



PIVOTAL TOPIC:

Neuropsychological Assessment in Sports Concussion

In this issue of the NAN Bulletin, three colleagues present clinical and research topics pertinent to the practice of neuropsychology within athletic settings. In recent months, the NFL acknowledged potential risks associated with football and the long-term health of professional athletes. The death of University of Pennsylvania football player, Owen Thomas, drew particular attention after the New York Times reported that his autopsy showed evidence of chronic traumatic encephalopathy. Media coverage has certainly increased public awareness of sports concussion, though the associated risks, assessment techniques, and methods of long-term care and management remain controversial within the field of neuropsychology. Neuropsychologists and athletic trainers have applied assessment techniques both on the field and in the clinic to guide decisions about return-to-play and individual player health. However, there are significant challenges to clearly defining a clinical syndrome associated with repeated sports concussions, as well as challenges to using psychometrically sound procedures within the physical and cultural contexts of athletics. Drs. Macciocchi, Echemendia, and Randolph offer topical summaries on these issues as supported by research and their clinical experiences. We hope that this issue of the Bulletin serves to generate additional discussions and debate, particularly in terms of how our field can continue to contribute to the science of sports concussion and the care of affected athletes.

Tyler J. Story, PhD- Associate Editor

Deborah K. Attix, PhD, ABPP/CN- Editor

We have now published three issues of the new Pivotal Topics Bulletin (Emerging Roles in Neuropsychology; Patient Diversity and the Practice of Neuropsychology; Sports Concussion) and are interested in your feedback. To send comments about your perspective on the utility and relevance of the Bulletin to your practice, please contact Drs. Story and Attix and NAN Publications Committee Chair Dr. Wilma Rosen at tylerjstory@gmail.com, koltai@duke.edu, wilmakay@aol.com.

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Risk and Harm Associated with Sports Concussion

Stephen Macciocchi, PhD, ABPP/CN

When considering potentially problematic outcomes following a brain injury, it is helpful to focus on the risk and the harm of a brain injury as separate constructs. Risk is the probability that an injury may occur and harm is the negative impact or consequence of the injury. The probability or risk of sustaining sports concussion has been shown to be related to the sport in question, as well as factors such as age, type of

participation (game versus practice), the number of previous concussions (Guskiewicz, McCrea, Marshall, Cantu, Randolph, Barr, Onate & Kelly, 2003) and equipment type (Collins, Lovell, Iverson & Maroon, 2006). The risk of a first time concussion varies to some degree, but is somewhere between 5-10% of athletes per year depending on the sport in question (Macciocchi, 2006). The risk of concussion appears very similar for men and women who compete in the same sport, although one study has shown a differential impact of concussion on women athletes (Broshek, Kaushik, Freeman, Erlanger, Webbe & Barth, 2005).

Risk of a concussion in football has been shown to increase somewhat as the number of concussions sustained increases (Guskiewicz, McCrea, Marshall, Cantu, Randolph, Barr, Onate & Kelly, 2003). Since concussions are reported by players or more often, observed by others, not all concussions may be reported or observed, and some research suggests that the risk for concussion is actually higher than that reported in most epidemiological studies (McCrea, Hammeke, Olsen, Leo, & Guskiewicz, 2004).

The harm associated with a single concussion has been shown to be limited. Some studies have shown that a single concussion in an otherwise healthy young athlete has virtually no persisting impact on cognition or physical functioning beyond 5-10 days, and in many cases beyond 2-3 days (Macciocchi, Barth, Alves, Jane and Rimel, 1996; McCrea, Kelly, Randolph, Cisler & Berger, 2002), but other research suggests recovery time following a concussion may be somewhat longer (McClincy, Lovell, Pardini, Collins, & Spore, 2006) and clinical experience shows that some athletes take much longer to recover from the effects of a concussion. Concussions often present differently and recover differently, although in aggregate, scientific studies have shown that single concussions do not involve persisting cognitive or physical problems (Randolph & Kirkwood, 2009).

The harm associated with multiple concussions has not been studied extensively, but players with multiple concussions seem to have a different symptom presentation and pattern of recovery (Collinis, Lovell, Iverson, Cantu, Ide & Maroon, 2006), although the long term consequences of multiple concussions have not been systematically studied in large populations. There are no well controlled studies looking at the effect of multiple concussions on functioning 1, 3, 5 or 10 years post competition.



A recent study found an association between repeated concussions and mild cognitive impairment in retired professional football players (Guskiewicz, Marshall, Bailes, McCrea, Cantu, Randolph & Jordan, 2005). While the study is often interpreted as providing evidence for a link between multiple concussions and Alzheimer's disease, the authors actually found an increased risk for mild cognitive impairment (MCI), but not Alzheimer's disease (Carone & Bush, in press).

The association between cerebral trauma and dementia, including Alzheimer's disease, in general populations has been studied for many years with mixed findings. The general conclusion from these studies, at least at the current time, is that severe brain injury may impact the onset of dementia, but mild brain injuries are not associated with onset or progression of cognitive disorders in late life (Plassman et al, 2000). Of course, population based studies have typically addressed single or a very limited number of mild brain injuries, not multiple concussive injuries.

The risk of a catastrophic brain injury occurring following a previous concussion typically referred to as "second impact syndrome" (SIS) has been discussed widely, but the risk of such an injury has been shown to be extremely small (McCory, 2001; Randolph and Kirkwood, 2009), which is why it is important to separate risk from harm. In such cases, the harm associated with a catastrophic brain injury is so great that the risk is often presumed to be greater than is actually the case. Not only is the risk of SIS extremely low, but there is compelling evidence that SIS is not related to a previous concussion, but rather a failure in vascular autoregulatory mechanisms unrelated to trauma (McCory, 2001).

While multiple concussions have not been adequately studied, there is preliminary and plausible evidence of associated morbidity, particularly considering the biomechanical forces sustained during participation (Broglia et al, 2009). Some athletes are prone to multiple concussions while others are not, which suggests that idiosyncratic factors are operative above and beyond biomechanical forces. In other words, variability in central nervous system function likely explains why some players sustain multiple concussions.

Chronic traumatic encephalopathy (CTE), which has traditionally been viewed as a consequence of boxing due to the repeated nature of trauma sustained in the sport, has recently gained traction in the sports concussion literature. CTE is hypothesized to occur secondary to many concussions, which ultimately cause changes in brain structure and function over time. The presumption is that multiple concussions would have an additive effect that results in pathophysiologic abnormalities and associated neurocognitive and neurobehavioral dysfunction. The CTE concept is plausible, but much more research needs to be undertaken in order to better understand the cumulative effect of multiple concussions.

Existing research has principally focused on cognitive test performance and rarely on other aspects of functioning, such as emotional and behavioral adjustment. Clinically informed, methodologically rigorous research is needed to answer many of the questions regarding the impact of concussive injuries on current and later life health.



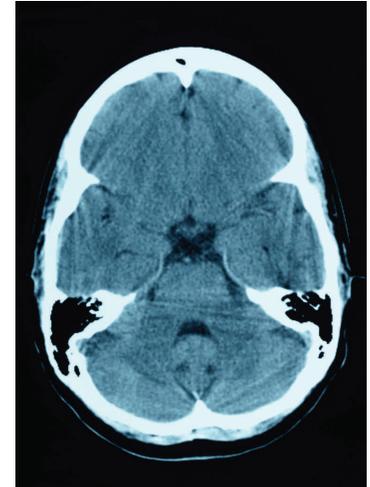
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Measurement Issues in Sports Neuropsychology Ruben J. Echemendia, PhD

The use of neuropsychological tests and techniques has been placed at center stage in the evaluation and management of sports-related concussion, or Mild Traumatic Brain Injury (MTBI). Reports of sports-related concussions are ubiquitous in the media from youth athletes to professional sports. At the professional ranks, it is common to hear that players have either “passed” or “failed” their neurocognitive tests in their bid to return to play. The purpose of this short piece is to highlight the key issues underlying the measurement of sports-related concussion, not to engage in a comprehensive review of the literature. My goal is to point out the salient issues in the hope of stirring up interest that will lead to additional research.



During the early phases of sports neuropsychology, brief 30-minute batteries were comprised of traditional “paper and pencil” measures (e.g., list learning tasks, Trail Making Test, Digit Span, Verbal Fluency, etc.). While effective in distinguishing between concussed athletes and controls in the hours and days following MTBI (e.g. Echemendia et al., 2001; Collins et al. 1999; Barr et al. 2001), these batteries were difficult to administer to large groups of individuals because they required one-on-one test administration. The advent of computerized platforms led to a sea of change for sports neuropsychology since computerized tests allowed for relatively rapid standardized assessment of large numbers of athletes in a cost-effective manner. Several computer batteries have now become available. Although different in their content, these batteries typically assess simple and complex information processing speed and reaction time, which have been shown to be key deficits following concussion. Some batteries also assess visual and verbal memory.

Computerized and traditional batteries have different strengths and weaknesses. The traditional batteries allow for one-on-one administration, which generates a wealth of information regarding the athlete’s motivation, emotional status, the process by which the athlete solves problems, and a more thorough assessment of memory than is available with computers. In addition, traditional tests have a long history of normative and validation studies in a wide range of clinical samples. Computerized testing allows for group testing formats, standard administration, theoretically infinite alternate forms, more precise measurement of reaction time, decreased costs, and instant score reporting. However, the accuracy of timing in computerized tests can be hampered by numerous factors including processor speed, server capabilities, computer platform, mouse differences, bandwidth, etc.

A large, robust multidisciplinary literature has established the value of neuropsychological testing in detecting neurocognitive changes in the acute phase following sports-related MTBI. Although space limitations preclude a thorough discussion of specific studies, an examination of recent meta-analyses can be helpful. Belanger and Vanderploeg (2005) examined 21 studies encompassing 790



concussed athletes and 2014 controls. They found an overall effect size for acute assessment of sports related concussion ($d = 0.49$) to be comparable to that of MTBI in the general population ($d = .54$). Effect sizes for studies employing a control group were large ($d = 0.89$), whereas those based on intraindividual comparisons (baseline-post-injury) were less robust ($d = 0.19$), largely due to practice effects. The data were also examined by domain of functioning, with the following outcomes: global functioning ($d=1.42$), memory acquisition ($d=1.03$) and delayed memory ($d=1.0$). No significant effects were found after 7-10 days post-injury although the authors did note that delayed memory remained problematic 7 days post-injury in studies that employed a control group. More recently, Broglio and Puetz (2008) examined 39 studies spanning 4,145 concussed athletes and controls. They reported an average effect size of -0.81 (Hedge's g) for neurocognitive functioning assessed acutely, with larger effect sizes for studies employing a control group ($g = -0.92$) compared to those without a control group ($g=-0.63$). Larger effect sizes were found in the acute period (1st assessment post-injury) for self-reported symptoms ($g = -3.31$) and postural control ($g = -2.56$). Reduced effects were found for all three outcomes in follow-up assessments. A noteworthy finding was that those studies employing traditional tests had larger effect sizes during the 14-day follow-up period when compared to computer based tests. Iverson (in press) compared the effect sizes of neurocognitive functioning following concussion to the effects of other neuropathological conditions and found them to be comparable to MCI/dementia and Moderate/Severe TBI after more than 2 years post injury.

Despite the development of a robust literature supporting the use of neuropsychological measures in the acute evaluation and management of sports concussion, the field is not without its detractors, (e.g. Randolph, et al. 2005; Kirkwood, Randolph & Yeates, 2009; Randolph & Kirkwood, 2009). This debate sheds light on areas that are in further need of development. For example, there have been no empirical studies to my knowledge that have established the utility of baseline testing in sports concussion, though as a field we value the precision that longitudinal assessment adds to clinical judgment in neuropsychology. As noted earlier, having accurate pre-injury assessments has always been a quest in neuropsychology that was not readily attainable except in the sports domain. In this sense, athletic centers have truly become a laboratory in which to examine many basic hypotheses. Baseline neurocognitive testing has become a cornerstone of concussion surveillance programs because of the innate rationality of the approach (e.g., intraindividual pre-post assessments) and aggressive marketing by test developers. Indeed, the use of intra-individual evaluations should theoretically eliminate many confounding variables that would be present if normative test data were used instead. However, the use of baseline testing introduces significant complexity into the interpretation of post-injury test data. Critics have noted that test-retest correlations have been in the low to moderately high range. For example, for traditional tests Barr and colleagues (2003) reported test-retest coefficients ranging from .39 to .78. Using an average retest interval of 6 days, Iverson, Lovell and Collins (2003) reported test-rest correlations ranging from .67 to .86 on the four major ImPACT indices. In contrast, Broglio and colleagues (2007) reported low to moderate test-retest stability on three contemporary computer-based programs with ICCs of .15 to .65. It should be noted that this latter article has been criticized for significant methodological shortcomings. Nevertheless, there are few who would quarrel with the need for developing measures with greater temporal stability



given that it is not unusual for an athlete to have their first concussion 1 or 2 years following their initial baseline. This is particularly important in the pediatric population where developmental changes in cognitive functioning would lead to changes in “baseline” scores. Yet it is also important to note that although the arguments against psychometric fidelity have been put forth in the sports neuropsychology literature, these arguments can be applied across the field of neuropsychology, particularly in instances where individuals are tested serially.

Test-retest reliability is directly impacted by practice effects, in which performance may be a function of prior experience and not cognitive improvement per se. There are two forms of practice effects, content and procedural. A content practice effect occurs when the same test content is used at Time1 and Time2, such as a repeated word-list. Alternate forms of tests (e.g., using different word lists, different designs, etc.) help to reduce content practice effects. A procedural practice effect occurs when the patient benefits from exposure to the test format and demands, and thus is not dependent on test content or mitigated by using alternate forms. Practice effects for computer programs are less significant than traditional tests but they do exist (Iverson et. al, 2003). Clearly, the presence of practice effects complicates the interpretation of test data, particularly when the average group practice effects are unknown. Of significance in the sports population is the finding that athletes with acute concussions do not show a practice effect whereas uninjured controls demonstrate significant practice effects (Echemendia et al., 2001). This finding highlights possible value for the use of baseline assessments despite the concerns noted above.

Athletes have been lauded as an ideal population for the study of MTBI because they are typically motivated to return to play and generally not subject to the secondary gain issues that are seen in MTBI patients involved in litigation and/or seeking disability. Bailey, Echemendia and Arnett (2006) demonstrated that differential motivation at baseline and following concussion may be problematic. They noted that players at baseline may be much less motivated to perform well due to indifference, boredom, suspicion, peer pressure, deliberate attempts to score low, etc. In contrast, when evaluated post-injury, most players are highly motivated to perform well so that they can return to play. This difference in motivation may lead to premature return to play for players who were not fully motivated at baseline.

It must be understood that in order to accurately interpret change scores, an index should account for the multiple sources of error noted earlier (interested readers are referred to Chelune [2003] and Crawford & Garthwaite [2007]). Reliable Change Indices use the standard error of the difference (S_{diff}) to calculate a confidence interval for the Time1-Time2 difference (see Chelune, 2003). Subsequent formulas have been used to account for practice effects. Linear regression models (see Crawford & Garthwaite, 2007) have also been developed that account for regression to the mean, which is particularly useful with scores at extreme ends of the distribution. These models generate predicted retest scores that can be compared to observed scores.

The complexity underlying interpretation of test data begs the question of who should administer and interpret neuropsychological tests in the sports population. A desperate need among sports medicine professionals, coupled with the desire for simplicity and attractive marketing have led to the view that these tests can be administered and interpreted by non neuropsychologists who



attend basic interpretation courses. Echemendia, Herring and Bailes (2009) discuss this issue at length and conclude that while paraprofessionals can be adequately trained for the administration of tests, proper interpretation of neuropsychological tests is best left in the hands of neuropsychologists whose training in psychology and neuropsychology make them uniquely qualified for this purpose.

In my clinical practice and research, I have begun to utilize what has been termed the “hybrid” approach to measurement. I utilize both computerized testing and traditional testing in post-injury evaluations. Our research with professional and college athletes (in preparation for publication) suggests that a combination of the two approaches maximizes their strengths, which allows for greater sensitivity and specificity. Clinically, it is not unusual to observe “normal” performance on one set of measures and clear deficits on others. Typically, the computerized battery does a better job of assessing reaction time/processing speed, whereas the traditional battery is superior in assessing memory functions and complex processing speed.

In sum, sports neuropsychology has enjoyed a fast rise into the lexicon of American sports. Team medical staffs rely on neuropsychologists to provide important and unique information to assist in the return to play decision-making process. Like all new areas of research and practice, we have much to learn and many of our most basic assumptions (e.g., the need for baseline testing) must be carefully evaluated to assess their incremental utility. We also need to continue striving to refine our measurement techniques and develop better algorithms in order to have greater confidence in our findings. Irrespective of the baseline/no baseline debate, our measures continue to be central to the post-injury assessment of players and clinical decision-making regarding the presence or absence of neurocognitive dysfunction. In the last analysis, we must remember that applying neuropsychological techniques to the sports arena is a clinical enterprise that requires the best we have to offer from our psychological and neurological training.

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Challenges in the Care and Management of Sports Concussion
Christopher Randolph, PhD, ABPP/CN

In general, the development of any given algorithm for injury management should be based upon the modification of risk and/or outcome. That is, one would like to minimize further risks following an injury, and if possible, improve outcome (via more rapid or more complete recovery). The management of sport-related concussion, however, has evolved largely in the absence of any data regarding outcome modification, and very little discussion of risk reduction. It is perhaps the lack of such data that has led to the proliferation of various competing “guidelines” on management. In discussing management strategies, this section will focus upon post-injury management, recognizing that there are certain strategies (rule changes, equipment choices) that have the potential to alter (although not eliminate) the incidence of concussion. It is also recognized that there may be long-term consequences of repetitive head trauma/concussion, but a discussion thereof is beyond the scope of this section on post-injury care/management.

The management of concussion in a given athlete essentially involves decision-making in the acute (immediately post-injury), sub-acute (~ one week post-injury), and post-acute phases of recovery. In a recent paper, we reviewed the existing data on the epidemiology of risks, using American football as a model (Randolph & Kirkwood, 2009). The primary serious acute risk following sport-related head injury is subdural hematoma. Over a 10-year period involving 18 million player-seasons, there were 88 cerebral injuries that resulted in death or permanent neurological deficits. Almost all of these were due to acute subdural hematomas. While these injuries are very rare, the gravity of the outcome certainly warrants close monitoring of neurological status in the acute phase following a concussion, and the availability of rapid transport to a trauma center in the event of deteriorating status.

Moving to the sub-acute phase, there is little in the way of rationale for specific algorithms for management, most of which revolve around return-to-play decision-making. This is the post-injury phase that has received the most attention, however, and engendered the most controversy. There is a general belief that following a concussion, the brain is in a state of vulnerability, and that an athlete should not be returned to play until his/her brain has “recovered”. Symptom checklists, baseline neurocognitive testing, and balance testing have all been studied as techniques for monitoring recovery from concussion. Despite the near-universal agreement regarding the need for symptom resolution prior to return to play, there are almost no data to suggest that there is a significant risk associated with “premature” return to play.

The specter of “second impact syndrome” is often cited as a reason to ensure players are symptom-free before returning to play. This phenomenon involves diffuse brain swelling after a minor trauma, often following a period of lucidity. The relevant literature is fairly clear, however, in establishing



that this is a very rare condition, does not require two closely-spaced injuries, occurs more commonly in non-sports settings following a single minor head injury in children, and may be linked to a genetic mutation involving a calcium channel subunit. Moreover, there was only one case of diffuse cerebral swelling identified in our 10-year review involving 18 million player seasons, so it seems impractical to develop a management strategy around this particular risk.

There may be a slightly elevated risk of repeat concussion within the first 7-10 days following a concussion, but this risk remains quite low, is not associated with significantly worse outcome from the second concussion, and appears to be more tightly linked to time than to the resolution of symptoms (McCrea et al., 2009). In sum, there is no evidence that “premature” return to play carries any additional risks, and absolutely no evidence that the use of baseline testing (or any other measurement strategy) is helpful in modifying outcome. Given the absence of any such evidence, it seems most appropriate to encourage team medical personnel to rely upon their own clinical judgment in decision-making regarding return to play, rather than adhere to any rigid algorithm. In addition, there are a number of psychometric issues that complicate the use of baseline neurocognitive testing and may result in decision-making based upon unreliable information (Randolph, in press). Furthermore, in the recent study cited above (McCrea et al., 2009), it was determined that approximately 40% of players were returned to play while still symptomatic, suggesting that the various guidelines are routinely ignored, as they universally call for symptom resolution prior to return.

The vast majority of sport-related concussions are characterized by rapid and complete recovery of symptoms, balance impairment, and cognitive impairment. This recovery typically occurs over a few days, and no prospective controlled study has yet identified a group difference after one week post-injury. There are occasional cases of prolonged or atypical recovery, however, and these should be the focus of some discussion with respect to management. The exact incidence of “prolonged” recovery is currently unknown. The proportion of injured athletes falling into this category must be quite small, however, as they fail to affect group comparisons in controlled studies after about 7 days.

There are a number of potential contributors to prolonged or atypical recovery, and this is the area in which clinical neuropsychology clearly has the most to offer in terms of differential diagnosis and treatment planning. In doing so, we must be cognizant of the natural history of typical recovery, and of various neurological and psychological factors that might influence symptom expression over time. It is very clear that persistent post-concussive symptomatology (and even neurocognitive test performance) can be influenced by factors such as diagnosis threat/expectation as etiology, and that recovery can even be prolonged by iatrogenic influences. It is not uncommon to hear about practitioners advocating for weeks of complete “brain rest” following a concussion in a high school athlete. To date, there is no credible scientific basis for such a recommendation, and this type of advice is likely to engender fears of long-lasting or permanent symptomatology, prolonging recovery and interfering with academic progress. The literature regarding psychoeducational interventions for uncomplicated mild traumatic brain injury should provide a basis for the management of prolonged symptomatology following sport-related concussion, in the absence of any comparable controlled



studies of interventions in sport-related concussion. Neuropsychologists are the professionals best equipped to engage in the process of differential diagnosis and appropriate treatment planning for such individuals, on the basis of our training and the tools that allow us to tease apart the various factors that may be contributing to prolonged or atypical symptomatology. These tools involve not only standard neurocognitive assessments, but also measures of effort and of psychological symptomatology and personality profiles (e.g., MMPI-II) where indicated.

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Qualified candidates should submit a letter outlining their career goals and interests, CV, and sample reprints to: Edward A. Hurvitz, M.D., Associate Professor and Chair, Department of PM&R, University of Michigan Health System, 325 E. Eisenhower, Suite 100, Ann Arbor, MI, 48108. Phone: (734) 936-7190; Fax (734) 615-1770. ehurvitz@med.umich.edu; <http://www.med.umich.edu/pmr/>. We offer a competitive salary and a comprehensive benefits package.

For further information, contact David S. Tulsky, Ph.D., Director of Research and the Director of the Center on Rehabilitation Outcomes and Assessment Research, Department of Physical Medicine and Rehabilitation by e-mail at dtulsky@med.umich.edu.

The University of Michigan is an equal opportunity/affirmative action employer. We are committed to creating a diverse, cooperative work environment. Women, members of under-represented minority groups, and individuals with disabilities are encouraged to apply.



NATIONAL ACADEMY OF NEUROPSYCHOLOGY

NAN BULLETIN: VOLUME 25, 2 - *Sports Concussion*

Advertisements

NEUROPSYCHOLOGIST

Full-time neuropsychologist needed for a growing rehabilitation program in a Top 100 Hospital with a 24-bed CARF and JCAHO accredited Inpatient Rehabilitation Unit. Scope of responsibilities will be primarily inpatient related with some assistance in outpatient services. Duties include adult and occasional adolescent neuropsychological evaluations, participation in interdisciplinary team conferences, and patient/ family education about nature of deficits, functional implications, and recovery issues. Job also requires some neuropsychological consultations on other acute care hospital units including our Long Term Acute Care Hospital located within St. Luke's Hospital. The focus of these consultations is on the person's decision-making ability and level of care needed post-discharge. The ability to communicate effectively with a diverse group of health care professionals is essential. Position requires a Ph.D. or Psy.D. from an APA-accredited program and a postdoctoral fellowship in neuropsychology. Must be licensed or license-eligible in Iowa. Prior rehab experience with acute hospital, traumatic brain injury, and stroke patients is desirable. Pre-employment drug screening required. Qualified candidates are encouraged to apply online at www.stlukescr.org



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Prestigious Upper Midwest Multi-Specialty Group Seeking Neuropsychologists

Sanford Health is currently seeking two full-time Neuropsychologists (1 Adult and 1 Pediatric) to join its well-established Neuroscience Center in Fargo, ND. Post-doctoral training in neuropsychology and eligibility for board certification is required. Sanford Neuroscience Center is the premier neuroscience group in the region and currently includes one pediatric and one adult neuropsychologist, seven adult neurologists, one pediatric neurologist and three neurosurgeons. The practices include assessment and intervention for a broad spectrum of patients with CNS disorders. Academic appointments are available. Opportunities for clinical research, supervision and mentorship of practicum students are also available.

Sanford Health, an integrated health system headquartered in Fargo, ND and Sioux Falls, SD, is now the largest, rural, not-for-profit health care system in the nation serving 110 communities in six states. Sanford Health Fargo includes a 380-bed hospital; 203-bed CARF accredited rehabilitation unit, and a CARF-accredited brain injury program. Patient referral area of nearly 450,000.

The metro area of Fargo-Moorhead, home to nearly 190,000, features three universities, excellent school systems, and year-round cultural activities and sporting events. For more information about Sanford Health and the community Fargo-Moorhead visit websites www.sanfordhealth.org, www.fmchamber.com, and www.culturepulse.org. To learn more about these excellent practice opportunities contact:

Jean Keller, Physician Recruiter
Sanford Physician Recruitment
Phone: 701-280-4853
Fax: 701-280-4136
Email: Jean.Keller@sanfordhealth.org