The Handbook of
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The Handbook of Sport Neuropsychology

Frank M. Webbe, PhD
Editor
For my parents, Peggy and Dick Webbe, who always worried about my head.
Contents

Contributors ix
Foreword xi
Preface xiii
Acknowledgements xv

PART I Overview of Sport Neuropsychology 1

1 Introduction to Sport Neuropsychology 1
   Frank M. Webbe

2 Qualifications and Training of the Sport Neuropsychologist 17
   Christopher M. Carr and Adam W. Shunk

3 Ethical Issues and Practical Considerations 35
   Shane S. Bush and Grant L. Iverson

PART II Sport-Related Concussion 53

4 History and Epidemiology of Concussion in Sport 53
   Tracey Covassin and R. J. Elbin

5 Sport as a Laboratory Assessment Model 75
   Jeffrey T. Barth, Daniel J. Harvey, Jason Freeman, and Donna K. Broshek

6 Diagnosis and Assessment of Concussion 91
   William B. Barr and Michael McCrea

7 Neuroimaging Techniques and Sports-Related Concussion 113

8 Evidence-Based Neuropsychological Assessment in Sport-Related Concussion 131
   Grant L. Iverson

9 Effects of Repeated Concussive and Subconcussive Impacts in Sport 155
   Luke C. Henry and Louis de Beaumont

_S
_E
_L
viii  Contents

10  Computerized Neuropsychological Assessment in Sport  173
   Philip Schatz

11  Youth Sports Concussion: A Heads Up on the Growing
    Public Health Concern  187
   Rosemarie Scolaro Moser, Amanda Charlton Fryer, and Sheryl Berardinelli

12  Concussion Management Programs in College and
    Professional Sports  209
   Jamie E. Pardini, Eric W. Johnson, and Mark R. Lovell

PART III  Counseling and Therapy Issues  235

13  Counseling Athletes Within the Context of Neurocognitive
    Concerns  235
   Angelica Escalona, Ali Esfandiari, Donna K. Broshek, and Jason R. Freeman

14  Short-Term and Extended Emotional Correlates of Concussion  251
   Lynda Mainwaring

PART IV  New Directions in Sport Neuropsychology  275

15  When Science and Politics Confl ict: The Case of Soccer Heading
    in Adults and Children  275
   Frank M. Webbe and Christine M. Salinas

16  Concussion Management and Neuropsychological Concerns from
    the Perspective of an Athletic Department  295
   Eric A. Zillmer, Eugene Hong, Rebecca Weidensaul, and Michael Westerfer

17  Neuromotor Effects of Concussion: A Biobehavioral Perspective  325
   Anthony P. Kontos and Justus Ortega

18  Neurocognitive Development in Children and the Role
    of Sport Participation  357
   Phillip D. Tomporowski, R. Davis Moore, and Catherine L. Davis

19  Future Directions in Sport Neuropsychology  383
   Frank M. Webbe

Index  395
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FOREWORD

SPORT NEUROPSYCHOLOGY: HUMBLE BEGINNINGS TO DYNAMIC INFLUENCE

There are seminal moments and events in a nation’s awareness, a profession’s development, and people’s lives that create anchor points and define our histories. My generation can vividly recall where and what we were doing when President John F. Kennedy was assassinated, and I can remember who I was dating the first time I heard the song “I Want To Hold Your Hand” by an upstart, mop-headed British band called The Beatles. But how many of us can place the date when mild concussion first drew national attention and forever influenced the field of clinical neuropsychology? Well I can, since I was a very lucky, young coinvestigator in a study of mild head injury at the University of Virginia, the results of which were published in Neurosurgery in 1981. The article itself was not what drew attention to the previously underappreciated effects of concussion, but, rather, the November 24, 1982, appearance of an article by F. C. Klein on the front page of the Wall Street Journal, describing the University of Virginia findings, titled “Silent Epidemic: Head Injuries Often Difficult to Diagnose, Get Rising Attention.” Although others such as Dorothy Gronwall deserve considerable credit for discovering the potential neurocognitive effects of mild brain trauma, it was a well-respected global news organization flashing a disturbing headline of “Silent Epidemic” that launched a professional focus on this topic.

The interest in mild head injury gained momentum in the 1980s and culminated in the first pre- and post-concussion study of college football players as a model for clinical acceleration head injury. Again, it was not the publication of this 1989 University of Virginia scientific study of mild head injury in athletics that drew a national and international audience to sports concussion, but, rather, ESPN, other sports news enterprises, and the popular news outlets that fanned the flames of sports obsession and soccer-mom concerns. The next two decades saw the explosion of sport neuropsychology, which centered on concussion assessment and management with a number of contact sports including American soccer. Dr. Frank Webbe published one of the first studies on the neurocognitive deficits associated with soccer heading activity, and as such has been one of the pioneers in the study of concussion identification, management, and prevention. His experience with the genesis of sports neuropsychology has provided Dr. Webbe with the historical
prospective necessary to create the *Handbook of Sport Neuropsychology*, providing our field with a valuable resource and concise reference book. Dr. Webbe has assembled a distinguished cadre of chapter authors to provide a glimpse into the beginnings of sport neuropsychology, methods for diagnosing and assessing concussion, and guidance for management of concussion and return-to-play decision making. *The Handbook of Sport Neuropsychology* addresses important issues of counseling and psychotherapy for the concussed athlete with persistent neurocognitive deficits, as well as the effects of multiple concussive and subconcussive insults, and the ever increasing probability of a connection to histological evidence of chronic traumatic encephalopathy. Three of the most unique and interesting chapters involve the designation of training parameters for the sports neuropsychologist, ethical interests and practical considerations in the management and prevention of sports concussions, and the politics of conflicting interests in the concussion management and education debate. The final chapter by Dr. Webbe on “New Directions in Sport Neuropsychology” affords us both a summary of the most critical issues and controversies we continue to face in the struggle to understand sports concussion and plans for meeting these challenges. That chapter and the others that recount the commingling of neuropsychological approaches with brain changes in development and rehabilitation forecast some of the new, breaking areas in sport neuropsychology.

Dr. Webbe uses his vast knowledge and experience in the field of sport neuropsychology to create a superb road map that provides important information and direction for the study of sports concussion. This handbook reflects his skill at attracting some of the world’s leaders in sport neuropsychology as chapter authors, and his ability to organize and integrate their unique funds of knowledge. I am pleased to have been asked to contribute to this important addition to the literature, and I hope you will join me in experiencing Dr. Webbe’s passion and optimism regarding the future of sport neuropsychology, which is reflected in this extraordinary gift to our field.

Jeffrey T. Barth, PhD
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The Handbook of Sport Neuropsychology frames this rapidly evolving discipline within the context of its historical underpinnings, the science that has become its backbone, and the clinical applications that spring from it. In many ways, I conceptualize this Handbook as the content successor to two earlier compilations: Lovell, Barth, Collins, and Echemendia’s Traumatic Brain Injury in Sports, and Echemendia’s Sports Neuropsychology: Assessment and Management of Traumatic Brain Injury. In addition to the obvious fact that this book contains recently updated science and application information developed after the previous volumes were published, there are two other significant differences. First, an overriding goal was to bring to neuropsychologists, especially those who identify as sport neuropsychologists, not only the science and application that they see commonly in neuropsychology journals, but also knowledge that springs from sport and exercise science disciplines. The day has passed when purely parochial approaches will be successful. Second, this book elaborates on the primary topic area of sport-related concussion by (a) including the newest research on the role of neuroimaging and electrophysiological approaches in understanding concussion; (b) clarifying the professional training and ethical behavior of sport neuropsychologists; (c) highlighting the emotional component of concussion and the need to address emotional and personal issues following injury; and (d) elaborating the acute and chronic effects of repeated head trauma.

Although the word handbook implies content that is fully inclusive, the speed with which the field of sport neuropsychology moves in relation to the speed at which we authors move remains quite disparate. The temptation throughout the process of producing the book was to wait until new, exciting outcomes could be presented in additional chapters. There came a point at which the faucet had to be turned off and final production begun. Moreover, the definition of what exactly constitutes sport neuropsychology can be contentious, and a consensus agreement might have taken several life spans.

The book is organized into four parts. Some chapters represent needed review of knowledge and/or practice areas, but with critical updates from the past several years. Other chapters present new work that has not been presented previously in summary form. Chapter 1 describes extensively the flow and content of the chapters. My goal in defining chapter topics was to be inclusive of the discipline and also to highlight some areas that had been
developing somewhat under the radar. Nonetheless, the discipline had its origin in the study of sport-related concussion and that remains the best-researched and most visible face. Moreover, recent developments and implications of concussion within the sport context have ballooned in recent months, so focus on that topic is both inescapable and of critical importance.
Acknowledgements

The genesis for this book began eight years ago during a sabbatical leave at the University of Virginia Medical School. My gracious host, Jeffrey Barth, and his talented colleagues Donna Broshek and Jason Freeman helped me to frame and understand so many of the critical issues in sport-related concussion. Dr. Barth also shared with me many of the personal insights he gained while he developed the Sports as a Laboratory Assessment Model and the prospective, baseline testing approach for concussion management. Absent that fecund environment I never would have thought to begin this project. Other professional colleagues assisted in that nurturing, sometimes formally and sometimes informally. I thank Eric Zillmer, Ruben Echemendia, David Erlanger, Phillip Schatz, Andrew Rutherford, and Rosemarie Scolaro Moser for their critical insights and targeted discussions.

Edited books must be judged based on the contributions of the chapter authors. I was fortunate not only that incredibly busy subject experts agreed to write chapters, but also that they invested themselves in presenting to the readers new viewpoints, approaches, and science. To all of you, thank you for your dedication to this project.

The editorial staff at Springer Publishing has given me marvelous support throughout an odyssey stretching back almost three years since the initial planning and conceptualization of the Handbook of Sport Neuropsychology. Senior acquisition editor Nancy Hale stepped in midway through the process and variously encouraged, nudged, and supported me, always with exactly the right comments at the right time.

Much of the knowledge that I have gained over the years in this discipline came through interaction with my wonderful students. Adrienne Witol listened to my ideas about soccer heading and subconcussive impacts and designed and conducted the first research from my laboratory in this area. Shelley Ochs, Barry Skoblar, Trent DeVore, and Christine Salinas continued these efforts and taught me much along the way. My current students, Megan Frankl and Danielle Schuster, assisted me in the logistics of this book, also reading every chapter and sharing their insights with me.

Finally, my wife, Ellen, endured many solo weekends and evenings as I labored over the logistics of the book. She received partial payback with a trip to Ireland, but she has many more credits in the bank.
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Why Did It Happen?

Christopher Michael “Chris” Benoit wrestled his way to the top of his profession, earning recognition as the world professional heavyweight champion from the World Championship Wrestling and World Wrestling Entertainment organizations. The Canadian-born Benoit entered adolescence as an undersized overachiever. A chance exposure to the similarly undersized British wrestler Tom “Dynamite Kid” Billington provided Benoit with his mission in life: become the best professional wrestler in the universe. No matter that Billington was possibly the most despicable model to pattern oneself after, or that vast quantities of anabolic steroids were critical to the developmental process. Standing head and shoulders below a Hulk Hogan, and weighing nearly 100 lbs less, Benoit nevertheless earned his championships by being the hardest working athlete in the stable and also the most willing to risk life and limb in and out of the ring. There was nothing that he would refuse to do to himself or to others (Randazzo, 2009). The formerly polite Canadian kid had become the poster boy for big-time professional wrestling, and he would have it no other way.

Beginning on June 22, 2007, and extending through June 24, the 40-year-old Benoit sequentially murdered his wife and his 7-year-old son, and then he hanged himself. The brutality of the murders recapitulated his ring exploits. Yet, those who knew Benoit expressed total surprise at his actions, professing that he loved his wife and was a doting father. Benoit’s nearly 25 years of anabolic steroid use, coupled with amphetamine and prescription drug abuse, was seen as a proximal explanation of his behavior. However, examination of Benoit’s brain revealed additional alarming factors that also shed light on the years of erratic behavior leading up to and including the murders and suicide.

A who’s who of medical experts in sport-related concussion examined Benoit’s brain. They concluded unanimously that Benoit suffered from chronic traumatic encephalopathy (CTE; Cajigal, 2007). Examination of Benoit’s brain revealed the presence of marked amounts of intra and extra-neuronal tau protein, in a pattern similar to that found in the brains of other professional
I. Overview of Sport Neuropsychology

athletes who were diagnosed as suffering from CTE and who also engaged in problematic, often violent behavior (McKee et al., 2009).

Although the ultimate causes of Chris Benoit’s horrific final acts are uncertain, and the role of the pathologic brain changes in determining his behavior will always remain speculative, it is highly probable that appropriate social, medical, and psychological interventions could have prevented this tragedy. Identification of Benoit’s brain impairment, prevention of further damage, management of his multiple concussions, and rehabilitative counseling all fall within the purview of the discipline of sport neuropsychology.

HISTORICAL ORIGINS OF SPORT NEUROPSYCHOLOGY

Sport neuropsychology combines the twin disciplines of sport psychology and neuropsychology. The clear genesis of this relatively new subfield was the advent of study of sport-related concussion, and that thrust continues as the defining characteristic of the discipline. Although concussions in sport are anything but new, study of them as a distinct research field and management of them as a growing area of professional practice has a very recent origin extending back less than 25 years. The parent discipline of sport psychology extends back nearly a century further to a series of studies of social-facilitation effects in bicyclists conducted by Norman Triplett in the 1890s (Triplett, 1898). In many contexts that might represent a very short time period. But, given that historians date the origin of scientific psychology to Wilhelm Wundt’s publication of his Grundzüge der Physiologischen Psychologie in 1873 and the founding of his laboratory of experimental psychology at Leipzig 6 years later, it appears that sport psychology is nearly as old as psychology itself.

The other parent discipline of neuropsychology extends back even further, at the very least to Paul Broca’s study in 1861 of the brain origins of the speech difficulties exhibited by the aphasic patient LeBorgne (Broca, 1861). However, neuropsychology as a specific discipline really did not differentiate itself from neurology and psychology until the 1940s (Lezak, 1983).

Sport psychology can be defined as “the scientific study of people and their behaviors in sport and exercise activities and the practical application of that knowledge” (Weinberg & Gould, 2007, p. 4). Neuropsychology studies the relationship between the functioning brain and behavior, with behavior often broken down into intellectual, emotional, and control components (Lezak, 1983). Both parent fields exhibit several similarities. Each has its scientific and applied sides. Experimental neuropsychology uses methods from experimental psychology to uncover the relationship between the nervous system and cognitive function. This approach involves studying healthy humans in a laboratory setting, although animal experiments are not uncommon. Clinical neuropsychology applies neuropsychological knowledge to the assessment, management, and rehabilitation of people with neurocognitive problems due to illness or brain injury. It brings a psychological viewpoint
to treatment to understand how such illness and injury may affect and be affected by psychological factors. In sport psychology, the split is more complex. Exercise science is the predominant scientific side, but the psychology half also is divided into clinical versus scientific aspects. Obvious areas of overlapping interest exist between sport psychology and neuropsychology. For example, exercise science studies motor control and motor learning in sport. Brain injuries might obviously impact such learning and performance, and the rehabilitative effects of relearning motoric behavior might in turn affect recovery processes in the brain. A sport neuropsychological approach would map such relationships. Another study might examine the role of excessive metabolic demands in endurance sports in altering brain function and cognitive performance. Many other questions have already been studied. Most, however, are waiting to be asked.

MODERN ORIGINS OF SPORT NEUROPSYCHOLOGY

Two major research and practice areas define sport neuropsychology in the new millennium: sport-related concussion and neurocognitive/medical well-being. Sport-related concussion defines a phenomenon of mild traumatic brain injury (mTBI) that occurs within a sport context. For example, when a hockey player is smashed into the boards and comes off the ice wobbly, confused, and amnestic for the event, an instance of sport-related concussion has happened. Neurocognitive/medical well-being defines the use of neurocognitive assessment of athletes to determine the role that normal sport activities might have in affecting quality and duration of cognitive capacity and quality of life. These types of studies can identify costs or benefits of sport activities. For example, the role of aerobic activities in facilitating cerebral blood flow may point toward beneficial effects. The role of soccer heading may suggest a downside to normal play of a popular sport.

SPORT-RELATED CONCUSSION

Since the study of concussion and its after-effects represents such a large chunk of research and practice in sport neuropsychology, it is worthwhile to define the term.

Cerebral concussion is a closed head injury that represents a usually transient alteration in normal consciousness and brain processes as a result of traumatic insult to the brain. The alterations may include loss of consciousness, amnesia, impairment of reflex activity, and confusion regarding orientation. Although most symptoms resolve within a few days in the majority of cases, some physical symptoms such as headache, and cognitive symptoms such as memory dysfunction may persist for an undetermined time. (Webbe, 2006, p. 48)
I. Overview of Sport Neuropsychology

Just as Triplett’s study of cyclists and Broca’s study of LeBorgne were seminal in the origins of the parent disciplines, Barth’s study of sport-related concussion spurred the evolution of sports neuropsychology. In the early 1980s, Barth and colleagues, including Macciocchi, Ryan, Alves, Rimel, Jane, and Nelson, began studying college football players who suffered concussions (Barth et al., 1989; Macciocchi, Barth, Alves, Rimel, & Jane, 1996; Macciocchi, Barth, & Littlefield, 1998). Realizing the improbability of obtaining prospective participants for the study of brain injury in the general population, Barth identified college football players as individuals at a significantly high risk of brain injury. Neuropsychological tests were administered before the playing season began and were repeated for those players who suffered concussion as well as for a nonconcussed control group. From a medical, individual, and social perspective, the results were optimistic in that they portrayed the typical sport concussion in football as an event with transient neurocognitive impact. Perhaps more importantly, however, the methodology of the study established a standard that has shaped the discipline. Specifically, as Barth and his colleagues describe in Chapter 5, the approach of using the sport setting as a laboratory to study mTBI (sport as a laboratory assessment model—SLAM) established prospective, longitudinal methodology as the gold standard that has guided assessment and management progress for 20 years. When athletes engage in rough, physical play there is an inevitability of injury, including head injury. The notion of establishing baselines of neurocognitive performance against which post–head injury performance could be compared represented a monumental addition to the group normative comparisons that otherwise were the only choice. Moreover, along with pre-injury neurocognitive testing, researchers also could collect information on premorbid physical and cognitive symptomatology. Thus, the baseline assessment model greatly diminished the variance inherent in making group normative comparisons. The remaining variance associated with repeated testing, history, and maturation could be understood better within the individual context. What has not been eliminated, indeed it has been enhanced, is the observation of considerable individual differences in such critical and basic areas as the following: (1) differences in the severity of outcome between individuals who receive apparently similar head insults, (2) differences between individuals in duration of recovery from concussions of apparently similar magnitude, (3) differences between individuals in ultimate recovery from concussion such that they can resume their previous activities, (4) effects of recurrent concussions on neurocognitive performance, and (5) effects of subconcussive blows on neurocognitive performance (Webbe & Barth, 2003).

Epidemiology

More than 10% of all adult participants in formal athletic events can be expected to suffer a concussion this year (Cable, 2001). The Centers for Disease Control translate these statistics into the prediction that about 300,000
sport-related concussions will be reported each year (Kelly, 2000). Because many athletes participate in leagues where medical oversight is lacking, it is highly likely that many more concussions actually occur (Echemendia & Julian, 2001). All physical sports have the potential for causing brain injuries to their participants. In some sports such as golf or bowling, the risk is very low, but golfers do get hit with balls and clubs, and bowlers, curlers, and even shuffleboard participants do slip, fall, and crack their heads. Typically, though, we consider the roughness and speed of play as critical factors that determine risk of concussion. American football has been the “model” sport because of the roughness, speed, and player size factors in interaction with a large number of participants (Barth et al., 1989). In Chapter 4, Covassin and Elbin show us the panorama of sport concussion epidemiology, clarifying the methods of study in this field and delineating sports where participants are most at risk, and also introducing the interaction of gender and age into the equation. In cross-comparisons of gender by sport, college females have a somewhat increased likelihood of concussion, a greater risk of more serious head injury, and also a more problematic recovery (Covassin, Swanik, & Sachs, 2003a, 2003b). The fact that gender may differentially determine TBI incidence, severity, and symptom resolution is a common thread of discussion in experimental neurology, but less well-known in neuropsychology. There are considerable gender differences in the neural anatomy and physiology, cerebrovascular organization, and cellular response to concussive stimuli. In addition to the obvious gender differences in levels of circulating sex steroid hormones that may affect susceptibility to and recovery from brain injury, other critical gender-based differences have been noted. For example, cortical neuronal densities are greater in males, while the number of neuronal processes is greater in females (de Courten-Myers, 1999). Females also exhibit greater blood flow rates and higher basal rates of glucose metabolism (Andreason, Zametkin, Guo, Baldwin, & Cohen, 1994; Esposito, Van Horn, Weinberger, & Berman, 1996). To the extent that female brains may have higher cortical metabolic demands, the typical decrease in cerebral blood flow along with the increased glycemic demands caused by TBI may interact with the already high gendered demands and result in greater impairment in females than males.

In Chapter 11, Moser, Fryer, and Berardinelli develop in greater detail the epidemiology of concussion in youth sports, elaborating gender determinants of frequency and recovery from injury as well as differences between adult and youth populations. The clinical management of youthful concussion sufferers is detailed. Of particular concern is the unknown incidence of sport-related concussion in children. For example, Guskiewicz, Weaver, Padua, and Garrett (2000) reported that high school athletes were at higher risk for concussion than were most collegiate players. Moser and Schatz (2002) reported that considerably more of their concussed high school–level athlete participants (ages 14–19) appeared to have longer lasting neurocognitive and somatic symptoms than would have been expected based upon
previous studies of older athletes. Moser and colleagues conclude their chapter with a strong appeal for education and advocacy directed to this underserved population.

**Diagnosis and Assessment**

The diagnosis and assessment of sport-related concussion crosses many disciplines and moves fluidly outward from the traumatic incident itself. The genesis of assessment may begin prospectively with baseline testing. Post-incident assessment often begins on the sideline of a sporting event when a participant has received a blow to the head, continues in the training room, may extend into the emergency department of a hospital or in a physician’s office, and at some point may reach the neuropsychologist. Because this topic is so broad and all encompassing, four chapters cover the various elements, and two additional chapters address issues critical in understanding the totality and validity of assessment. In Chapter 6, Barr and McCrea take us from the moment of injury through sideline assessment, medical examination, and neurocognitive testing. The first assessment of sport-related concussion in organized leagues is likely to take place on the sideline or in a locker room during or immediately following a game. The most common instrument for this assessment is the Sideline Assessment of Concussion (SAC; McCrea et al., 1998), administered by an athletic trainer or a team physician. The SAC aims to determine the instant level of confusion, disorientation, and amnesia of the injured player. This standardized, quantifiable approach represented a considerable leap over the qualitative and inexact attempts to assess mental status previously common on the football sidelines (e.g., asking the questions “Where are you? What’s the score? What’s your name?”). Players who score positive on the SAC will commonly be referred for follow-up medial treatment. This typically implies a neurological evaluation. If a protocol has been established, neuropsychological testing may also be mandated, but that outcome is highly variable. In professional football and hockey leagues where concussions are a fact of life, follow-up neuropsychological evaluation is very likely to occur (Lovell & Barr, 2004). Because of recent high-profile cases of sport-related concussion and controversies over the absence of prevention or attention, both the NFL and the NCAA have mandated new policies and procedures for pre- and posttrauma assessment and management.

Because of the large number of athletes who may have to be tested and the limitations on hours of availability, neuropsychological batteries used in sport neuropsychology are generally briefer than might be used in normal clinical practice. The typical time frame is 45 minutes to an hour. The batteries consist of tests that measure critical domains of functioning known to be at risk for impairment following TBI. Thus, processing speed, memory, and executive functioning have priority for assessment (Gronwall, 1989). Although, the briefer assessments are the norm in the majority of cases, when
the situations become more complex, more traditional neuropsychological batteries are likely to be employed.

A vexing question for sport neuropsychologists relates to the exact role played by neuropsychological assessment in managing sport-related concussion and in clearing athletes to return to competition. Randolph, McCrea, and Barr (2005) have recently challenged the profession to demonstrate that neuropsychological evaluation following concussion actually provides unequivocal conclusions regarding impaired versus recovered functioning. Specifically, the authors asked the following questions: (1) Are the batteries used in concussion assessment valid? (2) Is information provided by the neuropsychological assessment unique compared to other categories of testing (e.g., neurological, scanning/imaging, balance testing)? and (3) Do the neuropsychological outcomes reveal information regarding recovery of function that would otherwise not be known and that is critical for the return-to-play decision? In asking the first question on validity, Randolph and colleagues considered the reliability, sensitivity, validity, change scores/classification rate, and clinical utility of sport neuropsychological assessment batteries used in many published studies. The authors found these test batteries to be lacking in several areas. The chances are good, however, that similar findings would have been obtained had the authors sampled neuropsychological batteries in more general settings. One of the key issues at play, as mentioned earlier, is that assessment in the sport domain often carries with it the requirement for briefer batteries than might be chosen for general practice. A practitioner might be comfortable with the sensitivity and clinical utility of the Halstead-Reitan Neuropsychological Test Battery (HR NTB), for example, and choose that as the gold standard. However, the likelihood of HR NTB actually being used routinely in the sport setting is near zero. Clinicians and researchers have pieced together short batteries that assess major areas of functioning known to be impacted in many sport-related head trauma cases (as is described in Chapter 12 by Pardini, Johnson, and Lovell). A second issue of note in Randolph et al.’s criticism is that they considered group differences as the key arena for evaluating such critical issues as the sensitivity of tests. In many research studies these differences are certainly critical. However, the outcomes of mild brain trauma clearly differ greatly across individuals. In Chapter 6, Barr and McCrea hone in on this issue and contend that baseline neuropsychological testing, the historic “gold standard” first introduced by Barth in 1989, has not been shown empirically to be sufficiently germane and sensitive to the mild concussions usually seen in the sport context: “While this model holds much in terms of intuitive appeal, its success and wide acceptance appears to be based more on the effects of professional recommendations and opinion than the results of empirical research.”

Two people of similar morphology may be exposed to similar concussive forces in similar settings. One may be notably affected and the other not, and neuropsychological and other tests may clearly discern this outcome. The variables that determined the differential outcome remain unknown. They
may relate to subtle differences in the actual event, or they may relate to characteristics of the individual. Subtle differences in the actual concussive event may also result in somewhat different brain areas receiving differential injury. Individual tests within a battery could then exhibit different outcomes, and this may appear to create unreliability. Thus, too great a focus on group data, and on considering concussion more unitary in the expression of dysfunction, may easily cloud good science and good practice.

In demanding that post-concussion neurological assessment contribute additional knowledge of concussion severity, potential for recovery, and determination of return to play than can be garnered through neurological imaging, symptom inventories, or other present methods, Randolph and colleagues certainly stand on solid ground.

In Chapter 8, not unlike Barr and McCrea, Iverson argues for an evidence-based approach for judging the adequacy of neuropsychological testing within the context of sport-related concussions, but he expresses more optimism that extant data are providing differential support both in diagnosis and in case management. He reviews meta-analyses that cross over the various modalities of evaluation—symptom, balance, and neurocognitive—and demonstrates that neuropsychological assessment does add convergent validation to the other measures as well as provides some unique prediction of case outcomes even in the acute phase following injury. He concludes that “The real issue for future researchers is to determine if baseline testing adds incremental validity and improves accuracy in cognitive assessment following concussion.”

Contributing in part to the diagnostic and philosophical debate over the role and value of neurocognitive testing within the sport domain is the prevalence of computerized neuropsychological screens that now predominate in the baseline approach to concussion management. Barr and McCrea suggest that such tests may lack sensitivity in the sport context. Iverson in Chapter 8 and Pardini, Johnson, and Lovell in Chapter 12 present data to the contrary and argue that computerized testing, used appropriately, provides valuable information throughout the management of concussions. In Chapter 10, Schatz reviews the various computerized instruments and presents data documenting the effectiveness of such instruments, but he also details their limitations within the sport concussion venue. For example, it is ironic that the computer measures reaction times and processing speed to the microsecond in these tests, but factors such as the distance of the hand from the keyboard may go totally uncontrolled, adding monstrous error to measurements. While very optimistic over the role of the computerized instruments, Schatz also cautions that failure of clinicians to understand vagaries of computerized testing can impact clinical decisions and adversely affect treatment and recovery.

The various controversial and sometimes heated arguments over the use and validity of neuropsychological assessment in sport-related concussion sometimes overshadow the consensual common threads espoused by all authors,
specifically that (1) no single test or approach can stand alone as sufficient to adequately diagnose, (2) the involvement of a neuropsychologist with expertise is crucial for interpretation of whatever tests are administered, and (3) the validity of all tests and approaches must be judged empirically. This final point of unity likely is the key component that will determine the ultimate success and acceptance of neuropsychological testing within the discipline.

Concussion Management Programs

All athletes risk injury when they take the field, court, ice, and so forth. There is a presumption, however, that the ruling bodies of sport have taken steps to reduce the risk of injuries, particularly those that are debilitating or life-threatening. And although few would characterize most present-day professional sports organizations as humanistic in nature (the same might be said of many college programs), the financial and public relations ramifications of player injury have positively impacted the development and introduction of protective equipment and legislation of protective rules.

For the NFL, it was the interaction of this latter reality with the warnings given by the medical and neuropsychology community that spurred development of the NFL Neuropsychology Program in 1993. Mark Lovell, Joseph Maroon, and colleagues began this program with 23 of the players from the Pittsburgh Steelers football club. At the present time, all 32 teams participate (Lovell & Barr, 2004). The program tests each player prospectively in the preseason, often at conditioning camps. Because of the practical issues of access to players, the battery that has been developed is brief, taking approximately 30 minutes to administer. A similar program was developed in the NHL in 1997. Chapter 12 by Pardini, Johnson, and Lovell and Chapter 16 by Zillmer, Hong, Weidensaul, and Westerfer detail the development of concussion management programs and comment on their effectiveness. In Chapter 12, the authors discuss typical concussion management programs for both college and professional sports from the viewpoint of the neuropsychologist. They describe the rationale for test selection, frequency of retest following injury, and the return to play decision from the perspective of the neuropsychologist.

Zillmer and colleagues take a different approach and consider concussion management from the viewpoint of the athletic director, team physician, athletic trainer, and academic counselor. This allows neuropsychologists to view the concussion management issues through the lens of administrators and other professionals, all of whom have the concern of the athlete as the central focus, but different approaches to decision making and different pressures.

Taken together, these chapters provide a window into the acceptance of the necessity of these programs as well as the commitment required to make such programs effective. Clearly, if colleges or professional sport teams adopt a concussion management strategy just to allow a box to be checked on a
form of institutional requirements, the pro forma actions may be remarkably ineffective on an individual basis.

Severity

Concussion, of course, is considered to mark the mild end of a continuum of brain injury. The historic concept of concussion was that brain activity is disrupted temporarily and then returns quickly to normal with few or no residual symptoms and no morphological damage. As better measurement devices have been developed, that style of definition has lost credibility because we now know that morphological change, including axonal and somatic necrosis, does occur in some cases of concussion (Hovda et al., 1999). What still remains problematic is differentiating and predicting whether a given individual who suffers concussion will exhibit a quick, unremarkable recovery, as Barth and colleagues found for the vast majority of concussed college football players, versus a lengthy period—possibly months or years—filled with physical and cognitive disturbances. Although neuropsychological assessment may reveal fundamental changes in cognitive processing, reactions, and judgment, it has not yet proven predictive of who will fall into one or the other of the above categories—the research continues. Exciting new developments in the areas of viewing the living brain are now beginning to contribute to our overall understanding of concussion and may show promise of assisting in this daunting task of predicting outcome. First introduced in Chapter 6 by Barr and McCrea, modern structural and functional techniques such as MRI variants, fMRI and PET, as well as advances in electro-physiological approaches, such as EEG, ERP, and MEG, are now being used to study sport-related concussion. In Chapter 7, Pardini, Henry, and Fazio detail how far these studies have advanced. Although most neuropsychologists will be familiar in a generic way with the outcome studies employing functional imaging, the wealth of data arising from work with event-related potentials and evoked potentials has been largely underused. As Pardini and colleagues comment, “the protocols are usually time efficient, non-invasive, resistant to practice or motivation effects, and the findings are more objective than athlete self-report of symptoms.” Of particular interest is the possibility that such techniques may not only be available to predict functional outcomes following traumatic injury to the brain, but they may also ease the tension among practitioners, litigants, and their advocates regarding the presence of persistent post-concussion decrements.

Ethics and Training

Carr and Shunk, in Chapter 2, discuss the issues critical in the qualification and credentialing of sport neuropsychologists. Because this disciplinary area is new and developing, the issues have been less clear and more fluid than in
more established areas, and recommendations are proffered for future professional development. Clinical psychologists would be aghast at the prospect of nonclinical personality specialists advertising their services for clinical assessment. Neuropsychologists would be aghast at the prospect of neuropsychologically naïve clinical psychologists advertising their services for neuropsychological evaluations. Sport psychologists would be aghast at either clinical or neuropsychologists advertising their services for sport-related assessment of athletes. Moreover, licensing and certification bodies would take a dim view of the first two of these examples. The third is less known because the practice of sport psychology is not protected by state laws or certification agencies. Nonetheless, the major sport psychology organizations (e.g., Association for the Advancement of Applied Sport Psychology and Division 47 of the American Psychological Association [APA]) have issued clear guidelines for educational and experiential qualifications of such practice (APA, Division 47). When it comes to sport neuropsychology, practice qualifications are even more obscure because a combination of knowledge and skills from the twin domains of sport psychology and neuropsychology must be considered. A potential consultant may have the neuropsychology background but may lack the sport-specific background or knowledge. That background may be crucial for understanding the context in which neurocognitive deficits occur and the issues that the athlete-patient faces in recovery and adaptation. For example, neuropsychological testing may reveal some slight psychomotor slowing that may be borderline on an impairment index. For an athlete, such a change may well be catastrophic because exceptional capabilities in this area are likely the norm and separate a champion from an average performer. The sport-naïve practitioner may totally miss such implications.

In Chapter 3, Bush and Iverson expand upon training issues and carry further the discussion of professionalism. Unlike many clinical or consulting situations, the question of who the client is may be particularly fuzzy in sports neuropsychology and even more so in sport psychology. For example, the practitioner may be employed by the team or organization to examine players prospectively and following head trauma. The identity of the patient is clear—it is the athlete. However, she or he may not be the client; that may be the organization/employer. The normal issues of client confidentiality become blurred in such a situation. The team wants to know unequivocally whether the player is disabled or ready to return to action. How will such a revelation affect the player and their future livelihood? Is this the concern of the psychologist? Sport psychology is not the only arena where such ticklish ethical issues arise. Industrial or organizational and military psychologists often face similar dilemmas. As Bush and Iverson discuss, the key in any of these settings is for the psychologists to clarify the issues ahead of time and potentially refuse a consultation if their ethical obligations are compromised. Sport neuropsychologists also face a potential adversary in the media. Particularly when high profile college and professional athletes suffer traumatic brain injury, a media circus can ensue. Again, the issue of ethics remains
paramount, but the extensions become even more arcane. For example, betting on professional sports is legal in Nevada. The starting quarterback on the top-ranked team in the country suffered a concussion 2 weeks earlier. Although the team neurologist has cleared the quarterback to play, neuropsychology consultant Dr. X is well aware that the athlete’s reaction times and speed of processing remain impaired. Are there added ethical considerations here? How does patient and client confidentiality apply? Such questions are complex and can entangle the unwary sports neuropsychologist in a sticky web that is not easily escaped. The savvy consultant will consider such issues before accepting a case and consult experts and ethicists along the way (Parker, Echemendia, & Milhouse, 2004).

Counseling and Psychotherapy

The therapeutic aspects of sports neuropsychology have been long in coming. Broshek (2003) first described the evolution of “Therapeutic Neuropsychology” within the context of comprehensive psychological and neuropsychological services delivered to student athletes within the athletic department of a major state university. In Chapter 13, Escalona, Esfandiari, Broshek, and Freeman expand upon the structure and function of neuropsychologically-based counseling within the athletic context. Although concussion management provided the initial entrée, additional services are seen as including academic evaluations, preseason academic and neurocognitive screening, psychotherapeutic interventions, learning disabilities (LD), and attention-deficit/hyperactivity disorder (ADHD) assessments and treatment. The authors document particularly how issues in recovery from sport-related brain trauma impact all facets of the person, including self-concept and emotional reactivity.

In Chapter 14, Mainwaring focuses squarely on the emotional concomitants of sport-related concussion and explores both the short- and long-term sequelae. As she describes, such study has been slow in developing because of the subjective and experiential nature of emotion and the multitude of definitions. Using measures long accepted in sport psychology, Mainwaring describes consistent patterns of post-concussion emotional correlates that contrast with patterns seen commonly in effective champion athletes. She also sets the stage for the development of new theoretical models within which to place and interpret the empirical observations.

New Directions and Approaches

Although the primary focus in sport neuropsychology has been and continues to be on issues related to concussion, a number of approaches that have sprung from more traditional sport psychology and exercise science as opposed to clinical psychology are receiving more exposure. In Chapter 18,
Tomporowski, Moore, and Davis describe the interrelationship between neural maturation and exercise activity. Adopting a developmental neuropsychological approach, they explain how physical activity may interact with children’s emerging brain structures, their functions, and plasticity. They buttress their model of interaction with results from recently conducted studies that examine the effects of exercise on children and adults’ executive function. They suggest that the emergence of executive functions in children may be tied to the context in which movement skills are learned and by the learner’s level of mental engagement. This is an exciting approach that ties together traditional exercise science with data emerging from the neuropsychological and cognitive neuroscience study of executive function.

A somewhat different approach to relate neurocognitive and motor functions is adopted by Kontos and Ortega in Chapter 17. Indeed, this chapter provides a very vital bridge for the sport neuropsychologist working with concussions to understand the basis for the movement and postural deficits that may occur following concussion. Although there has been no inherent reason for it given the obvious neurological basis, testing of postural reflexes and other motor correlates of concussion has been somewhat ignored by neuropsychologists. Certified athletic trainers have stepped into that vacuum and have become the primary users of posture-based variables.

Although Chapter 16 by Zillmer, Hong, Weidensaul, and Westerfer has already been mentioned in the context of the concussion management programs, it has been included in the section on new directions because it presents a model for such programs at the university level from the perspectives of the multiple professionals involved. It provides insight for neuropsychologists on some of the issues important for other professionals and also illustrates a guide for the development of comprehensive programs at institutions or in organizations that host a large number of athletes.

In Chapter 15, Webbe and Salinas describe the intricacies that occur when empirical knowledge conflicts with the politics and tradition of sport. The story of soccer heading as a potentially injurious act has been very controversial, partly because heading as a risk factor in causing neurocognitive impairment has not been reported uniformly across well-done studies and partly because of the resistance of the sport and its governing bodies to allow for the possibility that a well accepted and exciting aspect of the game might have to be changed for the protection of the participants. The authors review relevant studies and describe factors that might contribute to the lack of scientific uniformity in nearly two decades of research. They also address the issue of heading the ball in youth soccer and recommend constraints based upon age and other crucial factors. However, perhaps the most critical lesson to be learned is that heading the soccer ball serves as one model for repetitive, subconcussive brain insults that occur within the context of sport. The importance of subconcussive trauma was highlighted in Henry and de Beaumont’s Chapter 9, a chapter that would fit equally well in this section on new directions. Henry and de Beaumont paint a not very rosy portrait of the
I. Overview of Sport Neuropsychology

acute and chronic effects of repetitive concussive and subconcussive impacts on brain and behavioral functioning. They incorporate the newest findings from neuroimaging and electrophysiological studies and also the gross and histopathological data from the brains of retired or deceased athletes (such as Chris Benoit) studied by McKee and Stern (McKee et al., 2009). They conclude that rather than a dichotomous all-or-none profile of damage, the role of repetitive brain trauma is both cumulative in nature and progressive in its effects. This progression includes a sequence that radiates from the accumulating structural and metabolic impairments to expression in cognitive, behavioral, and emotional impairment. Whether we ultimately will see a predictable progression or whether the pattern of impairment remains idiopathic is left for future research. However, the former naïveté of athletes, team organizations, and fans that allowed us to view concussions in sport as a minor price to pay for participation no longer is viable. As Pardini and colleagues document in Chapter 12, the NFL now has turned the corner on this issue, as has the NCAA. How other sport-sanctioning bodies may react is unknown. There still is the disturbing growth of mixed martial arts and ultimate fighting events where the major aim is to cause brain impairment to the opponent. As in ancient Rome, the public is more than willing to pay to see opponents devastate each other. Although sport neuropsychology has a rather small public persona at the moment, continued production of empirically valid data regarding the role of repetitive head trauma may well have greater societal impact in the future.

My own concluding chapter expands upon some of these new directions in sport neuropsychology. For example, the groundbreaking work with the athlete brain bank by McKee, Stern, and colleagues (McKee et al., 2009) at Boston University is forcing a closer look at all contact sports with respect to the potential for acute and chronic brain injury, even when participants play by the existing rules. How this translational work may affect public policy and sport structure remains open to conjecture, but it has already had considerable impact on forcing sport leagues and organizations to implement new strictures regarding management of possible concussions and return-to-play, as well as focus on rules of play.

Clearly, sport neuropsychology has grown to be a robust discipline, filled both with new research and applied knowledge, but also replete with the excitement that sport brings to us. The games of childhood may help develop the brain, as Tomporowski and colleagues describe, and the games of adulthood may impair the developed brain. Understanding how these processes flow and how to measure them defines modern sport neuropsychology.

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