. (2009). Is there a gender difference in concussion incidence and outcomes? British Journal of Sports Medicine, 43, i46-i50.

References, cont.

Dvorak, J., McCrory, P., & Kirkendall, D. T. (2007). Head injuries in the female football player: Incidence, mechanisms, risk factors and management. British Journal of Sports Medicine, 41(Suppl 1), i44-i46.

Echemendia, R., & Comper, P. (2008). The National Hockey League concussion management program: Preliminary data. Paper presented at Concussion in Sport: A Clinical Symposium. New York City, New York.

Farace, E., & Alves, W. M. (2000). Do women fare worse: A meta-analysis of gender differences in traumatic brain injury outcome. Journal of Neurosurgery, 93, 539-545.

Field, M., Collins, M. W., Lovell, M. R., & Maroon, J. (2003). Does age play a role in recovery from sports-related concussion? A comparison of high school and collegiate athletes. Journal of Pediatrics, 142, 546-553.

Gessel, L. M., Fields, S. K., Collins, C. L., Dick, R. W., & Comstock, R. D. (2007). Concussions among United States high school and collegiate athletes. Journal of Athletic Training, 42, 495-503.

Gerring, J. P., Brady, K. D., Chen, A., Vasa, R., Grados, M., Bandeen-Roche, J. J., ...Denckla, M. B. (1998). Premorbid prevalence of ADHD and development of secondary ADHD after closed head injury. Journal of the American Academy of Child and Adolescent Psychiatry, 37, 647-654.

Gessel, L. M., Fields, S. K., Collins, C. L., Dick, R. W., & Comstock, R. D. (2007). Concussions among United States high school and collegiate athletes. Journal of Athletic Training, 4, 495-503.

Gioia, G. A., Schneider, J. C., Vaughan, C. G., & Isquith, P. K. (2009). Which symptom assessments and approaches are uniquely appropriate for paediatric concussion? British Journal of Sports Medicine, 43(Suppl I), i13-i22.

Giza, C. C., & Hovda, D. A. (2001). The neurometabolic cascade of concussion. Journal of Athletic Training, 36, 228-235.

Guskiewicz, K. M., Weaver, N. L., Padua, D. A., & Garrett, W. E. (2000). Epidemiology of concussion in collegiate and high school football players. American Journal of Sports Medicine, 28, 643-650.

Hajek, C. A., Yeates, K. O., Taylor, H. G., Bangert, B., Dietrich, A., Nuss, K. E., ...Wright, M. (2011). Agreement between parents and children on ratings of post-concussive symptoms following mild traumatic brain injury. Child Neuropsychology, 17, 17-33.

Hootman, J. M., Dick, R., & Agel, J. (2007). Epidemiology of collegiate injuries for 15 sports: Summary and recommendations for injury prevention initiatives. Journal of Athletic Training, 42, 311-319.

Kontos, A. P., Elbin, R. J., Covassin, T., & Larson, E. (2010). Exploring differences in computerized neurocognitive concussion testing between African American and White athletes. Archives of Clinical Neuropsychology, 25, 734-744.

Mainwaring, L., Hutchison, M., Camper, P., and Richards, D. (2012). Examing emotional sequelae of sport concussion. Journal of Clinical Sport Psychology, 6, 247-274.

Manly, J. J., Jacobs, D. M., Touradji, P., Small, S. A., & Stern, Y. (2002). Reading level attenuates differences in neuropsychological test performance between African American and White elders. Journal of the International Neuropsychological Society, 8, 341-348.

McCrory, P., Meeuwisse, W., Johnston, K., Dvorak, J., Aubry, M., Molloy, M., & Cantu, R. (2009). Consensus statement on concussion in sport: The 3rd International Conference on Concussion in Sport, Zurich, Germany, November 2008. British Journal of Sports Medicine, 43 (Suppl I), i76-i84.

McCrory, P., Meeuwisse, W. H., Aubry, M., Cantu, B., Dvorak, J., Echemeddia, R. J., ...Turner, M. (2013). Consensus statement on concussion in sport: The 4th International Conference on Concussion in Sport held in Zurich, November 2012. British Journal of Sports Medicine, 47. 250-258.

McNally, K.A., Bangert, B., Dietrich, A., Nuss, K., Rusin, J., Wright, M., Taylor, H. G., & Yeates, K. O. (2013). Injury versus noninjury factors as predictors of postconcussive symptoms following mild traumatic brain injury in children. Neuropsychology, 27 (1), 1-12.

Meehan, W. P., d'Hemecourt, P., & Comstock, R. D. (2010). High school concussions in the 2008-2009 academic year: Mechanism, symptoms, and management. The American Journal of Sports Medicine, 38, 2405-2409.

Mittenberg, W., Wittner, M. S., & Miller, L. J. (1997). Postconcussion syndrome occurs in children. Neuropsychology, 11, 447-452.

Moser, R. S., Schatz, P., & Jordan, B. D. (2005). Prolonged effects of concussion in high school athletes. Neurosurgery, 57, 300-306.

Newman, J. B., Reesman, J. H., Vaughan, C. G., & Gioia, G. A. (2013). Assessment of Processing Speed in Children with Mild TBI: A "First Look" at the Validity of Pediatric ImPACT. The Clinical Neuropsychologist, 27 (5), 779-793.

Pritchard, A. E., Nigro, C. A., Jacobson, L. A., & Mahone, M. (2012). The role of neuropsychological assessment in the functional outcomes of children with ADHD. Neuropsychology Review, 22, 54-68.

Puente, A. E., & Puente, A. N. (2009). The challenges of measuring abilities and competencies in Hispanics/Latinos. In E. L. Grigorenoko (Ed.). Multicultural psychoeducational assessment (pp. 417-441). New York: Springer.

Salinas, C. M., & Webbe, F. M. (2012). Sports neuropsychology in diverse athlete populations: Contemporary findings and special considerations. Journal of Clinical Sport Psychology, 6, 363-384.

Salinas, C. M., Webbe, F. M., & Devore, T. T. (2009). The epidemiology of soccer heading in competitive youth players. Journal of Clinical Sport Psychology, 3, 1-20.

Shuttleworth-Edwards, A. B., Whitefield-Alexander, V. J., Radloff, S. E., Taylor, A. M., & Lovell, M. R. (2009). Computerized neuropsychological profiles of South African versus U.S. athletes: A basic for commentary on cross-cultural norming issues in the sports concussion arena. Physician and Sports Medicine, 37, 45-52.

Stein, D. G. (2008). Progesterone exerts neuroprotective effects after brain injury. Brain Research Review, 57, 386-397.

Tsushima, W. T., & Oshiro, R. (2008). Neuropsychological test performance of Hawaii high school athletes: Hawaii ImPACT normative data. Hawaii Medical Journal, 67(4), 93-95.

Webbe, F. M., & Salinas, C. (2010). Pediatric sport neuropsychology. In A. S. Davis (Ed.) Handbook of Pediatric Neuropsychology (pp. 1095-1109). New York: Springer Publishing Company.

Yeates, K.O., Taylor, H.G., Woodrome, S.E., Wade, S.L., Stancin, T., & Drotar, D. (2002). Race as a moderator of parent and family outcomes following pediatric brain injury. Journal of Pediatric Psychology, 27 (4), 393-403.

Yeates, K. O., Taylor, H.G., Rusin, J., Bangert, B., Dietrich, A., Nuss, K., & Wright, M. (2012). Premorbid child and family functioning as predictors of post-concussive symptoms in children with mild traumatic brain injuries, International Journal of Developmental Neuroscience, 30 (3), 231-237.

Youth Assessment and Management of Concussion

Gerard A. Gioia, Ph.D.
Children's National Medical Center, George Washington University School of Medicine

The assessment and management of concussion has gained substantially greater attention clinically[1] and in the research literature over the past ten years, including its application to children. The neuropsychology profession has played a central role in the evolution of our knowledge base as described in the 2012 Neuropsychology Inter-Organization Position paper[2]. A concussion is defined as a traumatic brain injury typically caused by acceleration/deceleration forces from a blow to the head or body which in turn produces biochemical and neurometabolic changes in the brain. The injury can result in a variety symptoms including somatic (e.g., headache, nausea, or dizziness), cognitive (e.g., problems with attention, memory, or information processing speed) and emotional (e.g., irritability, anxiety) issues.

Concussions can present in variable ways affecting a number of different functional domains, supporting the importance of a multimodal concussion assessment and treatment model. The skillset of the neuropsychologist positions us well as key members of the multidisciplinary medical team in assessing and managing concussion. Our role is particularly highlighted when considering concussion as a biopsychosocial problem, given our expertise in the assessment and management of cognitive and social-emotional issues, family factors, and school/ work performance challenges.

The evaluation and management of concussion in children present additional unique challenges to the clinician. While the assessment domains in children are generally similar to those in adolescents and young adults, important differences must be understood, including differences in their cognitive, physical and emotional development, capacity to serve as the primary reporter of their symptoms, and their active role as a student in school. The evaluation of a concussion in a younger child is not a simple "downsizing" of an adult model to children. Concussion evaluation tools ultimately require significant construction from a developmental perspective for use with children and adolescents. Such modifications should account for differences in neurocognitive development (e.g., information processing speed, attentional/ memory competencies) and differences in the child's ability to detect and report symptoms and possible changes from pre- to post-concussion. Thus, parents, and possibly other key adults such as teachers, will play an important complementary role in the evaluation and treatment process[3,4].

Fundamental to the concussion evaluation is a thorough understanding of the injury characteristics and the type and severity of post-concussion symptoms and neuropsychological dysfunction in the context of the child's history. The clinician must differentiate between the onset of new symptoms, exacerbation of pre-existing symptoms, or no symptoms. Understanding the child's developmental, medical, family, educational, and psychological history is therefore critical to defining the post-injury symptom profile. The evaluation of a concussion can be complicated as the symptoms also are common to those of other medical or psychiatric conditions (e.g., post-traumatic stress disorder, depression, attention-deficit/hyperactivity disorder) and must be differentiated from these other sources. The temporal proximity to the injury of symptom onset is important to establish. To assist more standardized office assessment and management, Micky Collins and this author developed the Acute Concussion Evaluation (ACE)[5] tool to provide a systematic assessment protocol and management guidance for children and adults. The ACE and its Care Plans are available online in the CDC's "Heads Up: Brain Injury in your Practice" toolkit[6].

Injury Definition and Characteristics. Defining the acute injury characteristics is important to frame the severity and possible risks of the injury. This involves a description of the injury and the types of forces involved, mechanism of injury, location (e.g., frontal or temporal) of the blow, evidence of alteration of conscious and/or confusion, presence of retrograde and anterograde amnesia, seizure activity, early signs and symptoms, and radiologic findings. Post-injury signs such as retrograde amnesia or confusion can be important as they have been shown to be predictive of later neurocognitive dysfunction and protracted symptom resolution.

Pre-Injury History. A thorough developmental history, medical/ neurological history (including personal/ family history of chronic headaches), school history, and psychiatric history (including sleep disorders, anxiety, depression) provides essential information about the child's pre-injury functioning. In addition, one must obtain a history of prior concussions, including the duration of symptoms for each injury, and the type of blow. Each of these risk factors has been associated with a longer period of recovery from a concussion.

Symptom Assessment. A thorough assessment of post-concussion symptoms is an essential component of the evaluation. The four symptom types - physical, cognitive, emotional, and sleep-related – should be fully explored in terms of their presence, severity and change over time. It is most useful to track symptoms from the onset of injury to the time of the evaluation in order to understand the rate of recovery and assess the degree and type of impact that the injury is having on the child's life. This assessment should include collecting structured symptom ratings from the parents and the injured child[7]. Accurate evaluation of post-concussion symptoms requires developmentally appropriate assessment measures congruent with the child's cognitive level, reading skill and vocabulary, and capacity to perceive their own symptoms accurately[8]. To meet this need, the CDC funded this author's group to develop the Post-Concussion Symptom Inventory (PCSI) for children, appropriate to the age/ developmental level of the child[9]. The PCSI for the 5-7 age group rates 5 symptoms, while the scale for 8- to 12-year-olds includes 17 items, using a 3-point ordinal scale asking whether the symptom is present "not at all," "a little," or "a lot." The PCSI for age 13-18 years and the Parent scale rates 21 items using the more traditional 7-point severity scale.

Neurocognitive Assessment. Neurocognitive testing provides an objective, quantifiable set of data that is sensitive in detecting the often subtle effects (e.g., reaction time) of a concussion. Specific neurocognitive domains have demonstrated sensitivity to the effects of concussion including attention/ concentration, working memory, information processing speed, learning/memory, and executive functions[10,11,12]. Focused, targeted neuropsychological testing of key neurocognitive domains can be an important component in the post-acute stage of pediatric concussion[13], particularly when return to play (i.e., high risk return) decisions are pending. Additionally, the student's profile of cognitive performance obtained from the neuropsychological assessment can be useful in guiding the management of school learning. A large body of research has found neuropsychological testing to be sensitive to the acute effects of concussion[14], resulting in its recommendation as one of the tools to consider in the concussion evaluation. The aforementioned CDC funding also resulted in the development of a neurocognitive battery for children ages 5 to 12 years assessing memory and information processing speed.

Assessment of Exertion Effects. In addition to the assessment of the full array of possible post-concussion symptoms, children can often experience a worsening or re-emergence of certain symptoms with exertional activity. It is important to ask the child if they experience any worsening of symptoms with physical activity (e.g., running, climbing stairs, bike riding) and/or cognitive activity (e.g., academic studies, multi-tasking, reading or other tasks requiring focused concentration). This information can be important in guiding treatment recommendations.

Management and Treatment of Pediatric Concussion

With a full definition of the concussion its neuropsychological factors, symptom manifestations, and exertional indicators, individualized management can proceed. Children and adolescents will need the help of their parents, teachers, and other adults to assist with their recovery. Symptom management involves all aspects of the patient's life including home life, school, work, and social-recreational activities.

The foundation of concussion treatment is individualized management of physical and cognitive exertional activity within the context of the child's symptom presentation. A basic treatment assumption is that symptom exacerbation or re-emergence in the wake of physical or cognitive activity is a signal that the brain's dysfunctional neurometabolism is being pushed beyond its tolerable limits. Therefore, in guiding recovery, the therapeutic goal is to manage cognitive and physical activity at a level that is tolerable (i.e., does not exacerbate or cause the re-emergence of symptoms).

Daily Home/Community Activities. It is helpful to define the child's typical daily schedule and types of activities at home and in the community. Patients should be advised to obtain adequate sleep at night and to take brief daytime naps or rest breaks when significant fatigue is experienced. The return or exacerbation of symptoms is their guide to the level of activity that is safe and tolerable and physical and cognitive exertion should be limited accordingly. Physical activity to be managed might include physical education (PE) class, sports practices, weight-training, running, exercising, heavy lifting. Cognitive activities to be managed might include heavy concentration, memory, reasoning, reading or writing (e.g., homework, classwork, computer or other electronic screens, job-related mental activity). As symptoms decrease, patients may return to their regular activities gradually. Return to high-risk activities such as driving or operating heavy machinery must be carefully considered, especially if the patient has problems with attention, processing speed, or reaction time.

Return to School. An under-recognized aspect of concussion treatment involves the management of the student's return to school[6]. First, a determination must be made as to when return to school is appropriate. In the first few days after a concussion, there is an increased likelihood of adverse symptom exacerbation with mental and physical exertion. From a practical standpoint, the student should not return to school until they can tolerate at least 30 minutes of sustained cognitive activity. The school team (e.g., teacher(s), the school nurse, psychologist/counselor, and administrator) should be informed of the student's symptoms and cognitive deficits and advised to monitor for problems paying attention/concentrating, remembering/learning new information, longer time required to complete tasks, increased symptoms (e.g., headache, fatigue) during schoolwork, and greater irritability/ less tolerance for stressors. Symptomatic students will require active support and accommodations in school. Students with prolonged symptoms (i.e. longer than several weeks) may require special accommodations and services, such as those provided under a Section 504 Plan. As symptoms decrease, and/or as cognitive test results show improvement, patients may gradually return to their regular activities. However, the patient's overall status should continue to be monitored closely by a designated person at the school. A list of classroom accommodations related to the kinds of post-concussion symptoms is provided in Sady et al.[15]. For example, students who fatigue easily may benefit from regular rest breaks in the school nurse's office. The teacher, school nurse, and/or guidance counselor should monitor the student's symptoms periodically to modify the types and intensity of the academic supports across recovery.

Return to Play (Sports and Recreation). The return to sports and recreational activities is a strong motivating factor to recover for most children and adolescents. Avoiding re-injury or prolonging recovery is a central management goal. As a fundamental tenet of sports concussion management, and as reinforced in the four international conferences on Concussion in Sport, an individual should never return to competitive sport or recreational activities while experiencing any lingering or persisting concussion symptoms, including PE class, sports practices and games, and other high-risk/high-exertion activities. The individual must be completely symptom free at rest and with physical exertion (e.g., sprints, non-contact aerobic activity) and cognitive exertion (e.g., studying, schoolwork) prior to their full return to sports. Return to play should occur gradually and systematically with supervision monitoring symptoms, balance, and cognitive functioning during each stage of increased exertion.

Summary

Neuropsychologists can play a pivotal role in the evaluation and management of a concussion in a child or adolescent. Essential components of the evaluation include a thorough definition of the injury's characteristics, followed by a full assessment of post-concussion symptoms, neuropsychological evaluation, and a definition of the child's risk history that may modify the course of recovery. Treatment of a concussion involves assisting the child and family to carefully guide physical and cognitive activity as the child gradually returns to their normal activity schedule.

Dr. Gioia is a pediatric neuropsychologist and the Chief of the Division of Pediatric Neuropsychology at Children's National Medical Center, where he directs the Safe Concussion Outcome, Recovery & Education (SCORE) Program and two research core laboratories. He is Professor of Pediatrics and Psychiatry at the George Washington University School of Medicine. Dr. Gioia is a clinician, researcher, teacher/ trainer, and public health advocate for persons and families with brain injuries. He is an active researcher in the areas of the executive functions and youth concussions with a focus on the development of methods/ tools for the evaluation of post-concussion neuropsychological functioning. He works closely with the CDC on their "Heads Up" concussion educational programs, as a contributing author to their toolkits. Dr. Gioia has been an active participant in the International Concussion in Sport Group Consensus meetings, and was on the American Academy of Neurology Sports Concussion Guideline Author panel. He is the team neuropsychologist for the NHL's Washington Capitals and the NFL's Baltimore Ravens, multiple school systems, and numerous youth sports organizations in the Baltimore-Washington region. He consults with the local and National Governing Organizations of ice hockey, lacrosse, football, rugby, and soccer related to concussion management and is on the Medical Advisory Committee for USA Football.

References

1. Halstead, ME, Walters, KD and The Council on Sports Medicine and Fitness. Sport-Related Concussion in Children and Adolescents. Pediatrics. 2010;126: 597 -615.

2. Echemendia, RJ, Iverson, GL, McCrea, M, Broshek, DK, Gioia, GA, Sautter, SW, Macciocchi, SN, & Barr, WB. (2012) Role of Neuropsychologists in the Evaluation and Management of Sport-related Concussion: An Inter-Organization Position Statement. The Clinical Neuropsychologist, 27 (1), 119-122.

3. De Los Reyes, A. & Kazdin, A. E. (2005). Informant discrepancies in the assessment of childhood psychopathology: A critical review, theoretical framework and recommendations for further study. Psychological Bulletin, 131, 483-509.

4. Varni, J. W., Limbers, C. A., & Burwinkle, T. M. (2007a). How young can children reliably and validly self-report their health-related quality of life?: An analysis of 8,591 children across age subgroups with the PedsQL□ 4.0 generic core scales. Health and Quality of Life Outcomes, 5.

5. Gioia, GA & Collins, MW. Acute Concussion Evaluation. In "Heads Up: Brain Injury in Your Practice" tool kit developed by the Centers for Disease Control and Prevention (CDC). 2006. http://www.cdc.gov/concussion/headsup/pdf/ACE-a.pdf

6. Centers for Disease Control and Prevention (CDC). National Center for Injury Prevention and Control. Heads Up: Brain Injury in your Practice. Atlanta (GA): Center for Disease Control and Prevention; 2007. http://www.cdc.gov/ncipc/tbi/Physicians_Tool_Kit.htm.

7. Gioia, G. A., Schneider, J. C., Vaughan, C. G. & Isquith, P. K. (2009). Which symptom assessments and approaches are uniquely appropriate for paediatric concussion? British Journal of Sports Medicine, 43(Suppl I), i13–i22.

8. Fritz, G. K., Yeung, A., Wamboldt, M. Z., Spirito, A., McQuaid, E. L., Klein, R., et al. (1996). Conceptual and methodologic issues in quantifying perceptual accuracy in childhood asthma. Journal of Pediatric Psychology, 21, 153-173.

9. Sady, M.D., Vaughan, C.G., & Gioia, G.A. (2013) Psychometric Characteristics of the Post-Concussion Symptom Inventory (PCSI) in Children/Adolescents and their Parents. Submitted to Archives of Clinical Neuropsychology.

10. Catroppa, C., Anderson, V., Morse, S., Haritou, F., & Rosenfeld, J. (2007). Children's attentional skills 5 years post-TBI. Journal of Pediatric Psychology, 32, 354–369.

11. Babikian, T., & Asarnow, R. (2009). Neurocognitive outcomes and recovery after pediatric TBI: Meta-analytic review of the literature. Neuropsychology, 23, 283–296.

12. Schatz, P., Pardini, J. E., Lovell, M. R., Collins, M. W., & Podell, K. (2006). Sensitivity and specificity of the ImPACT Test Battery for concussion in athletes. Archives of Clinical Neuropsychology, 21, 91–99.

13. Kirkwood, M. W., Yeates, K. O., Taylor, H. G., Randolph, C. R., McCrea, M., & Anderson, V.A. (2008). Management of pediatric mild traumatic brain injury: A neuropsychological review from injury through recovery. The Clinical Neuropsychologist, 22, 769-800.

14. Echemendia, R.J., Iverson, G.L., McCrea, M., Macciocchi, S.A., Gioia, GA., Putukian, M., & Comper, P. (2013). Advances in neuropsychological assessment of sport-related concussion. British Journal of Sports Medicine, 47, 294-298.

15. Sady, M.D., Vaughan, C.G. & Gioia, G.A. School and the Concussed Youth: Recommendations for Concussion Education and Management. Physical Medicine and Rehabilitation Clinics of North America. 2011;22: 701-719.

Spotlight Corner

Sports Concussion: An Interview with Kevin Robinson, BMX Professional and NAN Foundation Board of Trustees Member

Eric Rinehardt, Ph.D., ABPP
Department of Neuropsychology, Carolinas Rehabilitation, Charlotte, NC Department of Psychiatry and Behavioral Neuroscience, University of South Florida, Tampa, FL

Michelle Mattingly, Ph.D., ABPP
Departments of Psychiatry and Behavioral Neuroscience, Neurology, and Neurosurgery, University of South Florida, Tampa, FL

Kevin Robinson, also known as "K-Rob," was a professional BMX rider for 23 years. During his career, he competed in 18 X Games and won numerous medals including four gold medals, while thrusting himself into the air as high or acrobatically as possible on his bicycle. At 41 years-of-age, he excitedly admits that, "I rode a little kids bike for a living…a pretty awesome job!" His occupation and passion, however, was high-risk and had consequences.

K-Rob has undergone over 40 orthopedic surgeries and suffered too many concussions to count. After a particularly gruesome accident while training in San Jose, CA, K-Rob found himself seriously injured in what he describes as, "a concussion and mild coma for 2 hours." K-Rob goes on to explain that "I couldn't speak right for 2 weeks" and "I suffered short-term memory loss." Fortunately for K-Rob, he lived near neuropsychologist Ruben Echemendía, who evaluated and treated his post-concussive symptoms. K-Rob recounts that Dr. Echemendía taught him relaxation techniques as well as educated him about the brain and how concussions can impact thinking; components he feels were essential to his recovery. K-Rob adds that, "I wish I did testing 10 years before I suffered so many concussions already," and wondered just how much cognitive ability he has lost due to his multiple concussions. He readily admits that "I still suffer from short-term memory loss today."

Despite these obstacles, K-Rob has persevered and turned his struggles into another passion – motivational speaking and public awareness about concussion. Kevin is currently a NAN Foundation Board Member and travels across the country speaking to youth about topics such as bullying and action-sports safety. He states, "If I didn't have a helmet on for so many head-hits, I wouldn't be here today." K-Rob also encourages his own children to practice safety and reports "My son doesn't get on his bicycle without a helmet." His personal aspiration as a Foundation member is to offer his insight from an "I actually lived it" perspective on head injury – to give his take on what it's like to suffer short-term memory loss, and to wake up from an injury not knowing where you are. He fervently expressed a need for greater awareness of the effects of head injury in all sports, not just those that get the most attention, such as football. "In the past we've had guys knocked out, and the next day they're trying to compete again… and no one had any awareness of what the risks were and didn't understand it."

K-Rob has also used his influence to found the K-Rob Foundation, a Non-Profit Organization that seeks to encourage children in his hometown of East Providence, Rhode Island to become involved, and remain active in athletics. Through this organization, K-Rob aims to encourage perseverance, goal setting, and overcoming adversity by assisting deserving families remain active in healthy, lifestyles via the safe practice of sport. He has furthered extended his mission into a company, Grindz, which sells pants with hidden knee, hip, and tailbone pads, so as to remove any excuses for not wearing safety gear.

With a long career in BMX, riddled with several physical and cognitive injuries, K-Rob knew going into this year's X Games he was going to retire from competitive sport. He anticipated his next competition in Brazil with subsequent games in Spain, Germany, and California, would be a way to end on his own terms. "I'm probably on my victory lap here," K-Rob said and added, "I'm tired of crashing." In Brazil, however, K-Rob found himself in a familiar situation. He crashed and sustained another concussion. K-Rob was put on a stretcher, his neck and head immobilized, and taken to the hospital where he wondered if his career was to end before his intended curtain call. Ultimately, K-Rob did take his final roll down the quarter pipe in Los Angeles without incident and walked away from competition on his on his own two feet, and into his new passion for motivating youth, encouraging the safe practice of action-sports, as well as commentating for the X Games. As a little retirement gift for himself, K-Rob will be getting a much-needed hip replacement this October.

http://espn.go.com/video/clip?id=9534888

When asked what he wanted to share with the neuropsychology community, K-Rob said, "It's all about following your passion and your dreams. Everyone has their own path, and their own destiny, life is one big journey, and enjoy the ride."

**Kevin was interviewed via telephone on 3/8/13.*

National Academy of Neuropsychology, Inc.
Founded 1975

34th annual CONFERENCE

New Horizons in Neuropsychology Research and Practice

November 12 – 15, 2014

El Conquistador Resort | Fajardo, Puerto Rico