Sex Differences and Self-Reported Attention Problems During Baseline Concussion Testing

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Sex Differences and Self-Reported Attention Problems During Baseline Concussion Testing

Brian L. Brooks\textsuperscript{abc}, Grant L. Iverson\textsuperscript{def}, Joseph E. Atkins\textsuperscript{g}, Ross Zafonte\textsuperscript{hf} & Paul D. Berkner\textsuperscript{i}

\textsuperscript{a} Neurosciences Program (Brain Injury and Rehabilitation), Alberta Children's Hospital, Calgary, Alberta, Canada
\textsuperscript{b} Departments of Pediatrics and Clinical Neurosciences, Cumming School of Medicine, University of Calgary, Calgary, Alberta, Canada
\textsuperscript{c} Alberta Children's Hospital Research Institute, University of Calgary, Calgary, Alberta, Canada
\textsuperscript{d} Department of Physical Medicine and Rehabilitation, Harvard Medical School
\textsuperscript{e} Spaulding Rehabilitation Hospital, MassGeneral Hospital for Children Sports Concussion Program
\textsuperscript{f} Red Sox Foundation and Massachusetts General Hospital Home Base Program, Boston, Massachusetts
\textsuperscript{g} Department of Psychology, Colby College, Waterville, Maine
\textsuperscript{h} Department of Physical Medicine and Rehabilitation, Spaulding Rehabilitation Hospital, Massachusetts General Hospital, Brigham and Women's Hospital, Harvard Medical School
\textsuperscript{i} Health Services and Department of Biology, Colby College, Waterville, Maine

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Sex Differences and Self-Reported Attention Problems During Baseline Concussion Testing

Brian L. Brooks
Neurosciences Program (Brain Injury and Rehabilitation), Alberta Children’s Hospital, and Departments of Pediatrics and Clinical Neurosciences, Cumming School of Medicine, University of Calgary, and Alberta Children’s Hospital Research Institute, University of Calgary, Calgary, Alberta, Canada

Grant L. Iverson
Department of Physical Medicine and Rehabilitation, Harvard Medical School, Spaulding Rehabilitation Hospital, Massachusetts General Hospital for Children Sports Concussion Program, and Red Sox Foundation and Massachusetts General Hospital Home Base Program, Boston, Massachusetts

Joseph E. Atkins
Department of Psychology, Colby College, Waterville, Maine

Ross Zafonte
Department of Physical Medicine and Rehabilitation, Spaulding Rehabilitation Hospital, Massachusetts General Hospital, Brigham and Women’s Hospital, Harvard Medical School, and Red Sox Foundation and Massachusetts General Hospital Home Base Program, Boston, Massachusetts

Paul D. Berkner
Health Services and Department of Biology, Colby College, Waterville, Maine

Amateur athletic programs often use computerized cognitive testing as part of their concussion management programs. There is evidence that athletes with preexisting attention problems will have worse cognitive performance and more symptoms at baseline testing. The purpose of this study was to examine whether attention problems affect assessments differently for male and female athletes. Participants were drawn from a database that included 6,840 adolescents from Maine who completed Immediate Postconcussion Assessment and Cognitive Testing (ImPACT) at baseline (primary outcome measure). The final sample included 249 boys and 100 girls with self-reported attention problems. Each participant was individually matched for sex, age, number of past concussions, and sport to a control participant (249 boys, 100 girls). Boys with attention problems...
had worse reaction time than boys without attention problems. Girls with attention problems had worse visual-motor speed than girls without attention problems. Boys with attention problems reported more total symptoms, including more cognitive-sensory and sleep-arousal symptoms, compared with boys without attention problems. Girls with attention problems reported more cognitive-sensory, sleep-arousal, and affective symptoms than girls without attention problems. When considering the assessment, management, and outcome from concussions in adolescent athletes, it is important to consider both sex and preinjury attention problems regarding cognitive test results and symptom reporting.

Key words: adolescents, baseline, children, gender, return to play, TBI

INTRODUCTION

It is estimated that 1 out of every 10 injuries sustained in high school athletic programs is a concussion (Gessel, Fields, Collins, Dick, & Comstock, 2007). More than 700,000 concussions were estimated to have occurred in U.S. high school athletics during a 5-year longitudinal study, with 13% of these injuries being deemed as recurrent (Castile, Collins, McIlvain, & Comstock, 2012). It has been suggested that children and adolescents might take longer to recover from a concussion (Collins, Iverson, Gaetz, Meehan, & Lovell, 2012; Collins, Lovell, Iverson, Ide, & Maroon, 2006; Field, Collins, Lovell, & Maroon, 2003; Guskiewicz & Valovich McLeod, 2011; Makdissi et al., 2013; McClincy, Lovell, Pardini, Collins, & Spore, 2006; Pellman, Lovell, Viano, & Casson, 2006; Sim, Terryberry-Spohr, & Wilson, 2008), and there have been clarion calls for more research with youth athletes (Choe, Babikian, DiFiori, Hovda, & Giza, 2012; McCrory et al., 2009, 2013; Purcell, 2009; Zemek, Farion, Sampson, & McGahern, 2013). During the past few years, every state in the United States has passed legislation relating to the management of concussions in amateur athletics.

Despite conflicting opinions in the literature on the pros (Van Kampen, Lovell, Pardini, Collins, & Fu, 2006) and cons (Echemendia et al., 2012; Kirkwood, Randolph, & Yeates, 2012; Randolph, 2011) of computerized cognitive testing, amateur athletic programs continue to use this assessment method as part of their concussion management program, including preseason assessments. There is some evidence, however, that adolescent athletes with a history of attention problems may have different results on baseline computerized testing compared with those athletes without a history of attention problems (Elbin et al., 2013; Zuckerman et al., 2013). A recent consensus statement on the management of sport concussion deemed developmental conditions, such as preinjury attention problems, a “modifier” that may influence the investigation, management, and potentially the outcome from concussion (McCrory et al., 2013). Considering that a significant minority of adolescent athletes have attention problems (Putukian et al., 2011; White, Harris, & Gibson, 2014), it is important to better understand how this developmental condition may affect the assessment of functional abilities (i.e., cognitive skills, symptom reporting) even in the absence of an injury.

Despite recent evidence that cognitive testing and symptom reporting used for concussion management are different in those with attention problems (Elbin et al., 2013; Zuckerman et al., 2013), it is not known whether there are sex differences on preseason testing in those with or without preinjury attention problems. The consensus guidelines suggest that sex may be another potential “modifier” of concussion management and outcome (McCrory et al., 2013). The goals of this study were to: (a) examine the effects of preinjury attention problems on baseline cognitive performance and symptom reporting, and (b) determine if there are sex differences related to preinjury attention problems and baseline testing. It was hypothesized that boys and girls with preinjury attention problems would perform more poorly on cognitive testing than those without preinjury attention problems and that the effect size differences would be similar (i.e., the magnitude of the difference would not differ between the sexes). In addition, it was hypothesized that girls in both groups would report more symptoms than boys and that boys and girls with preinjury attention problems would report more symptoms than adolescents without preinjury attention problems.

PARTICIPANTS AND METHODS

Participants for this study were derived from a large database of 6,840 adolescent athletes aged 13 to 18 years...
old (boys, \( n = 3,905 \); girls, \( n = 2,935 \)) in Maine who completed Immediate Postconcussion Assessment and Cognitive Testing (ImPACT) as part of their baseline evaluations for sport participation in 2010. Because these are baseline evaluations, all athletes were cleared for participation in sport and their data would be considered prior to an injury sustained in the season.

Participants were excluded for the following reasons (and were excluded if they were missing data for any of these reasons): (a) if their primary language was not English (\( n = 327 \) were identified as speaking another primary language and \( n = 118 \) had missing information on language; total excluded \( n = 445 \)); (b) if they reported a history of neurological problems (e.g., epilepsy/seizures, \( n = 70 \); meningitis, \( n = 27 \); and brain surgery, \( n = 8 \); \( n = 877 \) had missing data on neurological problems; total excluded \( n = 982 \)); and/or (c) if they were flagged by the ImPACT program as having “invalid” test scores (\( n = 263 \)). The final sample consisted of 2,860 boys and 2,290 girls who were eligible for inclusion.

The ImPACT health survey asked the athlete whether he or she had had “problems with ADD/hyperactivity,” with the response being either yes or no. It is important to emphasize that responses to this question are not equivalent to identifying those with a confirmed diagnosis of an attention disorder but do apply directly to those who would endorse having a problem with attention. Self-reported attention problems based on this response were present in 249 boys (8.7% of the included sample; 6.4% of the initial total sample before exclusions) and 100 girls (4.4% of the included sample; 3.4% of the initial total sample before exclusions). Control participants from this database were individually matched to the participants with attention problems on sex, age, number of self-reported past concussions, and sport.

The ImPACT is a brief computerized screen of cognitive abilities that has been used previously in several studies investigating neurocognitive functioning following concussive injuries (Brooks et al., 2013, 2014; Covassin, Elbin, Larson, & Kontos, 2012; Iverson, Brooks, Collins, & Lovell, 2006; Iverson, Brooks, Lovell, & Collins, 2006; Iverson, Echemendia, Lamarre, Brooks, & Gaetz, 2012; Iverson, Lovell, & Collins, 2003; Maroon et al., 2000; Schatz, 2010; Thomas et al., 2011). The ImPACT includes six tests/modules (i.e., Word Discrimination, Design Memory, Xs and Os, Symbol Match, Color Match, Three Letters) that yield four primary composite scores (i.e., Verbal Memory, Visual Memory, Visual-Motor, Reaction Time) and one secondary composite score (i.e., Impulse Control). The ImPACT also contains a 22-item symptom scale, with each symptom being rated from 0 (none) to 6 (severe). Based on factor analysis (Kontos et al., 2012), the Postconcussion Symptom Scale can be divided into four subscales: (a) Cognitive-Sensory (e.g., sensitivity to light, difficulty concentrating); (b) Sleep-Arousal (e.g., fatigue, trouble falling asleep); (c) Vestibular-Somatic (e.g., headache, balance problems); and (d) Affective Symptoms (e.g., irritability, sadness).

Statistical analyses were completed using IBM Statistical Package for the Social Sciences Statistics for Windows Version 19.0 (IBM Corporation, 2010). Group comparisons (control vs. attention problems) for performance on the four primary ImPACT composite scores (i.e., Verbal Memory, Visual Memory, Visual-Motor, and Reaction Time) used multivariate analyses of variance (MANOVA) with univariate follow-up group comparisons for each of the domain scores. Group comparisons for Impulse Control, symptom ratings, and subtest scores along with any variable that violated assumptions of the general linear model used nonparametric techniques such as Mann-Whitney U tests. Experiment-wise alpha was set at \( p \leq .01 \) for all analyses. Cohen’s \( d \) effect sizes were also computed (conventional interpretation of effect sizes: \( d = 0.2 \), small; \( d = 0.5 \), medium; and \( d = 0.8 \), large).

**RESULTS**

The boys in this study (\( n = 249 \) without attention problems, \( n = 249 \) with attention problems) were a mean age of 15.9 years (SD = 1.3 years, range = 13–18 years) and had 9.1 mean years of education (SD = 1.4 years) and on average 0.4 previous concussions (SD = 0.8, range = 0–4, median = 0). The most common sports for boys were football (34.5%), soccer (21.7%), and ice hockey (10.4%). For the boys with self-reported attention problems, 34% reported that they were on a medication for this condition, 10% did not list a medication for attention problems but did list a medication for another health problem (e.g., allergies), and 56% had missing data on medications.

The girls in this study (\( n = 100 \) without attention problems, \( n = 100 \) with attention problems) were a mean age of 16.0 years (SD = 1.3 years, range = 13–18 years) and had 9.4 mean years of education (SD = 1.8 years) and on average 0.4 previous concussions (SD = 0.9, range = 0–5, median = 0). The most common sports for girls were soccer (21%), cheerleading (21%), and field hockey (13%). For the girls with self-reported attention problems, 41% reported that they were on a medication for this condition, 12% did not list a medication for attention problems but did list a medication for another health problem, and 47% had missing data on medications.

Because of the matching design of this study, there were not significant differences with age, education, prior concussions, or proportions in various sports.
between those with and without attention problems for either the boys or girls. There were not significant differences in the use of medications for attention problems between boys and girls, $\chi^2(1) = 1.29, p = .257$. Compared with youth without attention problems, boys and girls with attention problems were more likely to have a learning disability, $\chi^2(1) = 26.08, p < .001$ for boys, $\chi^2(1) = 26.98, p < .001$ for girls; to attend a special education class, $\chi^2(1) = 26.32, p < .001$ for boys, $\chi^2(1) = 15.87, p < .001$ for girls; and to repeat a grade, $\chi^2(1) = 22.26, p < .001$ for boys, $\chi^2(1) = 5.70, p = .017$ for girls. However, there were no sex differences when comparing proportions of boys and girls with a learning disability—attention problems, $\chi^2(1) = 1.88, p = .171$; controls, $\chi^2(1) = 3.02, p = .082$—or those who attended a special education class—attention problems, $\chi^2(1) = 0.51, p = .474$; controls, $\chi^2(1) = 3.44, p = .064$—although boys with attention problems were more likely to have repeated a grade compared with girls with attention problems, $\chi^2(1) = 5.26, p = .022$; controls, $\chi^2(1) = 2.51, p = .113$.

Cognitive Performance

Performance on the ImPACT is presented in Table 1. Comparison of the four primary ImPACT composite scores in boys with or without attention problems was done using a MANOVA. However, Box’s M Test was significant ($p = .034$; suggesting the covariance matrices differed significantly across the dependent variables), and Levene’s test for equality of error variances was nonsignificant for all four variables. There was a significant multivariate effect, Wilks’s Lambda = .90, $F(4, 195) = 5.16, p = .001$, partial eta squared = .096. The univariate ANOVAs revealed significantly worse performance for girls with attention problems on the Processing Speed composite ($p < .001, d = 0.57$).

Symptom Ratings

Group comparisons revealed that boys with attention problems reported significantly more baseline symptoms ($p < .001, d = 0.26$) compared with boys without attention problems. On the four symptom subscales, boys

<table>
<thead>
<tr>
<th>TABLE 1</th>
</tr>
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<tbody>
<tr>
<td><strong>ImPACT Performance and Symptom Ratings at Baseline in Boys and Girls With or Without Attention Problems</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ImPACT Scores</th>
<th>Boys</th>
<th>Girls</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Composites</strong></td>
<td>No Attention Problems</td>
<td>Attention Problems</td>
</tr>
<tr>
<td><strong>Verbal Memory</strong></td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td><strong>Visual Memory</strong></td>
<td>72.8</td>
<td>13.0</td>
</tr>
<tr>
<td><strong>Visual-Motor Speed</strong></td>
<td>35.3</td>
<td>8.0</td>
</tr>
<tr>
<td><strong>Reaction Time</strong></td>
<td>0.60</td>
<td>0.08</td>
</tr>
<tr>
<td><strong>Impulse Control</strong></td>
<td>8.1</td>
<td>5.4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Symptoms</strong></th>
<th>No Attention Problems</th>
<th>Attention Problems</th>
<th>p Values</th>
<th>Cohen’s $d$ Effect Sizes</th>
<th>No Attention Problems</th>
<th>Attention Problems</th>
<th>p Values</th>
<th>Cohen’s $d$ Effect Sizes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total Symptoms</strong></td>
<td>4.9</td>
<td>9.0</td>
<td>7.3</td>
<td>10.3</td>
<td>&lt; .001</td>
<td>.26</td>
<td>7.4</td>
<td>11.6</td>
</tr>
<tr>
<td><strong>Cognitive-Sensory Symptoms</strong></td>
<td>1.2</td>
<td>2.9</td>
<td>2.3</td>
<td>4.1</td>
<td>&lt; .001</td>
<td>.31</td>
<td>1.8</td>
<td>3.9</td>
</tr>
<tr>
<td><strong>Sleep-Arousal Symptoms</strong></td>
<td>1.7</td>
<td>3.1</td>
<td>2.6</td>
<td>3.5</td>
<td>.001</td>
<td>.27</td>
<td>2.5</td>
<td>3.6</td>
</tr>
<tr>
<td><strong>Vestibular-Somatic Symptoms</strong></td>
<td>0.7</td>
<td>2.0</td>
<td>0.8</td>
<td>2.4</td>
<td>.675</td>
<td>.05</td>
<td>1.0</td>
<td>2.4</td>
</tr>
<tr>
<td><strong>Affective Symptoms</strong></td>
<td>1.0</td>
<td>2.2</td>
<td>1.2</td>
<td>2.6</td>
<td>.498</td>
<td>.08</td>
<td>1.8</td>
<td>3.3</td>
</tr>
</tbody>
</table>

*Note:* Scores marked with a † indicate that lower raw scores suggest better performance or fewer symptoms. Bolded $p$ values are interpreted as significant group differences ($p \leq .01$). By convention, Cohen’s $d$ effect sizes are interpreted as follows: $d = 0.2$, small; $d = 0.5$, medium; and $d = 0.8$, large. ImPACT = Immediate Postconcussion Assessment and Cognitive Testing; SD = standard deviation.
with attention problems rated more problems with cognitive-sensory \( (p < .001, d = 0.31) \) and sleep-arousal symptoms \( (p = .001, d = 0.27) \) compared with boys without attention problems. They did not differ on vestibular-somatic \( (p = .675, d = 0.05) \) or affective \( (p = .498, d = 0.08) \) symptoms. The most commonly reported symptoms for boys with attention problems were difficulty concentrating \( (38.2\%) \), trouble falling asleep \( (30.5\%) \), sleeping less than usual \( (28.5\%) \), and drowsiness \( (25.3\%; \text{see Table 2}) \). When considering the prevalence of “elevated” symptom reporting in boys (i.e., having a total symptom score of 13 or greater; Lovell et al., 2006), 14\% of girls without attention problems and 23\% of girls with attention problems were deemed to meet the criteria, \( \chi^2(1) = 2.69, p = .101 \).

Sex Differences

In the control participants, girls had significantly better performance on the Visual-Motor composite score \( (p = .007, d = 0.32) \) compared with boys (Box’s M test for MANOVA was significant so group comparisons were completed using ANOVA and the Mann-Whitney U Test). Group differences were not found for Verbal Memory \( (p = .040, d = 0.24) \), Visual Memory \( (p = .287, d = 0.13) \), Reaction Time \( (p = .960, d = 0.01) \), or Impulse Control \( (p = .024, d = 0.27) \). There was no group difference on Total Symptom score \( (p = .057, d = 0.26) \), but the girls did report more problems with cognitive-sensory symptoms \( (p = .03, d = 0.41) \) compared with boys. There was also a trend for more sleep-arousal

### TABLE 2

| Individual Symptom Reporting by Sex and Presence/Absence of Attention Problems |
|---------------------------------|-----------------|-----------------|-----------------|-----------------|
|                                 | Boys No Attention Problems | Boys Attention Problems | Girls No Attention Problems | Girls Attention Problems |
| Headache                        | 19.7              | 20.1             | 24.0             | 35.0             |
| Nausea                          | 4.4               | 6.4              | 8.0              | 11.0             |
| Vomiting                        | 1.2               | 2.0              | 1.0              | 0.0              |
| Balance Problems                | 5.2               | 6.0              | 4.0              | 11.0             |
| Dizziness                       | 7.6               | 9.6              | 14.0             | 16.0             |
| Fatigue                         | 20.5              | 24.5             | 29.0             | 34.0             |
| Trouble Falling Asleep          | 20.9              | 30.5             | 24.0             | 49.0             |
| Sleeping More Than Usual        | 9.6               | 10.0             | 6.0              | 10.0             |
| Sleeping Less Than Usual        | 19.7              | 28.5             | 33.0             | 42.0             |
| Drowsiness                      | 19.7              | 25.3             | 22.0             | 32.0             |
| Sensitivity to Light            | 7.2               | 9.6              | 16.0             | 22.0             |
| Sensitivity to Noise            | 4.8               | 10.8             | 8.0              | 17.0             |
| Irritability                    | 16.5              | 20.9             | 20.0             | 38.0             |
| Sadness                         | 8.0               | 10.0             | 16.0             | 25.0             |
| Nervousness                     | 18.1              | 15.7             | 24.0             | 39.0             |
| Feeling More Emotional          | 10.4              | 10.0             | 25.0             | 32.0             |
| Numbness or Tingling            | 6.0               | 4.4              | 1.0              | 2.0              |
| Feeling Slowed Down             | 9.6               | 11.6             | 8.0              | 15.0             |
| Feeling Mentally “Foggy”        | 8.8               | 9.2              | 9.0              | 14.0             |
| Difficulty Concentrating        | 16.1              | 38.2             | 26.0             | 59.0             |
| Difficulty Remembering          | 9.2               | 15.3             | 12.0             | 18.0             |
| Visual Problems                 | 4.8               | 8.0              | 9.0              | 9.0              |
| Elevated symptom reporting*     | 10.4              | 21.7             | 14.0             | 23.0             |

*Elevated symptom reporting for boys: percent of sample with a total score of 13 or greater. Elevated symptom reporting for girls: percent of sample with a total score of 21 or greater. Source: Lovell et al. (2006).
symptoms in girls ($p = .05, d = 0.45$) and a medium effect size for more affective symptoms in girls ($p = .126, \ d = 0.45$). In adolescents with attention problems, there was not a significant multivariate effect. Wilks’s Lambda $= .97, F(4, 344) = 2.89, p = .022,$ partial eta squared $= .096,$ Box’s $M$ test, $p = .283,$ for the four primary composite scores and there was no group difference on the Impulse Control composite score ($p = .675, \ d = 0.05$). Symptom ratings, however, were significantly higher in girls with attention problems than in boys with attention problems ($p < .001, \ d = 0.51$). Girls with attention problems reported significantly more problems with cognitive-sensory ($p = .005, \ d = 0.28$), sleep- arousal ($p = .005, \ d = 0.43$), vestibular-somatic ($p < .001, \ d = 0.32$), and affective ($p < .001, \ d = 0.69$) symptoms compared with boys with attention problems.

DISCUSSION

There is worldwide interest in the assessment, management, and treatment of concussive injuries in amateur athletics. The Concussion in Sport Group, by consensus, has considered both sex and attention problems to be potential modifiers of concussion outcome or management (McCrory et al., 2013). However, little is known about how these modifiers can potentially predict prolonged or persistent problems or how they might influence the assessment and management of youth following a concussion. If attention problems alter baseline (preinjury) assessments of cognition and symptom reporting and these alterations differ for boys and girls, then this could in turn affect the assessment and management of athletes following a concussive injury. The primary goals of this study were to examine how self-reported attention problems impact baseline performance on cognitive testing and symptom reporting and to determine whether the impact was different in adolescent boys versus girls.

The present study replicates and supports the existing literature showing that adolescent athletes with attention problems have different baseline performance, on average, compared with those without attention problems (Elbin et al., 2013; Zuckerman et al., 2013). In fact, it has long been known that youth with attention problems have neuropsychological deficits when compared with children and adolescents without this neurodevelopmental disorder (Wasserman & Wasserman, 2012). However, the effect sizes in the present study were smaller than anticipated, especially for boys. Boys with attention problems had lower scores on the ImPACT Reaction Time composite compared with boys without attention problems, but the effect size was small ($d = 0.27$). Girls with attention problems had lower scores on the ImPACT Visual-Motor Speed composite compared with girls without attention problems, and the effect size for this difference was medium ($d = 0.57$) and more clinically meaningful.

In regards to symptom reporting, girls reported more symptoms than boys, and youth with attention problems reported more symptoms than youth without attention problems. Many studies (Brooks et al., 2014; Dougan, Horswill, & Geffen, 2014; Frommer et al., 2011; Kontos, Dolese, Elbin, Covassin, & Warren, 2011; Kontos et al., 2012), although not all (Covassin, Elbin, Harris, Parker, & Kontos, 2012; Piland, Ferrara, Macciocchi, Broglio, & Gould, 2010; Zuckerman et al., 2012), support sex differences associated with symptom reporting. Examples of symptoms reported more commonly by girls than by boys (both without attention problems) are difficulty concentrating (26% in girls, 16% in boys), sleeping less than usual (33% in girls, 20% in boys), sadness (16% in girls, 8% in boys), and feeling more emotional (25% in girls, 10% in boys). Boys with attention problems reported more symptoms than boys without attention problems in the cognitive-sensory and sleep-arousal domains, although the effect sizes were small. Examples of symptoms reported more commonly by boys with attention problems than boys without attention problems were trouble falling asleep (31% in boys with attention problems, 21% in boys without attention problems) and difficulty concentrating (38% in boys with attention problems, 16% in boys without attention problems). Girls with attention problems reported more symptoms than girls without attention problems in the cognitive-sensory, sleep-arousal, and affective domains, with effect sizes that were more clinically meaningful. Examples of symptoms reported more commonly by girls with attention problems than girls without attention problems are trouble falling asleep (49% in girls with attention problems, 24% in girls without attention problems), difficulty concentrating (59% in girls with attention problems, 26% in girls without attention problems), and irritability (38% in girls with attention problems, 20% in girls without attention problems).

Although the present study provides similar support as Elbin et al. (2013) and Zuckerman et al. (2013) regarding the impact of attention problems on baseline performance, the sex differences highlight unique and interesting aspects. Elbin et al. only found very small effect sizes on the cognitive composite scores ($d = 0.11$–$0.19$) and a small effect size on total symptoms ($d = 0.32$) in relation to attention-deficit hyperactivity disorder (ADHD; Cohen’s $d$ were calculated based on the data presented in Elbin et al., 2013). Zuckerman et al. (2013) found small-to-medium effect sizes ($d = 0.27$–$0.42$) with all cognitive composite scores and total symptom ratings ($d = 0.45$) in relation to having ADHD (Cohen’s $d$ was calculated based on the data presented in Zuckerman et al., 2013). With the boys in...
the present study, there were very small to small effect sizes associated with attention problems. In girls, most effect sizes were small, with a medium effect size for visual-motor speed. These results suggest that the effect of attention problems on both cognitive performance and symptom reporting may be more pronounced in girls than in boys.

There are some limitations with the present data. First, attention problems were self-reported by the youth who participated in the baseline testing, and there is evidence that self-reported histories on the ImPACT health survey do not always match up with parental report (McKay, Schneider, Brooks, Mrazik, & Emery, 2014). However, it is important to note that often the self-reported answers during the health survey are the only source of information available for these baseline and rapid screening assessments. Second, the youth were asked if they had “problems with ADD/hyperactivity,” so endorsement is not diagnostic and does not confirm that a diagnosis has been made. Third, the participants indicated whether they were taking medication for attention problems, but there was no confirmation that the medication was taken prior to the testing. Therefore, it is assumed that medication would be taken as per usual.

Sex differences and the effect of attention problems on obtained data may need to be considered when managing a concussion, determining a return to baseline, and guiding return to play (McCrory et al., 2013). Considering the studies to date (Elbin et al., 2013; Zuckerman et al., 2013), the effect sizes of differences between those with attention problems versus controls on the ImPACT have been mostly small and occasionally medium. At present, there are no representative normative data for students with attention problems, and there are no specific guidelines or recommendations for how to interpret cognitive test scores differently in these students. Clinicians and amateur athletic programs need to be aware that having attention problems is associated with lower scores on ImPACT domains (i.e., slower reaction time in boys; slower visual-motor speed in girls) and with more symptoms being endorsed (i.e., cognitive and sleep symptoms for boys; cognitive, sleep, and emotional symptoms for girls). As well, the relation between attention problems and symptom reporting, in particular, appears greater in girls than in boys. These findings might have an impact on the management of athletes following a concussion, particularly when determining if cognitive problems or symptoms have resolved and considering return to play.

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