Sports Medicine and Athletic Training in the 21st Century: Bridging the Gap Between Research and Clinical Practice

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Sport and recreational activity is a vital part of today’s society, and athletic training researchers are playing an important role in gaining a better understanding of how to promote safe and healthy participation for athletes of all ages. This article aims to illustrate the importance of research to prevent and effectively treat sport and recreational injuries. Increased physical activity among Americans is helping to combat chronic diseases such as obesity and diabetes, but injuries related to increased activity are on the rise. We must be responsible in our approach to promoting physical activity and participation in sport, while minimizing risk of injury. Athletic training researchers and colleagues from other disciplines within kinesiology, allied health sciences, and medicine must work collaboratively to identify predispositions to athletic injuries and illnesses. They must further conduct prospective studies that will help clinicians better manage these injuries and prevent their recurrence. This article highlights the progress that athletic training researchers have made to bridge the gap between research and clinical practice.

We live in a sport-crazed society, a society in which sport has evolved into a major component of everyday life. In the competitive arena, we see staggering numbers of youth involved in dozens of club, scholastic, collegiate, professional, and recreational sports. Participation in high school sports alone has grown from an estimated 4 million participants in 1972 to 7.2 million in 2006 (Centers for Disease Control and Prevention [CDC], 2006; National Federation of State High School Associations [NFSHSA], 2005). In addition, more than 30 million youth and adolescents participate in club and recreational sports (Hergenroeder, 1998; Koester, 2000).

Engaging our youth in recreation and sporting activities at an early age is helping to answer the U.S. Surgeon General’s plea for “exercise as a means to reduce the risk of chronic diseases such as obesity and diabetes” (U.S. Department of Health and Human Services [USDHHS], 2001) and responds to the Healthy People 2010 initiative (USDHHS, 2002a, 2002b). For youth, recreational sports also offer an outlet to grow physically, mentally, emotionally, and socially (Wiersma, 2000). For adults, exercise and recreation are preventative medicine. However, the price of
this increased activity is an estimated 2 million injuries, 500,000 doctor visits, and 30,000 hospitalizations annually (CDC, 2006). Conn, Annest, and Gilchrist (2003) reported that sport and recreational injuries in the United States are substantial, especially for participants between the ages of 5 and 24 years.

**Increasing Physical Activity, While Minimizing Risk of Injury**

The challenge facing professional organizations responsible for establishing exercise guidelines is to determine how much is too much and evaluate the cost–benefit ratio of society’s increased emphasis on physical activity. Given the estimated $117 billion annual health care costs associated with obesity (Wolf & Colditz, 1998) and an additional $183 billion for heart disease, cancer, diabetes, and arthritis (USDHHS, 2002), exercise interventions must be a priority. But there is also a price to pay for becoming a healthier active society. It is the rare physical activity or sport that does not carry some risk of injury, either an acute traumatic injury or overuse injury. Each sport has its unique injury profile, and each sport has a so-called “Achilles Heel”: the pitcher’s and tennis player’s strained shoulder or elbow, the runner’s overuse tendinitis, the soccer player’s ankle sprains, and the football player’s concussion. Fortunately, most sport injuries are not career ending; however, some carry a significant morbidity such as future knee osteoarthritis after meniscal injury or neuropsychological impairment following recurrent concussions. The medical cost associated with treating these injuries has risen dramatically in recent years and has also resulted in time lost from school in our youth and work in adults, further burdening society and the health care system (Conn et al., 2003).

The U.S. Consumer Product Safety Commission and the Centers for Disease Control and Prevention (2000) reported that sports-related injuries land 2.6 million young people in emergency rooms each year. The top 10 sports reasons (and number of cases) for emergency room visits for the 5- to 14-year-old group were bicycles (336,250), basketball (193,400), football (185,740), baseball/softball (117,250), soccer (85,430), trampolines (70,870), skateboards (49,930), in-line skating (57,760), ice skating (54,160), and exercise without equipment (21,630). Unfortunately, these statistics were reported as absolute number of hospital visits, rather than as injury rates or incidences. Regardless, these statistics illustrate the vast number of injuries that occur across many activities in organized and recreational sports.

**Sports Medicine and Athletic Training Researchers Answering the Call**

Since sport has become more of a fixture in the lives of young Americans, the burden of responsibility has fallen on the shoulders of the various sporting organizations, coaches, parents, clinicians, officials, and researchers to help provide an environment that minimizes the risk of injury in all sports (Marshall & Guskiewicz, 2003). Preparing researchers for addressing these important issues has been an evolving, but slow, process. The first master’s graduate program in athletic training was
approved in 1972, with the requirement that research be a component of the program of study. It wasn’t until the early 1980s that doctoral programs with an emphasis in athletic training and sports medicine research were established; 25 years later there are still fewer than 10 doctoral programs with this focus. As a result, athletic training has a shortage of terminal degree research faculty compared with other subdisciplines in kinesiology, but progress is being made.

So, with plenty of good research questions being asked every day and the potential to contribute to a healthier physically active society, some athletic trainers have begun pursuing doctoral degrees in more-traditional subdisciplines such as biomechanics, exercise physiology, motor control, and epidemiology. Interdisciplinary doctoral programs, such as those with an emphasis on “human movement science,” have also afforded athletic trainers the opportunity to study alongside a variety of clinicians and scientists to address research questions from different perspectives. This later route to the doctoral degree has become especially popular given the National Institutes of Health (NIH) roadmap for interdisciplinary research. Currently there are more doctoral-trained athletic trainers entering the workforce than at any prior period. In time, the increased opportunities will certainly help in meeting the aforementioned responsibilities but only if doctoral-trained faculty are hired into research positions and positioned to succeed as researchers.

As mentioned by Perrin (2007, p. 120–121), “The proliferation of athletic training education programs has outpaced the preparation and professional development of doctoral trained athletic training faculty.” Unfortunately, as Perrin points out, many of our new doctoral-trained athletic training faculty are being employed as athletic training education program directors rather than researchers. The administrative demands of directing a program, combined with the requirements for promotion and tenure, can place young faculty members into a very tenuous situation. Furthermore, the hiring of newly trained athletic training researchers into positions that prohibit them from focusing on research does little to advance our scientific understanding of best-practice methods for preventing and managing sport-related injuries. Academic administrators and department heads in kinesiology and exercise science departments must recognize the significant impact these well-trained athletic training researchers can make.

Professional Organizations and Funding Agencies Answering the Call

Organizations such as the American College of Sports Medicine (ACSM), National Athletic Trainers’ Association (NATA), National Collegiate Athletic Association (NCAA), and National Football League Players Association (NFLPA) have more recently secured significant funding to address important research questions related to sport-injury prevention and management. Several athletic training researchers, along with sports epidemiologists, have made a difference in helping to promote a healthier and safer sporting environment. Since 1991, The National Athletic Trainers’ Association’s Research and Education Foundation (NATA-REF) has funded over 170 faculty and student research grants totaling nearly $2.5 million (http://www.natafoundation.org) in an effort to answer clinically relevant questions for the sports medicine community.
The goals of the NATA-REF include advancing the knowledge base of the athletic training profession and encouraging research among athletic trainers who can contribute to the athletic training knowledge base. By identifying research priorities, the NATA-REF promotes research topics that achieve these goals and provide evidence for the effectiveness of services provided by certified athletic trainers. Much of the foundation’s work this decade has focused on knee pathology and the athlete’s predisposition to ACL injury, especially the female athlete (Appendix A). The management and rehabilitation of chronic ankle instability and the inherent risk for developing osteoarthritis later in life has also become an area of great interest among athletic training researchers (Appendix A). In addition, significant funding has been provided for investigation of potentially catastrophic injuries and illnesses such as sport concussion and heat illness (Appendix B). Other important areas of research include disordered eating and amenorrhea, cardiovascular illness risk factors, and sport-specific injury risk factors (Appendix C).

As a result of much of the recent research conducted by athletic trainers and their research colleagues, the NATA has published research-based position statements for best-management practices on several topics such as fluid replacement for athletes (Casa et al., 2000), exertional heat illnesses (Binkley, Beckett, Casa, Kleiner, & Plummer, 2002), sport-related concussion (Guskiewicz et al., 2004), head-down contact and spearing in football (Heck, Clarke, Peterson, Torg, & Weis, 2004), and management of asthma in athletes (Miller, Weiler, Baker, Collins, & D’Alonzo, 2005). The purpose of these position statements is to provide the sports medicine community, including certified athletic trainers, team physicians, and family physicians, with clinical recommendations based on the latest research findings. The goal is that these position statements will help bridge the gap between research and clinical practice and help to reduce the incidence of these potentially catastrophic injuries.

Because of the increased awareness regarding the various injuries sustained in sport and the public health implications, more federal funding has become available for sport and recreational injuries. The NIH and CDC have funded several projects in recent years related to biomechanics of ACL injury and evaluation and biomechanics of sport-related concussion.

Concussion Research As an Example

We might take a brief look at one of these areas, sport-related concussion, and the manner in which it has evolved into a science of its own—a science in which clinicians and researchers have worked closely together to study what has sometimes been labeled a “hidden epidemic.” Concussion is common within organized sports such as football, soccer, rugby, wrestling, and lacrosse; likewise, they can occur while skateboarding in the driveway or bouncing on the trampoline in the back yard. Approximately 15 years ago, the subjective nature in which concussions were being evaluated and managed began raising concerns among the medical community. Fortunately, the response from the research community has influenced clinical management for concussion. Since 2007, the medical literature has published more refereed papers on sport-related concussion than were published in the previous four decades combined (Figure 1). Although not as drastic, we have witnessed similar trends in the literature on ACL injury, osteoarthritis, and heat illness.
An important step in this evolving line of concussion research was to first gain a better understanding of the causes and predispositions to this potentially disabling and catastrophic injury. The anecdotally observed increased risk for repeat concussions after an initial concussion has been studied prospectively and confirmed in recent years (Guskiewicz et al., 2003; Zemper, 2003; Schulz et al., 2004), further emphasizing the need for accurate and empirically based return to play (RTP) decisions, especially in younger athletes. Cooperation from clinical athletic trainers was necessary to accomplish this, and fortunately certified athletic trainers, who on average care for 7 concussive injuries per year, have participated in prospective studies such as the NCAA Concussion Study. The NCAA Concussion Study resulted in identifying sensitive and objective assessment tools such as a graded symptom checklist, the Standardized Assessment of Concussion, and the Balance Error Scoring System for concussion management (McCrea et al., 2003; Guskiewicz et al., 2003). These and several other interdisciplinary studies involving athletic trainers, neuropsychologists, and related medical specialists have forced clinicians to rethink how they manage sport-related concussion.

Advanced technologies and collaborations with biomechanists and neuroradiologists are now taking this work a step further by investigating the relationship between biomechanical, neuroanatomical, and clinical factors associated with sport-related concussion. Symptoms, neuropsychological function, and postural stability measured at selected postinjury points are each being correlated to neuroanatomical measures taken with susceptibility weighted imaging and diffusion tensor imaging, as well as to linear and rotational acceleration of the head at impact. This research is funded by the CDC and uses the Head Impact Telemetry System. This system uses spring-loaded accelerometers placed in the helmets of football players to

Figure 1 — Number of refereed publications on “Sport-Related Concussion” across the decades. (PubMed Central, 2007).
measure the magnitude and location of impacts to the head. The preliminary results have begun to shed light on establishing a threshold for concussive brain injury and assist researchers and clinicians in understanding how mechanisms of injury are associated with clinical outcomes (Guskiewicz, Mihalik, et al., 2007; McCaffrey, Mihalik, Crowell, Shields, & Guskiewicz, 2007; Mihalik, Bell, Marshall, & Guskiewicz, 2007). The results will hopefully assist in the development of safer return to play guidelines, while subsequently preventing the complications associated with repeated sport-related concussion.

Finally, recurrent concussions to several high-profile athletes, some of whom were forced into retirement, have increased awareness among sports medicine personnel and the general public about the long-term effects of concussion. Our research group at the Center for the Study of Retired Athletes at the University of North Carolina–Chapel Hill embarked on a project investigating the long-term consequences of recurrent concussions in retired professional football players. Two recent publications identified an elevated risk for cognitive impairment (Guskiewicz et al., 2005) and clinical depression (Guskiewicz, Marshall, et al., 2007) among these football players with a history of three or more concussions during their professional playing career. These findings will hopefully improve the management of concussive injury to athletes of all ages across several sports and activities.

Conclusions

So how do we increase physical activity without increasing risk of injury? Athletic training researchers must develop lines of research that will help advance the body of knowledge on (a) identifying predispositions to sport and recreational injuries of all types and for athletes of all ages, with special attention being given to those injuries and illnesses that are potentially catastrophic or debilitating in a chronic state; (b) improving assessment and treatment techniques to allow safe return to activity with minimal risk of reinjury; and (c) keeping people physically active and recognizing that “exercise is medicine.” Human movement scientists, especially athletic training researchers, bear the responsibility of finding answers to these important questions. Academic administrators bear the responsibility of supporting the research faculty to conduct this important work.

References


**Appendix A**

Musculoskeletal research funded by the NATA Research and Education Foundation (2000–2007) for athletic training faculty and student initiated grants:

**Ankle**
- “Neuromuscular Inhibition of the Dynamic Ankle Stabilizers in Patients With Functional Ankle Instability” (faculty)
- “The Effects of Prolonged Prophylactic Ankle Brace Use in High School Basketball Athletes on Dynamic Posture Control” (student)
- “The Effect of a 4-Week Balance Training Program on Postural Control and Gait Performance in Those With Chronic Ankle Instability” (student)
- “The Effect of Ankle Bracing on Lower Extremity Kinetics, Kinematics, and Muscle Pre-Activation Amplitude” (student)

**Knee**
- “Muscle Performance and Functional Outcome After ACL Injury” (faculty)
- “The Effects of Estrogen on Motorneuron Activity and Knee Joint Laxity” (faculty)
- “The Effects of Knee Joint Effusion and Cryotherapy on Lower Chain Function” (faculty)
- “Gender, Structure, and Activity: Variables Affecting Knee Kinematics” (student)
- “Effects of Patellar Taping and Patellofemoral Pain Syndrome on Joint Kinematics and Dynamic Postural Control” (student)
- “Predictors of Functional Outcome Following Anterior Cruciate Ligament Reconstruction” (student)

**Shoulder**
- “The Effect of Shoulder Plyometric Training on Muscle Activation Strategies and Kinematics” (faculty)
- “The Effects of Neuromuscular Control Exercises on Functional Stability in Unstable Shoulders” (faculty)
- “Acute and Chronic Adaptations in the Throwing Shoulder of Professional Baseball Players With Implications Concerning Injury” (faculty)
- “Three-Dimensional Joint Position Sense on Shoulder Instability” (student)
- “Comparison of Shoulder and Elbow Joint Position Sense Using a Vibration Stimulus” (student)
Appendix B

Sport-related concussion and heat-related illness research funded by the NATA Research and Education Foundation (2000–2007) for athletic training faculty and student initiated grants:

**Concussion**
- “Motor Evoked Potential Differences Between Concussed and Non-Concussed Athletes As Determined by Transcranial Magnetic Stimulation” (student)
- “Postural Sway and Neuropsychological Performance Following an Acute Bout of Soccer Heading” (student)
- “An Assessment of High School Coaches’ Knowledge of Sport-Related Concussion” (student)
- “Does Dehydration Predispose Athletes to Signs and Symptoms, Neuropsychological Deficits, and Postural Stability Deficits Often Associated With Concussion” (student)
- “Gender Differences and Neuropsychological Impairments in Collegiate Athletes” (student)

**Heat Illness**
- “Influence of Creatine Use on Exercise Heat Tolerance in Dehydrated Athletes” (faculty)
- “Middle and High School Athletic Coaches’ Knowledge of Prevention, Recognition and Treatment of Heat Illness” (student)
- “The Effects of Hypohydration, Hyperthermia and Electrolyte Depletion on Exercise Associated Muscle Cramps” (student)
- “Examining Heat Acclimatization in High School Football Players” (student)

Appendix C

General sports medicine research funded by the NATA Research and Education Foundation (2000–2007) for athletic training faculty and student initiated grants:

- “Reversing Energy Deficiency in Amenorrheic Athletes: Effects on Bone Turnover and Physical Performance” (faculty)
- “On-Line Surveillance of High School Sports Injuries” (faculty)
- “The Accuracy of Screening Echocardiography in Detecting Hypertrophic Cardiomyopathy in the Pre-Participation Athletic Physical” (faculty)
• “Predictors of Stress Fracture in Active Female Adolescents” (faculty)
• “High School Sports Injury Patterns Among Girls: Trends and Risk Factors” (faculty)
• “An Epidemiological Investigation of the Female Athlete Triad Among Female High School Athletes” (faculty)
• “The Contribution of Socioeconomic Status and Maturity to Injury Risk in Youth Soccer” (student)
• “Prevalence of Disordered Eating, Menstrual Dysfunction and Musculoskeletal Injury in Female High School Athletes” (student)
• “The Effects of Phantom Tissue Samples on Therapeutic Ultrasound Beam Profiles” (student)
• “The Effects of Ultrasound Delivery Method and Energy Transfer on Skeletal Muscle Regeneration” (student)
• “Electrical Stimulating Currents and the Effects on Serum Beta-Endorphin, Serum, Cortisol, and Pain Perception in Experimentally Induced DOMS” (student)