Association Between Previous Concussion History and Symptom Endorsement During Preseason Baseline Testing in High School and Collegiate Athletes

Johna K. Register-Mihalik, MA, ATC, Jason P. Mihalik, MS, CAT(C), and Kevin M. Guskiewicz, PhD, ATC
From the University of North Carolina at Chapel Hill, Chapel Hill, North Carolina

ABSTRACT

Background: A graded symptom checklist is one commonly used concussion evaluation measure. Little is known about preseason baseline symptomatology of high school and college athletes with and without a previous concussion history.

Hypothesis: The primary hypothesis investigated was the association between prior concussion history and symptom presence at baseline. The effects of gender and age on symptoms were also examined.

Study Design: Cross-sectional study.

Methods: Subjects included 8930 high school and collegiate athletes (height, 177.79 ± 9.97 cm; mass, 75.20 ± 19.21 kg; age, 16.60 ± 1.64 years). Subjects completed a self-report–graded symptom checklist and concussion history questionnaire during a preseason clinical testing session. Symptoms reported (yes or no) on the 18-item graded symptom checklist served as the dependent variables.

Results: A significant association was observed between symptoms on the graded symptom checklist and previous concussion history (P ≤ .001). No differences were observed between high school and college athletes regarding symptom endorsement (t_{1928} = 0.620; P = .535). A statistical but not clinically meaningful difference was observed between the means for males and females symptom endorsement (t_{1928} = −3.03; P = .002): men endorsed 1.88 ± 2.81 symptoms, and women endorsed 2.09 ± 2.90 symptoms. Headache, sleeping more than usual, difficulty concentrating, drowsiness, difficulty remembering, fatigue, difficulty sleeping, and irritability were reported by more than 10% of athletes.

Conclusion: High school and college athletes with a history of multiple concussions may be at risk for experiencing concussion-linked symptoms well beyond the acute stage of injury. Clinicians should be mindful of previous concussion history in athletes with increased presence of base-rate symptoms as they may be predisposed to future injury.

Keywords: preseason baseline; mild traumatic brain injury; symptomatology; concussion

A symptom checklist is one of the most commonly used clinical measures in concussion assessment, as almost 75% of certified athletic trainers employ some form of a symptom checklist in evaluating concussions. Despite its common and widespread use, little is known about the base-rate presence of common postconcussive symptoms in high school and collegiate athletes. These checklists typically include symptoms such as headache, fatigue, neck pain, and drowsiness. These symptoms are commonly experienced on a regular basis by healthy individuals, again reinforcing the need for an accurate assessment of symptoms both preinjury and postinjury.

Current literature has reinforced the need for “true” baseline assessment of symptoms. Baseline assessments should be taken seriously, as over- or under-representation of symptoms may influence interpretation of results postinjury. Understanding the typical presentation of symptoms...
commonly reported during preseason baseline in individuals with and without a history of concussion may aid clinicians in more accurately interpreting symptoms during postinjury testing when baseline scores are not available. This information may also be useful to physicians or other medical professionals as these individuals do not have access to preseason baseline information when evaluating an athlete postinjury. Knowing an athlete's regular symptomatology may aid the clinician in gauging injury severity and management decisions postinjury.

Symptoms present at baseline may be an indicator of existing conditions or previous history of injury. The presence of these symptoms may also influence neuropsychological performance and again should be taken into account during assessment. Recent studies suggest an association between presence of headache at baseline and previous concussion history. The question most frequently asked is whether increased symptomatology at baseline suggests long-term neurological and psychological consequences of recurrent concussion. These effects can range from consistent headache to memory problems and depression. Other consequences may include increased risk and longer recovery of subsequent concussions. These deficits can affect activities of daily living, especially schoolwork and attention. Little is known about these cumulative effects in younger athletes and how these effects may be magnified later in life. Suggestions have also been made that these effects are not as prominent in individuals with 1 or 2 previous concussions, but become more evident in individuals suffering from 3 or more. Another set of issues to consider are gender differences concerning symptoms present during baseline testing. Current literature suggests females report a greater number of mild baseline symptoms than males.

Concussion symptomatology is widely used to establish readiness to return to play following concussive injury; however, postconcussion symptom scores are only as good as the base rates to which they are compared. Therefore, the purpose of this study was to examine the association between prior concussion history and presence of symptoms at baseline. A secondary purpose was to assess the prevalence of preseason baseline symptoms in high school and collegiate athletes and in athletes with a previous concussion history.

**METHODS**

Institutional review board approval was obtained prior to the initiation of the study. Subjects included 7534 high school athletes and 1396 collegiate athletes (height, 177.79 ± 99.7 cm; mass, 75.20 ± 19.21 kg; age, 16.60 ± 1.64 years). Subjects completed a self-report concussion history questionnaire and an 18-item graded symptom checklist (GSC) (Table 1) during a preseason baseline assessment session as part of a larger clinical study. Using a GSC, subjects were asked to rate the presence and severity of symptoms experienced 3 or more days per week on a regular basis. The symptom checklist has been used and recommended in the literature.

The concussion history questionnaire asked subjects to report the number of previous concussions experienced. Both instruments were administered to subjects by the certified athletic trainer at his or her school. Certified athletic trainers were trained in administration of the instruments prior to the start of the research study.

**Statistical Analysis**

Subjects were stratified into 1 of 3 concussion history groups: no history of concussion (n = 6880), history of 1 or 2 previous concussions (n = 1942), or a history of 3 or more previous concussions (n = 102). Descriptive data were obtained, including the prevalence of symptoms in high school and college athletes, as well as symptom prevalence in high school and college athletes grouped according to concussion history. Independent samples t test were conducted to examine differences in symptoms endorsed between males and females and between high school and college athletes.

Separate chi-square tests of association were used to assess the association between presence of symptoms and previous history of concussion. Alpha (α) level was set to 0.05.

**Table 1. Graded symptom checklist**

<table>
<thead>
<tr>
<th>Symptom</th>
<th>None</th>
<th>Mild</th>
<th>Moderate</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Headache</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Nausea</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Vomiting</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Dizziness</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Sensitivity to light</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Blurred vision</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Sensitivity to noise</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Sleep more than usual</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Numbness/tingling</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Drowsiness</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Feeling in a “fog”</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Difficulty concentrating</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Difficulty remembering</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Neck pain</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Fatigue</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Difficulty sleeping</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Sadness</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Irritability</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>
priori. Based on previous literature, we divided the 18 symptoms into 4 distinct categories: somatic, cognitive, emotional, and sleep problems. In order to minimize Type I errors while running multiple chi-square analyses, our a priori $\alpha$ level was adjusted for the number of symptoms classified within a particular cluster. The a priori $\alpha$ values for the groups were as follows: cognition (0.01), somatic (0.0056), emotional (0.025), and sleep problems (0.025).

RESULTS

Nine of the 18 symptoms on the GSC were endorsed by at least 10% of our sample (Table 2). Further, the prevalence was greater for all of the symptoms in individuals reporting a history of concussion compared to those with no preexisting history of concussion (Table 2). Nearly 23 percent of subjects (2044/8930) reported at least 1 previous concussion. There was a statistical difference in number of symptoms endorsed at preseason baseline between males ($1.88 \pm 2.81$) and females ($2.09 \pm 2.90$) ($t_{8928} = –3.03; P = .002$). The effect size for this analysis was 0.07, suggesting this statistical difference was clinically insignificant.

There was no difference in symptoms endorsed between high school and college athletes ($t_{8928} = 0.620; P = .535$). Therefore, these 2 groups were combined for the analyses of association between each symptom and previous concussion history. There was a significant association between presence of each symptom at baseline and previous history of concussion ($P < .001$) (Table 3). These results are magnified in individuals with a history of 3 or more concussions.

DISCUSSION

The main finding of our study is the association between the presence of reported baseline symptoms

<table>
<thead>
<tr>
<th>Symptom, %</th>
<th>High School (n = 7534)</th>
<th>College (n = 1396)</th>
<th>No History (n = 6886)</th>
<th>History 1-2 (n = 1942)</th>
<th>History 3+ (n = 102)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Headache</td>
<td>25.7 (1939)</td>
<td>23.4 (326)</td>
<td>22.9 (1574)</td>
<td>32.9 (638)</td>
<td>52.0 (63)</td>
</tr>
<tr>
<td>Nausea</td>
<td>6.6 (501)</td>
<td>6.2 (98)</td>
<td>6.0 (416)</td>
<td>6.2 (158)</td>
<td>11.8 (12)</td>
</tr>
<tr>
<td>Vomiting</td>
<td>2.3 (172)</td>
<td>1.7 (24)</td>
<td>1.8 (127)</td>
<td>3.2 (63)</td>
<td>5.9 (6)</td>
</tr>
<tr>
<td>Dizziness</td>
<td>10.0 (752)</td>
<td>7.1 (99)</td>
<td>8.1 (561)</td>
<td>13.7 (266)</td>
<td>23.5 (24)</td>
</tr>
<tr>
<td>Fatigue</td>
<td>21.3 (1605)</td>
<td>27.1 (378)</td>
<td>20.7 (1425)</td>
<td>26.8 (520)</td>
<td>37.3 (38)</td>
</tr>
<tr>
<td>Trouble sleeping</td>
<td>15.7 (1181)</td>
<td>16.9 (236)</td>
<td>14.6 (1005)</td>
<td>19.6 (381)</td>
<td>30.4 (31)</td>
</tr>
<tr>
<td>Sleeping more than usual</td>
<td>12.5 (945)</td>
<td>15.3 (213)</td>
<td>12.1 (831)</td>
<td>15.9 (309)</td>
<td>17.6 (18)</td>
</tr>
<tr>
<td>Drowsiness</td>
<td>16.8 (1264)</td>
<td>17.0 (238)</td>
<td>15.6 (1072)</td>
<td>20.8 (404)</td>
<td>25.5 (26)</td>
</tr>
<tr>
<td>Sensitivity to light</td>
<td>5.8 (438)</td>
<td>6.3 (88)</td>
<td>5.0 (347)</td>
<td>8.9 (172)</td>
<td>6.9 (7)</td>
</tr>
<tr>
<td>Blurred vision</td>
<td>5.7 (431)</td>
<td>5.4 (76)</td>
<td>4.7 (324)</td>
<td>8.5 (165)</td>
<td>17.6 (18)</td>
</tr>
<tr>
<td>Sensitivity to noise</td>
<td>3.4 (256)</td>
<td>2.9 (40)</td>
<td>2.8 (193)</td>
<td>5.0 (87)</td>
<td>5.9 (6)</td>
</tr>
<tr>
<td>Sadness</td>
<td>6.3 (476)</td>
<td>7.8 (109)</td>
<td>6.1 (421)</td>
<td>7.7 (150)</td>
<td>13.7 (14)</td>
</tr>
<tr>
<td>Irritability</td>
<td>12.4 (932)</td>
<td>14.5 (202)</td>
<td>11.6 (799)</td>
<td>15.9 (309)</td>
<td>25.5 (26)</td>
</tr>
<tr>
<td>Numbness</td>
<td>4.7 (352)</td>
<td>3.9 (55)</td>
<td>3.9 (271)</td>
<td>6.5 (126)</td>
<td>9.8 (10)</td>
</tr>
<tr>
<td>Feeling in a “fog”</td>
<td>4.0 (310)</td>
<td>5.2 (73)</td>
<td>3.5 (243)</td>
<td>5.9 (115)</td>
<td>15.7 (16)</td>
</tr>
<tr>
<td>Trouble concentrating</td>
<td>15.8 (1197)</td>
<td>15.8 (221)</td>
<td>13.8 (949)</td>
<td>21.5 (417)</td>
<td>41.2 (42)</td>
</tr>
<tr>
<td>Trouble remembering</td>
<td>12.3 (928)</td>
<td>12.4 (173)</td>
<td>10.7 (737)</td>
<td>17.1 (332)</td>
<td>31.4 (32)</td>
</tr>
<tr>
<td>Neck pain</td>
<td>12.0 (907)</td>
<td>9.5 (133)</td>
<td>10.5 (728)</td>
<td>15.0 (292)</td>
<td>27.5 (28)</td>
</tr>
</tbody>
</table>

Table 3. Association between presence of symptoms and previous history of concussion.

<table>
<thead>
<tr>
<th>Cluster</th>
<th>Symptom</th>
<th>$\chi^2$ (df)</th>
<th>$P$ Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Somatic</td>
<td>Headache</td>
<td>118.50</td>
<td>&lt;.001</td>
</tr>
<tr>
<td></td>
<td>Nausea</td>
<td>15.90</td>
<td>&lt;.001</td>
</tr>
<tr>
<td></td>
<td>Vomiting</td>
<td>20.37</td>
<td>&lt;.001</td>
</tr>
<tr>
<td></td>
<td>Sensitivity to light</td>
<td>40.00</td>
<td>&lt;.001</td>
</tr>
<tr>
<td></td>
<td>Blurred vision</td>
<td>68.26</td>
<td>&lt;.001</td>
</tr>
<tr>
<td></td>
<td>Sensitivity to noise</td>
<td>24.83</td>
<td>&lt;.001</td>
</tr>
<tr>
<td></td>
<td>Numbness/tingling</td>
<td>29.22</td>
<td>&lt;.001</td>
</tr>
<tr>
<td></td>
<td>Neck pain</td>
<td>55.93</td>
<td>&lt;.001</td>
</tr>
<tr>
<td></td>
<td>Dizziness</td>
<td>77.58</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Cognitive</td>
<td>Drowsiness</td>
<td>35.22</td>
<td>&lt;.001</td>
</tr>
<tr>
<td></td>
<td>Feeling in a “fog”</td>
<td>55.61</td>
<td>&lt;.001</td>
</tr>
<tr>
<td></td>
<td>Difficulty concentrating</td>
<td>117.60</td>
<td>&lt;.001</td>
</tr>
<tr>
<td></td>
<td>Difficulty remembering</td>
<td>91.89</td>
<td>&lt;.001</td>
</tr>
<tr>
<td></td>
<td>Fatigue</td>
<td>45.97</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Emotional</td>
<td>Sadness</td>
<td>15.09</td>
<td>.001</td>
</tr>
<tr>
<td></td>
<td>Irritability</td>
<td>40.59</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Sleep-related</td>
<td>Difficulty sleeping</td>
<td>44.95</td>
<td>&lt;.001</td>
</tr>
<tr>
<td></td>
<td>Sleeping more than usual</td>
<td>21.83</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

*All associations were significant.
$\chi^2$, degrees of freedom.
*Indicates Fisher’s exact $P$ value reported as 1 cell had an expected value of less than 5.
on the GSC and a previous history of concussion. Consistent
with current literature, this finding was magnified in individu-
als with a history of 3 or more concussions.20,21 Half of the
18 symptoms were present in 25% of those with 3 or more
concussions, while no symptoms were reported by more than
23% in the group with no history of concussion (Table 2). Our
results agree with previous research findings which suggest
that long-term effects of multiple concussions, such as experi-
encing an increase in symptoms on a regular basis, may exist.
Studies have also suggested acute effects, including more
on-field markers of severity and increased susceptibility to
future injury.4

More than 10% of high school and collegiate athletes
reported a variety of the symptoms on the checklist during a
baseline testing session. One possible explanation for the over-
all elevation of symptoms may have been the time at which
these symptoms were assessed by the various athletic trainers.
This increased presence of symptoms should remind clinicians
to be vigilant about the source of these symptoms, includ-
ing dehydration, difficult or long practices, or other conditions
such as depression.

These findings are important as our sample represents both
high school and college student-athletes, and they underscore
the importance of considering base-rate symptoms in the man-
agement of athletes both pre- and postconcussion. These indi-
viduals require a high level of attention and concentration
to be successful in their academic settings. Both age groups
reported relatively high prevalence of difficulty concentrat-
ing in conjunction with headache and fatigue, all of which may
affect performance in school. As previously mentioned, this
prevalence was magnified in individuals with a history of con-
cussion. A previous study indicated significant differences in
grade point average (GPA) in high school athletes with no his-
tory of concussion and individuals with a history of concussion
as well as decreased neuropsychological performance.14 Our
data suggests that athletes with a history of concussion experi-
ence more symptoms on a regular basis. We hypothesize that
these symptoms may confound their ability to perform aca-
demically and in activities of daily living. These data provide
an important look into the effects of multiple concussions in
both high school and collegiate athletes.

These data also suggest minimal effects of gender on presen-
tation of symptoms at preseason baseline, which is consistent
with current literature. One previous study3 reported statisti-
cally significant differences between males and females regard-
ing symptom score (0-6 based on severity) for each item on a
GSC during a baseline test session, but these findings also were
not clinically significant, with the largest difference between
males and females on any symptom being 0.56, and the dif-
ference in total symptom score only being 1.46, with female
subjects reporting slightly more mild symptoms. The variable
included in our study was also slightly different as we used
total number of symptoms endorsed, regardless of severity. As
with the aforementioned study, although our finding was statis-
tically significant, it was not clinically significant and should be
interpreted with caution. No differences were observed in total
number of symptoms endorsed between high school and
college athletes during preseason baseline.

Limitations
A discussion of limitations as they pertain to our study is war-
ranted. Self-reporting serves as a limitation to any study using
GSC. This information is often difficult to ascertain objectively.
However, recent studies have shown youth to be reliable in
reporting symptoms on a symptom scale.13 Although all subjects
were assessed during a preseason baseline test session, this is a
time of increased practice and intensity for athletes. An increase
in physical exertion could increase many of these symptoms.
Individuals with a history of previous concussion still exhibit
an increased prevalence of all symptoms assessed on the GSC.
Also, the self-report of concussion history is quite possibly an
underestimate given that nearly 75% of athletes may not be able
to identify signs and symptoms of a concussion,9 while the liter-
ature suggests that more than 50% of concussions may go unre-
ported.15 Unfortunately, we also do not have the timeframe for
the concussion history, which could have influenced our find-
ings. Lastly, given there is no gold standard for concussion iden-
tification, these methods appear to be justified because there
is a clear difference between individuals reporting a previous
conclusion and individuals who were free of concussion.

CONCLUSION
In summary, clinicians should be mindful of typical symp-
toms at baseline, specifically in individuals reporting a his-
tory of concussion. These baseline values should be taken
into account when evaluating an athlete postinjury. Individuals
reporting a high number or severity of symptoms during base-
line testing require careful screening, as the presence of these
symptoms may serve as an indicator of underlying pathology.
Athletes with increased rate of baseline symptoms may be pre-
disposed to future injury. Most importantly, athletes with a his-
tory of 3 or more concussions may be at risk for cumulative
intermediate, if not long-term, effects.

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