Pediatric Neurology 70 (2017) 44–49

Contents lists available at ScienceDirect

Pediatric Neurology

journal homepage: www.elsevier.com/locate/pnu

Original Article

Gender Differences in Concussion and Postinjury Cognitive Findings in an Older and Younger Pediatric Population

Sarah Tanveer BS, Nassim Zecavati MD, MPH, Elizabeth Bronson Delasobera MD, Temitayo Oyefunmike Oyegbile MD, PhD *

ABSTRACT

BACKGROUND: Studies have documented gender differences associated with concussion. The purpose of this study was to determine if these gender differences are also noted within a pediatric population. **METHODS:** This prospective study analyzed 1971 patients who had completed preconcussion and postconcussion neuropsychological testing within the Washington, DC, area. **RESULTS:** Our results showed that children and adolescents with concussion exhibit gender differences with respect to risk factors, recovery, and symptomatology. Females are more likely to present with a concussion ($P < 0.001$), experience more discomfort from a concussion ($P < 0.001$), and seek treatment for postconcussive headaches ($P < 0.001$). On the other hand, males are more likely to sustain a concussion from a contact sport ($P < 0.001$) and experience loss of consciousness, confusion, and amnesia with a concussion more frequently than females ($P < 0.001$). Postconcussive cognitive function also differs by gender. Both males and females exhibit a decline in cognitive testing compared with baseline ($P < 0.001$); however, visual memory ($P = 0.02$) is more affected in females than in males. These findings remain unchanged among pediatric patients aged ≥14 years; however, no gender differences were noted in individuals aged ≤13 years. **CONCLUSION:** It is important for health care providers, schools, athletic trainers, and coaches to be aware of these gender differences associated with concussion in order to provide adequate surveillance and appropriate monitoring and support during the recovery period.

Keywords: gender, concussion, cognitive testing, pediatric

Pediatr Neurol 2017; 70: 44-49

Introduction

Of the millions of youths who participate in sports yearly within the United States, approximately two million children and adolescents sustain concussions, accounting for over 160,000 emergency room visits and hospitalizations annually.[1-5] Female enrollment in sports has steadily increased over the past ten years.[6,7] Furthermore, females sustain concussions as do males and for any given sport, females may actually be more likely to sustain a concussion than males.[6,7,10,13] There may also be notable gender differences in symptoms of concussions,[9,13,17,19,21,23,24] specifically in postconcussive headaches and cognitive function, which suggests that there may conceivably be gender differences in treatment and recovery times as well.

The current guidelines for diagnosis and treatment of concussion do not differ between males and females in spite of the evidence that there may be clinically significant gender differences. This lack of difference is likely due to limited documentation available on gender differences in concussion. A clear characterization of these gender differences in concussion is imperative to assist with tailoring accurate and adequate concussion diagnosis and treatment to each individual.

Most of the evidence available on gender differences in concussion relies on the findings primarily gathered from an older adolescent population who are mostly high school or college athletes. Gender differences in a younger population of children and young adolescents have not been well established yet, as older adolescents are more often involved

The authors have no affiliations with or financial interest in any testing instruments discussed in this manuscript.

Article History:
Received August 2, 2016; Accepted in final form February 2, 2017

* Communications should be addressed to: Dr. Oyegbile; Pediatric Neurology; Sleep Medicine & Epilepsy; MedStar Georgetown University Hospital; 4200 Wisconsin Ave NW; Washington, DC 20016.
E-mail address: Temitayo.O.Oyegbile@gunet.georgetown.edu

0887-8994/$ – see front matter © 2017 Elsevier Inc. All rights reserved.
http://dx.doi.org/10.1016/j.pediatrneurol.2017.02.001

in organized sports compared with younger children. Furthermore, within the limited literature addressing gender differences in postconcussive symptoms, few have addressed neuropsychological outcomes following a concussion in females compared with males.[9,20,21] Addressing these gaps in the literature is necessary to fully characterize the gender differences in concussion.

The objectives of this study were twofold. First, we aimed to assess for gender differences in the incidence of concussion, postconcussive symptoms, and cognitive function in a pediatric population. Second, we aimed to characterize the effect of age on these gender differences in postconcussive symptoms and cognitive function.

We evaluated males and females of school age ranging from elementary school to college years within the Washington, DC, area before and after sustaining a concussion. Within the Washington, DC, area, many schools require baseline concussion testing with sports clearance by a physician or athletic trainer before the start of the sports season and require individuals to return to the clinic for evaluation and clearance after sustaining a concussion. In this prospective study, our patients were seen within the MedStar Georgetown University Hospital system in the pediatric and sports medicine clinics and completed the concussion evaluation. The testing includes a comprehensive neurocognitive battery in addition to an assessment on postconcussive symptoms. Within our unique model, these patients serve as their own healthy controls. These data have been collected prospectively over the past six years, resulting in a database of almost 2000 patients.

Methods

Study setting and design

Pediatric patients were seen for preconcussion evaluations in the MedStar Georgetown University Hospital from January 2010 to May 2016. When patients returned with a possible concussion, the concussion was diagnosed by one of the five physicians who were either sports medicine specialists or pediatric neurologists in the outpatient sports medicine and/or pediatric neurology concussion clinic at the MedStar Georgetown University Hospital. These patients underwent clinical reevaluation and repeat concussion testing following the diagnosis of a sports-related concussion. A total of 1971 concussion evaluation sessions were included in the study, 1276 preconcussion sessions and 695 postconcussion sessions. This study was approved by the Georgetown University Institutional Review Board (IRB ID# 2015-0807).

Participants

Patients ranged in age from ten to 20 years at the time of the initial cognitive testing, and they completed the subsequent cognitive testing at the clinic within one day to four weeks after injury. Most (~87%) of the patients were seen within three days of injury. The patient data consisted primarily of middle school, high school, and college-aged patients who had participated in multiple sports (Table 1). Patients were assigned randomized subject ID numbers to protect their identifying information in compliance with the institutional review board requirements.

Data collection

Preconcussion and postconcussion symptoms were assessed through clinical examination and a neuropsychological battery test: Immediate Postconcussion Assessment and Cognitive Assessment (ImPACT). This is a computer-based test that assesses an individual's cognitive function and cumulatively documents current concussion symptoms measured by the Post-Concussion Symptoms Scale. The test was administered via a web-enabled desktop computer and with the assistance of a clinical nurse, medical assistant, or resident or fellow who has undergone test administration training.

TABLE 1.
Breakdown of Sports Activities Associated With Individuals With Concussion

Sport	Total (%)	Males (%)	Females
Football	**118 (28)**	**118 (49.2)**	
Lacrosse	86 (20.4)	51 (21.3)	35 (19.3)
Soccer	44 (10.5)	20 (8.3)	24 (13.3)
Cheerleading	39 (9.3)		**39 (21.5)**
Field hockey	29 (6.9)		29 (16.0)
Basketball	28 (6.7)	11 (4.6)	17 (9.4)
Rugby	18 (4.3)	16 (6.7)	2 (1.1)
Volleyball	17 (4.0)		17 (9.4)
Baseball	11 (2.6)	11 (4.6)	
Softball	10 (2.4)		10 (5.5)
Ice hockey	9 (2.1)	9 (3.8)	
Diving	4 (0.6)		4 (2.2)
Swimming	2 (0.5)		2 (1.1)
Track and field	1 (0.2)		1 (0.6)
Martial arts	1 (0.2)	1 (0.4)	
Wrestling	1 (0.2)	1 (0.4)	
Rowing	1 (0.2)	1 (0.4)	
Road biking	1 (0.2)	1 (0.4)	
Boxing	1 (0.2)		1 (0.6)
No sport	274	122	152
Total	695	362	333

Highest rates are indicated in bold.

This test is a neuropsychological screening test that helps health care providers oversee the recovery progress in injured individuals within a clinical setting. The neurocognitive assessment consists of a demographic questionnaire, concussion symptom inventory, and a neurocognitive performance test. The data obtained from the neurocognitive component examined variables such as reaction time, processing speed, verbal memory, visual memory, and total symptoms score.[11]

Briefly, the testing has been shown to be specific and sensitive, as well as reliable and valid.[11-14] The reliability, validity, and testing instructions have been rigorously studied. Furthermore, this testing shows construct validity,[14] indicating that the test battery is an accurate and reliable measure of neurocognitive performance.

Six neuropsychological test modules measuring the cognitive domains of attention, memory, reaction time, and processing speed are administered via computer testing. The testing takes less than 25 minutes. Final scores from each of the modules are presented in four composite cognitive domains: verbal memory, visual memory, processing speed, and reaction time. In addition, this test provides an "Impulse Control" composite score that screens for invalidity by measuring the number of errors committed during the testing. Higher scores on verbal and visual memory and motor processing speed indicate a better performance. Verbal and visual memory scores are presented as a percentage. Motor processing speed is presented as a composite score. A lower score on reaction time indicates a better performance. All reaction time scores are presented in seconds.

In addition to the cognitive testing, the software uses a 22-item scale, the Post-Concussion Symptom Scale, which is used to test the severity of concussion symptoms. Patients rate their current symptom severity on a seven-point Likert scale, whereby 0 is asymptomatic and 7 is the most severe. All 22 items are then summed to produce the total symptom score evaluating headache, nausea, vomiting, balance problems, dizziness, fatigue, trouble falling asleep, sleeping more than usual, sleeping less than usual, drowsiness, sensitivity to light, sensitivity to noise, irritability, sadness, nervousness, feeling more emotional, numbness or tingling, feeling slowed down, feeling mentally foggy, difficulty concentrating, difficulty remembering, and visual problems.