ABSTRACT

A PRELIMINARY EXAMINATION OF CONCUSSION RECOVERY PATTERNS IN COLLEGIATE VARSITY AND CLUB SPORT ATHLETES

by Angela Marie Musille

Introduction: Collegiate varsity and club sport athletics differ in funding, services and personnel to manage concussions. The study’s purpose was to determine if variations in concussion recovery patterns existed between varsity and club sports. Methods: Preliminary retrospective records review was conducted of Immediate Post Concussion Assessment and Cognitive Testing (ImPACT®) and Post-Concussion Rating Scale (PCRS) among varsity and club athletes with concussions, 99 athletes met inclusion criteria. Stepwise regression model was utilized to analyze data. Results: No significant difference in recovery time between varsity and club sport athletes. The study revealed males return to baseline quicker than females (p=0.0116) and athletes with history of concussion have a longer recovery time (p=0.0932). Discussion: Findings applied with caution secondary to limited club athletes that met inclusion criteria due to challenges with student-lead organizations. Further examination of concussion management protocols and education programs that supports the unique needs of club sports is warranted.
A PRELIMINARY EXAMINATION OF CONCUSSION RECOVERY PATTERNS IN COLLEGIATE VARSITY AND CLUB SPORT ATHLETES

Thesis

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Recent figures estimate that approximately 3.8 million cases of sport and recreation related traumatic brain injuries occur each year in the United States (Harmon et al., 2013). As athletes, coaches and health professionals become more aware of the signs and symptoms of concussion, studies have revealed a higher incidence of sport-related head injuries (Guskiewicz & Teel, 2015). Even with this heightened awareness, approximately 50% of concussions go unreported (Harmon et al., 2013). Various external or self-imposed pressures unique to the individual can influence an athlete’s willingness to reveal possible injury (Kroshus, Garnett, Hawrilenko, Baugh & Calzo, 2015). Therefore, heightened monitoring of the athlete by medical and athletic support personnel has become necessary (Harmon et al., 2013). To further facilitate this effort, the National Collegiate Athletic Association (NCAA) in August 2010 required all collegiate varsity athletic programs to have a protocol in place to facilitate the prompt identification and management of sport-related concussions (NCAA Division I Manual, 2015-2016). Because of these efforts, many varsity athletes now receive education, injury prevention conditioning, baseline and post-concussion assessment, management and academic support pre and post-injury as part of their athletic program. While these gains in concussion management are promising, many non-varsity club-sport athletes do not participate in established programs that provide these services, hence increasing the reliance on the athlete to self-monitor and manage sport-related concussions.

Nature of Concussions

A sport-related concussion or mild traumatic brain injury (MTBI) is a pathophysiological process where biomechanical forces affect the brain (Jotwani & Harmon, 2010). Neurologic changes and symptoms experienced following a concussion can vary in degree and extent based on the severity of the impact and an individual’s pre-injury history (e.g., gender, number of previous concussions, history of learning disability) (Dashnaw, Patraglia & Bailes, 2012; Hanson, Stracciolini, Mannix & Meehan, 2014; Harmon et al., 2013). Hence, collegiate athletes can exhibit neurocognitive, behavioral, emotional, and physical changes post-injury which can negatively influence social, occupational, athletic and academic performance levels (Covassin, Stearne, & Elbin, 2008; Guskiewicz et al., 2003; Harmon et al., 2013; Jotwani & Harmon, 2010; Knollman Porter, Constantinidou, & Hutchinson-Marron, 2014). While some of these symptoms can be directly observable on the sidelines (e.g., balance difficulties), many of the more common
symptoms associated with concussion can only be known if revealed by the athlete (e.g. headache) or evaluated further through formal neurocognitive testing.

**Underreporting concussion symptoms.** In a recent study, 45% of athletes surveyed did not self-report their concussion-like symptoms to support personnel due to a variety of internal and external factors (Davies & Bird, 2015). Influencing internal factors can include a personal drive to perform at peak levels and an unwillingness to leave a game or practice for fear of letting teammates down (Guilmette, Malia & McQuiggan, 2007; Kroshus, Garnett, Hawrilenko, Baugh & Calzo, 2015). In addition, one in four athletes have received external pressures from teammates, coaches, parents and/or fans to play with a head injury (Kroshus et al., 2015). While some athletes may intentionally under report post-concussion symptoms; lack of knowledge or underestimating the seriousness of the injury can also play a factor (Kroshus et al., 2015). More specifically, research has revealed that 64% of people who failed to report their suspected injury did so because they did not believe their symptoms were severe enough to signify a concussion (Davies & Bird, 2015). These factors alone and combined suggest that athletes are not consistently reliable in accurately reporting concussion-like symptoms, possibly making them at risk for repeated and more significant injury (Davies & Bird, 2015; Kroshus et al., 2015).

**Cumulative effects of concussions.** Returning to high-impact activity before post-concussion symptoms have resolved leaves an athlete at risk for more severe symptoms and a longer recovery period (Cobb & Battin, 2004; Harmon et al., 2013). In addition, recent research findings suggest that sustaining repeated mild head injuries could result in Chronic Traumatic Encephalopathy (CTE), a neurodegenerative disease causing cognitive and mood changes including memory problems and depression (Alberts & Linder, 2015). Hence, using a systematic way to identify and treat concussions may prevent long-term implications of concussions in the future (Harmon et al., 2013; Guskiewicz & Teel, 2015).

**A Comparison: Varsity versus Club Sports**

Post-concussion identification and management is a complex multi-faceted process which is further confounded by the variety of neurobehavioral and neurocognitive symptoms that are internally experience by the athlete or externally observable by support personnel. Because of this, collegiate varsity athletic programs rely on support personnel to quickly and efficient identify and manage sport related concussions (Harmon et al., 2013; Jotwani & Harmon, 2010).
While both varsity and club sport organizations compete at the collegiate level, the management and support provided to these two athletic programs differ (Berg, 1993).

**Varsity athletics.** Around 460,000 athletes participate in collegiate varsity sport teams across the nation (“What is the NCAA”, n.d.). Universities alone spend an average of 28.8 million to 81.7 million dollars per year to support these athletic programs and are required to adhere to guidelines established by the NCAA (“Growth in Division I Athletics Expenses Outpaces Revenue Increases”, 2014; “Rise of College Teams Creates a Whole New Level of Success”, 2008; NCAA Division I Manual, 2015-2016). The NCAA governing body requires that all university varsity athletic programs develop, implement, and make public a concussion management protocol, which includes but is not limited to the following criteria:

1. **Education:** Institutions are required to furnish athletes, coaches, team physicians, athletic trainers and athletic directors with concussion educational materials and the management protocol developed by the university. All participants must sign, acknowledging an understanding of the information provided and a willingness to report concussion-like symptoms when they occur.

2. **Pre-participation assessment:** All athletes must complete a one-time pre-participation assessment, which includes a brain injury history, symptom evaluation, cognitive assessment and balance evaluation.

3. **Recognition and diagnosis of concussion:** All student athletes experiencing symptoms associated with a concussion must be removed from play and referred for concussion management. If diagnosed, the athlete cannot return to play for the remainder of the day.

4. **Post-concussion management:** Initial post-injury management should include individual serial assessment that occur at the time of the injury with oral and written instruction for care given to the athlete and a responsible adult who should continue to monitor and supervise the athlete during the acute phase of recovery. No athlete can return to play without prior clearance from a physician or the physician’s designee (NCAA Division I Manual, 2015-2016).

In addition to these requirements, coaches and athletic trainers are also present during all varsity practices and games with training provided to recognize potential signs and symptoms of concussions even when not directly reported by the athlete. It is the goal of this mandated
program to improve the safe and efficient management of post-concussion symptoms among athletes hence; reducing the risk of repeated or more significant injuries.

**Club sport athletics.** In comparison, approximately 2 million student athletes participate in club sports per year. The funds dedicated to support these programs can vary based on the university and the specific athletic organization ("Rise of College Teams Creates a Whole New Level of Success", 2008). In addition, club sport organizations are often managed by individual university based recreations departments with no national organization mandating specific concussion protocols or guidelines. Therefore, the educational and pre- and post-injury services available to the club athlete can vary. For example, club sport athletes may not be required to participate in educational programs on the signs or symptoms of concussion or participate in baseline or post-injury neurocognitive assessment even though many participate in high-impact sport activities (e.g., football and rugby). In addition, club sport teams are student lead organizations and therefore are not required to have coaches or medical support personnel trained in the identification of concussion present during practices (Berg, 1993). In recent years, various states in the United States have implemented bills which mandate that an athlete receive an evaluation by a health care professional prior to returning to play if suspected of experiencing a concussion ("Ohio’s Concussion Law", n.d.). However, this legislation can only be applied to athletes 19 years of age or younger. Therefore, many college club sport athletes are not required to complete post-injury testing even if recommended by student peers or coaches leaving them at greater risk for repeated injury.

**Purpose**

The educational, financial, medical and pre- and post-injury management supports available to collegiate varsity and club sport athletes differs greatly in the number and type of services provided (Berg, 1993). Therefore, one may question if these variations in management influence the post-concussion recovery patterns between varsity and club sport athletes. While this research is currently lacking, results may lead to development or re-examination of pre- and post-injury protocols required to best manage the impact of concussion on all athletes. Therefore, the purpose of his preliminary study was to determine if there is any difference in neurocognitive and neurobehavioral recovery patterns between club and varsity athletes post-concussion.
Methods

Research Design

The authors implemented a retrospective chart review of sports-related concussion cases from a mid-western university based concussion management program. Concussive injuries and associated neurocognitive testing sessions took place during an eight-year period (from July 2007 through October 2015). The lead author reviewed neurocognitive testing reports. The lead author and the second author determined whether student-athletes fulfilled study inclusion criteria.

Participants

All of the charts of student-athletes, who agreed to participate in the study, from a mid-western university based concussion management program were initially reviewed for inclusion in the study. Of these charts, the neurobehavioral symptoms reported or the neurocognitive testing results revealed that 121 athletes exhibited signs of a possible concussion. The following inclusion criteria were then applied for further chart review: (a) being a collegiate varsity or club sport athlete, (b) completing both baseline and post-injury neurocognitive testing and neurobehavioral symptom rating via The Immediate Post Concussion and Cognitive Test (ImPACT®) [Lovell et al., 2002] and the Post-Concussion Rating Scale (PCRS), modified by Lovell and Collins (1998) and (c) incurring a sport-related concussion which resulted in acute symptoms and one or more clinically significant decrease in neurocognitive performance during the initial post-injury test session. In addition, athletes were excluded from the study if they sustained a non-sport related concussion (e.g. motor vehicle accident) or had a history of learning disabilities. Of the charts reviewed, 5 student athletes exhibited a history of a learning disability, 3 incurred a non-sport related concussion, and 10 club sport athletes did not have baseline neurocognitive testing completed prior to the suspected concussion and therefore were excluded from the study. All varsity athletes completed the baseline and post-concussion protocol while only 47% (9/19) of club sport athletes (males and females) completed the baseline concussion testing.

Following review, 99 student athlete charts met all inclusion criterial and were included in the study. Of these student-athletes, 90 participated in varsity and 9 participated in club sport program. Sports represented included football, soccer, field hockey, ice hockey, basketball,
softball, diving, baseball, rugby, ice-skating, boxing, softball, water skiing and track. The average age of all participants was 19.4 years (SD=1.21) with a range of ages from 18-24 years. More specifically, 54 males and 36 female varsity athletes were included in the study with a mean age of 19.5 years (SD=1.24). In contrast, there were 3 males and 6 females representing club sports with a mean age of 19.2 years (SD=1.20).

**Measures**

**Neurocognitive testing.** Testing materials used to assess baseline and neurocognitive performance included the Immediate Post Concussion and Cognitive Test (ImPACT®) (Lovell et al., 2002). The ImPACT® test contains three general sections used to obtain information about an athlete’s medical history, baseline and post-injury symptoms, and neurocognitive performance. More specifically, information obtained from the demographic section includes the occurrence rate and nature of previously experienced concussions, medication use, academic and medical history. In addition, there are seven neurocognitive tests, which target various aspects of cognitive functioning including attention, memory, processing speed, and reaction time. Five separate composite scores obtained from these seven tests include the following: Verbal Memory, Visual Memory, Visuomotor Processing Speed, and Reaction Time and Impulse Control (Majerske et al., 2008).

**Neurobehavioral symptom rating.** All athletes also completed baseline and post injury symptoms rating via the Post-Concussion Rating Scale (PCRS), modified by Lovell and Collins (1998) from an original scale by Rosenthal and Mayer (1998). The PCRS provides a standardized procedure to organize a player’s subjective symptoms after concussion. The PCRS utilizes common terms to describe symptoms rather than medical terminology (e.g. sensitivity to light rather than photophobia) (Schatz et al., 2006). The rating scale used consists of 21 symptoms associated with concussion. Athletes rated their symptoms using a 7-point likert scale with possible scores from 0 (i.e. symptom not present) to 6 (i.e. symptom is severe).

**Procedure**

**Varsity athletes.** Prior to the start of every athletic season, the team physician and Certified Athletic Trainer (ATC) completed medical physicals on all varsity athletes. In addition, athletes could not participate in practices or games until the administration of neurocognitive and neurobehavioral baseline testing. ATC assigned throughout the season to a specified sport (e.g., field hockey) monitored varsity athletes during practices and games. If a
suspected concussion occurred, referrals for post-injury neurocognitive and neurobehavioral testing were made to the concussion management program within 24 to 48 hours. The ATC relayed details regarding the athlete’s injury. This information included but was not limited to the: (1) date and time of the injury; (2) location of the injury (e.g. head to knee hit to the left frontal region); (3) progression of post-concussive symptoms immediately post-injury and during subsequent medical checks (e.g. loss of consciousness, confusion, amnesia, denial of injury); and (4) prescribed medications to alleviate symptoms (e.g. acetaminophen for headache). The assessment team used this information to determine consistencies/inconsistencies between the ATC report and the athlete concerning the events and symptoms post-injury.

Club sport athletes: Prior to the start of the athletic season, the Director of Club Sports provided all club athletes and team captains with information on concussions and an optional baseline neurocognitive and neurobehavioral testing protocol being offered at no charge to the student. Participation in the testing program was purely voluntary with no direct consequences from the team for not participating. In addition, during all practices and games, club athletes were personally responsible to report and to remove themselves from play if they experienced any possible concussion-like symptoms. ATCs were not present at practices or games. Therefore, if an athlete suspected that they had sustained a concussion, they were expected but not required to self-refer themselves for post-injury neurocognitive and neurobehavioral testing.

Baseline testing. All athletes were encouraged to complete baseline testing (i.e., ImPACT© and PCRS) when well rested (e.g., no high impact physical activity four hours prior to testing). Trained graduate students administers all baseline testing while being supervised by a certified Speech Language Pathologist (SLP) who has extensive training and clinical experience in the assessment and treatment of individuals with neurocognitive impairments. All athletes were tested individually in a quiet, distraction free environment. The graduate students monitor the athlete throughout testing and document any signs of test confusion or behaviors that suggest the athlete is purposefully under performing.

Post-injury testing. The testing protocol utilizes the same diagnostic assessments administered during the baseline assessment. The session began by asking the athlete specific questions about the suspected injury, symptoms via the PCRS (e.g. immediately post-injury, 24 hrs. post, and current), and specific questions relating to academic performance. The athlete then completed the ImPACT© computer based assessment. Following testing, the athlete repeated
the PCRS to determine if greater post-concussion symptoms were reported following the diagnostic procedure. The assessment team closely monitors the athlete’s behaviors and responses throughout the testing process to document any inconsistencies in reported symptoms, and observe behavior consistent with mental and emotional fatigue, anxiety, frustration, disorientation, confusion, or failure to comply with testing procedures.

The testing protocol takes less than an hour to complete with the results immediately analyzed after testing by the certified SLP in charge of the program. All information obtained from the testing protocol was considered equally and was compared to the athlete’s individualized baseline performance levels. If scores on any section of the neurocognitive test battery deviated at least 1 SD from the pre-established baseline or if there was report of any concussion-like symptoms the athlete was educated by the SLP regarding test results and was provided individualized recommendations on how to best facilitate the recovery process and compensate for current cognitive limitations.

All athletes completed the same assessments for baseline and post-injury testing regardless of whether they participated in a varsity or club sport. However, both the varsity athlete and the ATC received testing results and recommendations to assist with carryover. In contrast, the club sport athletes receives testing results and recommendations with the information relayed to their personal physician only if the athletes provides signed consent.

**Statistical analysis**

Stepwise regression models were used to select predictor variables that significantly impact the recovery time of athletes post-concussion. Candidate variables were first considered by fitting comprehensive models using all candidate predictors and determining viable model options based upon an adjusted R-squared criterion. The two response variables, number of days until symptom free and back to neurocognitive baseline testing, were log transformed to adjust for the heavy skewness in the data.

In addition, two case studies were selected in order to further illustrate the differences and inherent challenges in the post-concussion management of varsity and club sport athletes. All methods and procedures were reviewed and approved by an institutional review board.
Results

Post-concussion symptom recovery patterns

Post-concussion symptoms (PCRS). Analysis revealed that the average time for varsity and club sport athletes to report no post-concussion like symptoms based on the PCRS was 10.04 days (SD=8.437) and 14.88 days (SD = 12.05) respectively. However, the stepwise regression statistical analysis revealed that there was no significant difference in symptom recovery patterns between these groups (p=0.7937). The level of significance for variables was p=0.1500.

However, further analysis did reveal that gender had a significant impact on the dependent variable, which is the number of days until an athlete is symptom free. More specifically, males are more likely to report no post-concussion like symptoms faster than females in varsity and club sports (p=0.0116). In addition, the more concussions reported by athletes at the time of baseline testing were found to have a marginal impact for the number of days until symptom free (p= 0.0932). See Table 1 for results.

Table I. Dependent variable: Number of days until symptom free

<table>
<thead>
<tr>
<th>Variable</th>
<th>Parameter Estimate</th>
<th>Standard Error</th>
<th>F (df)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sport=Varsity</td>
<td>0.06725</td>
<td>0.25644</td>
<td>0.07 (1, 89)</td>
<td>0.7937</td>
</tr>
<tr>
<td>Gender=male</td>
<td>-0.45134</td>
<td>0.17527</td>
<td>6.63 (1, 89)</td>
<td>0.0116</td>
</tr>
<tr>
<td>Number of Concussions at Baseline</td>
<td>0.15869</td>
<td>0.09357</td>
<td>2.88 (1, 89)</td>
<td>0.0932</td>
</tr>
</tbody>
</table>

Post-concussion neurocognitive performance (ImPACT©). Another dependent variable considered in the statistical analysis was the number of days until neurocognitive testing results on ImPACT© returned to baseline level. Males returned back to baseline neurocognitively faster than female athletes. (p=0.0020). There was no difference in recovery patterns between varsity and club sport athletes. See Table 2 for results.
Table II. Dependent variable: Number of days until return to baseline neurocognitive level

<table>
<thead>
<tr>
<th>Variable</th>
<th>Parameter Estimate</th>
<th>Standard Error</th>
<th>F (df)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sport=Varsity</td>
<td>-0.04197</td>
<td>0.25175</td>
<td>0.03 (1, 89)</td>
<td>0.8679</td>
</tr>
<tr>
<td>Gender=male</td>
<td>-0.56241</td>
<td>0.17697</td>
<td>10.10 (1, 89)</td>
<td>0.0020</td>
</tr>
</tbody>
</table>

Case Studies

Two case studies were selected to illustrate further the potential differences in management and recovery patterns between varsity and club sport athletes. Both cases involve female students with a history of multiple concussions who sustained a potential head-injury while competing in sports at the collegiate level. One athlete was participating on a varsity team while the other was a club sport athlete. These two cases illustrate resolution of post-concussion neurocognitive results with only one athlete exhibiting resolution of neurobehavioral symptoms.

**Case 1 varsity athlete: D.A.** Case 1 is a 19-year-old female collegiate varsity soccer player with a history of two prior concussions occurring in 2007 and 2011. According to the ATC, the athlete received a full body hit, including the face, from an opponent during a soccer game. Following the hit, the athlete fell to the ground with no loss of conscious. D.A. was able to get up and walk off the field independently but was removed from play. Initial symptoms reported immediately following the injury included feeling “out of it” with “fuzzy” vision.

**Post-concussion neurocognitive testing.** The ATC referred the athlete for formal post-concussion testing two days following the injury. The athlete reported the following neurobehavioral symptoms according to the PCRS: headache, dizziness, fatigue, trouble falling asleep, drowsiness, sensitivity to light and noise, irritability, sadness, nervousness, feeling more emotional, feeling slowed down, mentally “foggy” and difficulty concentrating. Neurocognitive testing results completed via ImPACT® indicated more than a two standard deviation change from baseline test results on the Visual Memory Composite score. The neurobehavioral and
neurocognitive results were reviewed with the ATC and the athlete with recommendations that the athlete refrain from physical and cognitively demanding activities. Individualized academic accommodations were implemented with the athlete’s college professors, which involved extended time for exams/projects, quiet, distraction free environment for exams, and extension of assignments. D.A. was encouraged to take extra rest breaks and to avoid noisy social activities. The ATC continued to monitor D.A. and encouraged compliance with post-injury recommendations.

Six days post-injury, neurocognitive and neurobehavioral testing was repeated. D.A. reported reduced symptoms but still experienced a mild headache, fatigue, irritability, sadness, drowsiness, sensitivity to noise, trouble falling asleep, feeling emotional, feeling slowed down, mentally foggy, and difficulty concentrating. Her neurocognitive testing results revealed a continued deviation when compared to baseline testing on Visual Memory Composite scores. Previous recommendations were maintained.

Ten days post-injury, follow up testing was implemented. The athlete reported continued headache, fatigue, drowsiness, trouble falling asleep, sensitivity to noise, irritability, sadness, nervousness, feeling more emotional, feeling slowed down and mentally “foggy”, and difficulty concentrating and remembering. Neurocognitive tests results returned to baseline levels but recommendations were maintained secondary to continued decline in symptoms scores on the PCRS. D.A. was seen a fourth time for neurocognitive testing 20 days following the original incident. At this time she did not report any post-concussion symptoms and her neurocognitive testing was at baseline levels of performance. D.A. gradually increased low-impact physical activity while being closely monitored by the ATC. Post-concussion symptoms did not reoccur and the athlete was able to return to athletic and academic activities. Table III displays the athlete’s baseline and post-concussion results.

Summary of findings. In this case study, a multiple disciplinary team of professionals (i.e., ATC, SLP and a physician) actively monitored D.A. throughout the recovery process. It should be noted; that D.A.’s return to baseline neurobehavioral and neurocognitive levels of performance took 20 days, which is not within the typical 7-10 day recovery period (Harmon et al., 2013). However, this case may reinforce this study’s statistical findings that recovery patterns can be longer for female athletes with a history of multiple concussions.
### Table III Test scores pre- and post-injury: Case 1

<table>
<thead>
<tr>
<th>Composite Scores</th>
<th>Baseline (%)</th>
<th>2 days post (%)</th>
<th>6 days post (%)</th>
<th>10 days post (%)</th>
<th>20 days post (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Memory Composite</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Verbal)</td>
<td>91 (66%)</td>
<td>85 (50%)</td>
<td>90 (73%)</td>
<td>89 (70%)</td>
<td>94 (82%)</td>
</tr>
<tr>
<td><strong>Memory Composite</strong></td>
<td>85 (86%)</td>
<td><strong>65 (27%)</strong></td>
<td><strong>71 (42%)</strong></td>
<td>94 (99%)</td>
<td>95 (99%)</td>
</tr>
<tr>
<td>(Visual)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Visual Motor Speed</strong></td>
<td>49.6(91%)</td>
<td>47.8 (88%)</td>
<td>48.6 (92%)</td>
<td>46.13 (81%)</td>
<td>52.45 (99%)</td>
</tr>
<tr>
<td><strong>Composite</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Reaction Time Composite</strong></td>
<td>.53 (69%)</td>
<td>.56 (50%)</td>
<td>.53 (66%)</td>
<td>.57 (45%)</td>
<td>.52 (71%)</td>
</tr>
<tr>
<td><strong>Impulse Control Composite</strong></td>
<td>3</td>
<td>6</td>
<td>2</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td><strong>PCRS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mild (1): x2</td>
<td>Mild (1): x5</td>
<td>Mild (1): x4</td>
<td>Mild (1): x6</td>
<td>No symptoms</td>
<td>reported</td>
</tr>
<tr>
<td>Mild-mod (2): x6</td>
<td>Mild-mod (2): x6</td>
<td>Mild-mod (2): x6</td>
<td>Mild-mod (2): x2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mod (3): x3</td>
<td>Mod (3): x3</td>
<td>Mod (3): x2</td>
<td>Mod (3): x4</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total Score:</strong></td>
<td></td>
<td></td>
<td></td>
<td>22</td>
<td>22</td>
</tr>
<tr>
<td><strong>Total Score:</strong></td>
<td>3</td>
<td>38</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. PCRS=Post Concussion Rating Scale.

Bold numbers >1 Standard Deviation from baseline

%-percentile scores

Point value for PCRS based on specific symptom: 0= not experiencing, 1= mild, 2=mild moderate, 3=moderate, 4=moderate-severe, 5 and 6=severe.
**Case 2 club sport athlete: A. B.** Case 2 is an 18-year-old female collegiate club rugby player who reported a history of one previous concussion in 2011. The current injury involved a kick to the forehead by an opponent during a rugby match. She left the match to rest and returned to play 10 minutes later. Upon return, an opponent fell onto the “right side of her head”. A.B. reported playing for five additional minutes then removed herself from the game. Following these incidents, she experienced a headache, sensitivity to light, and nausea. A.B. contacted the Concussion Management Lab three days following the injury. At that time, the athlete did not want her testing results shared with her personal physician and took sole responsibility for all post-injury management.

**Post-concussion neurocognitive testing.** Three days following the injury the athlete completed formal post-injury neurocognitive testing. Test results compared to baseline data revealed a deviation in Verbal and Visual Memory Composite scores, Visual Motor Speed Composite and Reaction Time Composite, in addition to the following neurobehavioral symptoms reported: difficulty remembering, balance problems, dizziness, numbness/tingling, nausea, fatigue, sleeping less than usual, drowsiness, sensitivity to noise and light, sadness, nervousness, feeling more emotional, difficulty concentrating, trouble falling asleep, and irritability. The examiner reviewed results and recommendations with the athlete post-testing. Recommendations included refraining from high-impact physical activity and cognitive challenging activities. Academic accommodations implemented included extended time and a quiet, distraction free environment for tests and projects. The athlete was encouraged to avoid loud social situations and to take breaks throughout the day as needed.

Ten days following the original incident, she reported continued balance problems, dizziness, trouble falling asleep, nervousness, sleeping less than usual, headache, nausea, fatigue, drowsiness, sensitivity to light, sleeping more than usual, sensitivity to noise and light, irritability, sadness, feeling more emotional, feeling slowed down, mentally foggy and difficulty remembering. Neurocognitive testing results revealed continued deviations in Verbal and Visual Memory Composite scores, Visual Motor Speed Composite and Reaction Time Composite when compared to baseline results. Previous recommendations were continued.

Seventeen days following the original incident A.B. continued to report feelings of nausea, dizziness, sensitivity to light and noise, nervousness, numbness/tingling, difficulty remembering, headache, balance problems, fatigue, trouble falling asleep, drowsiness,
irritability, sadness, feeling more emotional, feeling slowed down, mentally “foggy”, difficulty concentrating and sleeping more than usual. Neurocognitive results revealed continued deviation in Memory Composite Verbal.

Twenty-four days after the incident the athlete reported a decrease in the number of symptoms but continued to experience headache, balance problems, fatigue, trouble falling asleep, sleeping more than usual, drowsiness, sensitivity to noise and light, nervousness, mentally “foggy”, difficulty concentrating and visual problems. Neurocognitive results revealed a decline in Memory Composite (verbal) and Reaction Time Composite when compared to baseline. Previous recommendations were maintained.

A.B was seen for the fifth and final time 31 days following the original incident. She reported continued headache, trouble falling asleep, sensitivity to noise and difficulty concentrating. Neurocognitive testing results returned to baseline performance levels. It was suggested she gradually increase low-impact physical activity while self-monitoring for any increases in symptoms. Please refer to table IV for the athlete’s post-concussion test scores.

**Summary of findings.** This case illustrated some of the potential challenges experienced working with the club sport athlete. In addition, it also represents an athlete that experienced more extended and greater neurocognitive change and post-injury symptoms when compared to Case 1. Many factors could have contributed to these differences. First, the athlete had the primary responsibility of determining when to remove herself from play. As a result, she reported experiencing multiple hits that may have contributed to her prolonged recovery time. In addition, examiners relied solely on the athlete’s self-report of the nature of the injury and degree of compliance with strategies used to support recovery. The potential failure to accurately relay full willingness to follow recommendation may also contribute to recovery time. The athlete also failed to continue post-concussion monitoring even though symptoms were reported. Therefore, it is uncertain if and when then A.B.’s symptoms resolved. Finally, since this athlete was an adult, follow-up or referrals to other professional (e.g., primary physician or neuropsychologist) could not be made without A.B’s prior consent.
<table>
<thead>
<tr>
<th>Composite Scores</th>
<th>Baseline</th>
<th>3 days post (%)</th>
<th>10 days post (%)</th>
<th>17 days post (%)</th>
<th>24 days post (%)</th>
<th>31 days post (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Memory Composite (Verbal)</td>
<td>97 (92%)</td>
<td>66 (3%)</td>
<td>67 (3%)</td>
<td>84 (41%)</td>
<td>78 (22%)</td>
<td>97 (92%)</td>
</tr>
<tr>
<td>Memory Composite (Visual)</td>
<td>97 (98%)</td>
<td>47 (4%)</td>
<td>51 (10%)</td>
<td>90 (91%)</td>
<td>85 (86%)</td>
<td>86 (88%)</td>
</tr>
<tr>
<td>Visual Motor Speed</td>
<td>43.43 (67%)</td>
<td>26.98 (1%)</td>
<td>33.13 (18%)</td>
<td>44.63 (74%)</td>
<td>45.45 (75%)</td>
<td>51.72 (99%)</td>
</tr>
<tr>
<td>Reaction Time</td>
<td>0.59 (34%)</td>
<td>.91 (&lt;1%)</td>
<td>.93 (&lt;1%)</td>
<td>0.52 (75%)</td>
<td>.66 (11%)</td>
<td>0.54 (63%)</td>
</tr>
<tr>
<td>Impulse Control Composite</td>
<td>6</td>
<td>4</td>
<td>6</td>
<td>8</td>
<td>9</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Mild-mod x1</td>
<td>Mild-mod (2): x1</td>
<td>Mild-mod (2): x2</td>
<td>Mild-mod (2): x4</td>
<td>Mild-mod (2): x5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mod (3): x8</td>
<td>Mod (3): x3</td>
<td>Mod (3): x3</td>
<td>Mod-severe (4): x6</td>
<td>Mod-severe (4): x10</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mod-severe (4): x7</td>
<td>Score: 56</td>
<td>Mod-severe (4): x10</td>
<td>Total Score: 56</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Severe (5,6): x3</td>
<td>Total Score: 64</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Total</td>
<td>Score: 68</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Note. PCRS=Post Concussion Rating Scale. Bold numbers >1 SD from baseline. % -percentile scores. Point value for PCRS based on specific symptom: 0= not experiencing, 1= mild, 2=mild-moderate, 3=moderate, 4=moderate-severe, 5 and 6=severe.
Discussion

Recent research has indicated that repeated sport-related concussions can result in more pronounced post-injury symptoms and longer recovery periods (Cobb & Battin, 2004; Harmon et al., 2013). In order better prevent, diagnose, manage, and promote recovery, the NCAA now mandates that university varsity athletic programs implement and adhere to a concussion management protocol (NCAA Division I Manual, 2015-2016). As a result of these guidelines, training programs are in place to help varsity team physicians, ATCs and coaches recognize potential post-concussion symptoms, even when the varsity athlete may fail to self-report a possible injury. In comparison, directives for collegiate club sport programs to develop or implement a concussion management protocol do not exist. Instead, the student club sport athlete is often responsible for self-identifying, managing and seeking outside medical support for any suspected concussion. The differences in management protocols between varsity and club sport organizations suggest that the short-term impact on an athletes’ ability to recover from the neurocognitive and neurobehavioral symptoms associated with a concussion may be impacted. However, even with the management dissimilarities between these collegiate organizations, the findings from this current study revealed no statistically significant difference in recovery patterns between varsity and club sport athletes post-concussion. Nevertheless, the authors suggest that the findings from this preliminary study be interpreted with caution secondary to the difficulties encountered obtaining consistent and complete data from the self-managed club sport athlete as exhibited in the case studies provided.

Inherent challenges

Participation. A team of professionally trained support staff works together to guide and encourage varsity athletes to complete necessary athletic, academic and medical requirements. For example, all varsity athletes participating in high-impact sports at this mid-western university are required to complete preliminary baseline neurocognitive testing prior to engaging in team practices or games secondary to the institution’s concussion management protocol. Because of this, 100% of varsity athletes initially included in this study with a suspected concussion had personal baseline data available for comparison to their post-injury neurocognitive status. In contrast, club sport athletes can participate in team practices and games without completing baseline neurocognitive testing. Therefore, of the 19 club sport athletes with a suspected concussion, only 9 had completed preliminary baseline testing, thus limiting the
sample size of this group. It should be noted, that prior to the start of the athletic season, the second author and the director of the university club sport program encouraged club athletes to complete baseline testing prior to the start of the athletic season. In addition, all baseline and post-concussion testing and management services were available to all club sport athletes at no cost. Even with these incentives, only 10% of the approximately 1500 club sport athletes participated in baseline testing.

There are many factors that can contribute to why club sport athletes may not participate in baseline neurocognitive testing. For example, some of these athletes may be engaged in high-impact sport programs for the first time (e.g., quidditch, rugby) and lack knowledge about the nature and symptoms associated with a suspected concussion and therefore do not understand the need or benefit associated with pre-injury testing. While mandated education programs are in place for varsity athletes (NCAA Division I Manual, 2015-2016; Kroshus et al., 2014) these types of programs may be lacking or non-existent for club sport athletes. In addition, since many club sport organizations lack sufficient funding (“Rise of College Teams Creates a Whole New Level of Success” 2008), student athletes may choose to use financial resources for other more immediate costs (e.g., equipment, uniforms, travel expenses) versus testing that may not be needed if a concussion does not occur. Finally, because baseline testing is not mandatory, these full-time student athletes may feel they are too busy with academic responsibilities to take the time to schedule testing or they may not be aware of local programs close to campus that offer neurocognitive baseline testing services. Due to these inherent challenges, further examination of the unique needs of this student-lead sporting organization is warranted in order to develop better education programs and services to meet the needs of this growing collegiate student athlete population.

Even with these challenges, baseline neurocognitive testing is necessary in order to reduce the potential risk of misdiagnosing or making premature return-to-play decisions following concussion (Roebuck-Spencer, Vincent, Schlegel, & Gilliliand, 2013). The neurocognitive and neurobehavioral symptoms experienced by an athlete post-concussion may be subtle and unique based on the nature of the injury; thereby making it more challenging for the athlete or the support personnel to recognize when the athlete has returned to previous levels of performance (Roebuck-Spencer et al., 2013; Covassin, Elbin, Stillner-Ostrowski, Kontos, 2009; Guskiewicz et al., 2006). Because each individual’s pre-injury cognitive strengths and
limitations varies, research suggests that comparing post-injury with baseline neurocognitive levels of performance increases the reliability of diagnosis and in making appropriate return to play decisions (Kelly, Jordan, Joyner, Burdette, & Buckley, 2014; Guskiewicz et al., 2006; Lovell, Collin, Bradley & Johnston, 2004).

**Gender Influences.** An addition trend that the authors observed was a discrepancy in the number of male versus female club sport athletes participating in baseline neurocognitive testing. More specifically, 85% of baseline tests completed at this midwestern university were by female club sport athletes while only 15% of males completed testing. When comparing the participation of specific club sport teams, 23 female ice hockey players completed baseline tests with no male ice hockey players completing testing. This was a typical trend found among club sport organizations who were not required to complete neurocognitive baseline testing, with no male team exceeding female teams in participation in testing. This trend can also be found in health care, with females seeking out and visiting medical professionals more when compared to their male peers (Hart, 2014). These results suggest that similar patterns may be found in post-concussion injury reporting patterns, with males being more at risk for continuing to play through a suspected injury or not seeking services post-injury further explaining the small number of male participants included in this study (Zuckerman et al., 2014). Athletes often under report their symptoms of concussion, which may be challenging when relying on them to self-report (Kroshus et al., 2015). When completing post-concussion testing, it is not as reliable to only utilize the athlete’s symptoms alone when making return to play decisions because around half of athlete’s surveyed did not report symptoms of a concussion (Kroshus et al., 2015). The lack of reliable reporting of possible head injuries from athletes may be due to pressures induced by the athlete, teammates, family or coaches (Kroshus et al, 2015).

Even though no significance difference was found between recovery time in varsity and club sports, this study does indicate that males return to baseline neurocognitive scores and report no symptoms more quickly than females from sport-related concussion. Findings from the current study are consistent with previous research, which indicates men return to baseline levels of neurocognitive functioning around two days quicker when compared to females (Zuckerman et al., 2014). Females often report more symptoms and are twice as likely to experience cognitive impairment following a concussion (Cripps, 2015; Covassin, Schatz, & Swanik, 2007). In addition females are more likely to have reduced reaction time and processing speed post-
concussion when compared to male athletes (Broshek et al., 2005). Due to these factors, neural anatomy and physiology and musculature differences between genders could possibly explain a longer recovery time for female athletes (Zuckerman et al., 2014). Another possible theory is that female sports do not wear helmets while in some male sports the head is protected (e.g. football, lacrosse), which could explain a difference in recovery time (Broshek et al., 2005). Finally, male athletes may also under-report symptoms as previously discussed.

**Recovery patterns between those with previous concussions**

An additional finding this study revealed is that the number of previous concussions can contribute to an athlete experiencing greater and longer post-injury symptoms. For example, both of the athletes in the cases presented had a history of previous concussions, which may be an added factor contributing to why their post-injury symptom recovery time was more than double the 7-10 day average (Harmon et al., 2013). These findings provide support to the growing body of research suggesting that athletes with a history of head injuries often have additional and more severe symptoms as well as take a longer period of time to recover than those without a history of concussion (Chertok, 2013; Covassin, Moran, & Wilhelmy, 2013; Covassin et al., 2008). In addition, symptoms scores on the PCRS in this study were more sensitive than changes in neurocognitive function on ImPACT© to the number of previous concussions experienced by the athlete. Even with this difference, a comprehensive concussion protocol using a battery of tests to assess all areas of neurocognitive functioning is more sensitive than just using one test (Kelly et al., 2014). Athletes often under-report post-concussion symptoms that are unrecognizable to support staff. Therefore, assessing all areas of neurocognitive functioning in addition to balance, visual system and symptoms experienced for baseline and post-concussion testing may contribute to greater accuracy in diagnosis and making return to play decision post injury (Covassin, et al., 2009; Harmon et al., 2012; Kroshus et al., 2015). Varsity collegiate athletic programs, unlike club sport organizations often have the testing resources to implement this multi-modality testing protocol.

**Future Direction**

With approximately 2 million student athletes participating nationally in club sports, further research is warranted examining the unique concussion management needs of these student-managed organizations. Education and management protocols currently used in structured well-supported collegiate varsity sport programs may not be best suited for this
population. Therefore, team captains and officers may benefit from a more detailed concussion educational program, focusing on symptom recognition, the benefits of baseline testing and populations at risk for prolonged recovery patterns. With this education, peer leaders may have a greater influence on team participation in a concussion management protocol. In addition, secondary to limited funding and the demanding time demands of student athletes, developing educational programs and concussion management services that are more accessible may lead to greater participation rates. Finally, education programs specifically addressing the unique needs of the female athletes with a history of multiple-concussion are warranted regardless of the sporting organization.

Conclusion

All collegiate varsity and club sport athletes who compete in high-impact sports are at risk for sustaining concussions. The neurobehavioral and neurocognitive symptoms that result from these injuries can negatively impact performance in sport, occupational and academic activities for these student athletes. Over the past decade, great strides have been made to improve the swift and effective management of sport-related concussion in varsity athletics. More specifically, through the use of strategically funded programs, varsity athletes gain access to a multi-disciplinary team of professionals trained in the identification of concussions and support strategies needed to facilitate recovery. In contrast, many club sport teams lack the funding, resources and trained personnel needed to identify the signs of head-injury and make immediate return-to-play decisions that may decrease the risk for multiple-concussions.

While the results from this preliminary study suggest that there is no statistically significant difference in length of recovery between athletes from these 2 collegiate organizations, the discrepancy in the services provided to these organizations is great, making club sport athletes more at risk for premature return to play decisions that may extend the recovery process as illustrated in the case studies provided. In addition, findings from this study further suggests that female athletes with a history of multiple concussion may be at a greater risk for more severe symptoms and longer recovery times. The inherent management challenges associated with a student lead sporting organization make compliance with a concussion protocol more challenging, especially if there are no direct consequences for non-compliance with suggested concussion management protocols including baseline and post-injury neurocognitive testing. Therefore, further research examining educational and management techniques that will
facilitate effective concussion management of this growing population of student club sport athletes is warranted, so that safe and successful participation in both academic and athletic activities can be maintained.
References


