Concussion in collegiate athletics: A link to academic achievement

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Abstract

Context: After concussion, many different symptoms can occur and persist that can affect daily functioning. Many of these symptoms could have implications in an athlete’s ability to return to academics. Unlike return to play, return to academics is less studied and less regulated. There is little research examining the effects of concussion on grade point average (GPA) and results have been inconsistent.

Objective: To examine the effects of concussion on college GPA.

Design: Retrospective observational study

Setting: University laboratory

Participants: Division I athletes after their first concussion (n = 26) and Division I athletes without a history of concussion (n = 30).

Main Outcome Measures: GPA and demographic information was obtained for the semester before injury, the semester of injury, and the semester after injury.

Results: Statistical analysis using generalized linear mixed model analysis revealed a significant interaction (p < 0.05) of group (concussion vs. control) by time, with the concussed group having a significant decrease in GPA from semester before injury to semester of injury, and a significant main effect for sex (p < 0.05) with females having higher GPAs than males.

Conclusions: Since the cognitive demands of academics can potentially exacerbate symptomology of concussion, the identification of students at risk for difficulties is critical.

Keywords

Concussion, GPA, academic achievement, college student-athlete, sex

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Introduction

Concussion has become a major public health concern recently, as anywhere from 1.6 to 3.8 million people a year are affected.1 However, most current research has focused on return to play and there is little to no consensus on return to academic protocols. Most governing bodies at the high school and collegiate levels require or recommend management protocols;2 however, there are great inconsistencies between protocols at different levels of schooling.

Additionally, the academic demands differ greatly from elementary school, to middle and high school, to college. High school and college students are more likely to exhibit more significant post-injury academic difficulties due to the greater demand of the curriculum along with their other extracurricular activities.3 Therefore, protocols should presumably not be the same for all age groups due to the varying demands placed on students. In the United States, current recommendations by the NCAA include having a baseline assessment for all athletes that includes a symptom

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checklist, standardized cognitive and balance assessments, and neuropsychological tests. Following a concussion, cognitive rest is recommended immediately after injury for a period of 24 – 48 hours. Cognitive rest involves avoiding potential cognitive stressors and avoiding activities that involve mental exercise. Activities to avoid could include: working on a computer or any screen; listening to loud music; reading; texting; playing video or computer games, among others. These types of cognitive activities could cause additional strain on neurometabolic processes in the brain, potentially exacerbating symptoms. However, to date, there is conflicting research showing the benefit or harm of cognitive rest in the recovery of symptoms.

Currently, there seems to be a common consensus of recommending individualized approaches to return to academics. Additionally, it is suggested that return to academics should be based on the return to play protocol: implementing a step-wise or graded protocol. It is recommended that athletes undergo 24 – 48 hours of complete cognitive rest, then be reevaluated on their symptom burden and neurocognitive ability. This information could be helpful in determining their timeline for return to academics. Additionally, increasing cognitive activity in a step-wise fashion (like increasing activity in return to play) could provide clinicians additional information. If the athlete experiences symptoms during any stage, they can step back activity level and resume cognitive rest. After concussion, cognitive functioning is affected and return to academics before symptom resolution can exacerbate symptomology. It has previously been shown that the more cognitive activity following concussion, the longer the recovery time. Additionally, a history of multiple concussions (≥3) has been linked to lingering deficits in memory. These cognitive problems that can emerge highlight the importance of individualizing the progression of return to academics.

Researchers have also attempted to identify those at risk for more severe academic difficulties post-injury. Trinidad and colleagues examined baseline testing to see if they could predict students at risk for academic difficulties. They found that motivation level was not a significant predictor of baseline neurocognitive test performance. However, high school grade point average (GPA) was a significant predictor of processing speed performance and a sensory organization test (SOT) composite score. Additionally, standardized aptitude test (SAT) scores were significant predictors of complex attention scores, reasoning standard scores, and SOT composite scores. This is consistent with research showing the importance of the visuospatial working memory relationship with academic profiles.

Post-injury, Ransom and colleagues used an evidence based assessment model to show that post-concussion symptom severity score and executive dysfunction significantly predicted post-injury academic problems. Additionally, vision symptoms, along with concentration difficulty, were associated with academic difficulty and lasted up to 30 days post-concussion in children 5 to 18 years old. In addition to symptoms manifesting as cognitive and physical problems, emotional dysfunction is common, especially feelings of frustration, which is thought to compound academic difficulties experienced post-injury.

When examining the effects of concussion on GPA, there are minimal and inconsistent findings. In a review done by Rozbacher and colleagues, only three studies, all on high school aged individuals, were identified examining grades of students before and after concussive injury. These studies did not find significant evidence that grades differed before and after injury, but did note that attendance was affected after concussion, especially in those students who developed post-concussion syndrome (PCS). However, Russell and colleagues did see reductions (although nonsignificant) in grades from the academic calendar year before injury compared with the year of injury in high school students. This data may have been confounded by inconsistent grading policies of teachers across schools and different academic accommodations offered to students returning to school post-injury.

Due to the insufficient and inconclusive research on academic effects of concussion, the present study aimed to examine the GPA of Division I collegiate athletes over time using the semester before their injury, the semester of their injury, and the semester after their injury. It was hypothesized that GPA during the semester that their concussion occurred would be lower than the semesters before and after their concussion.

**Methods**

All subjects (n = 56) were Division I college student athletes (18 – 22 years old) at the Pennsylvania State University. Participants were separated into two groups based on their previous history of concussion: healthy controls and concussed. The concussed group (n = 26) consisted of athletes who were diagnosed with their first concussion by medical staff while athletes at Pennsylvania State University. The healthy control group (n = 30) was comprised of athletes with no history of previous concussion and who were also recruited by medical staff and matched based on semester standing (approximate age) and sex with the concussed group. Concussed participants self-reported symptoms (modified Acute Concussion Evaluation (ACE) checklist) they had after their injury. Participant information and symptom reporting can be found in Tables 1 and 2.
This was a retrospective study in which we obtained data from academic and medical records. GPA (out of 4.0) was obtained from school records for the semester before the injury occurred, the semester during which athletes experienced the injury, and the semester after they had the injury. Medical record search was done to confirm the semester the concussion was received and to obtain basic demographic information.

This study followed ethical guidelines set forth by the Pennsylvania State University, whose Institutional Review Board approved the protocol before testing began (IRB#1643). All participants signed an informed consent form before participating in this study.

All statistical analysis was done using SPSS V26 and for all analyses significance was set a priori at $p < 0.05$. Independent t-tests were run between groups to identify any potential covariates.

To compare the changes in GPA between the groups (concussion and control) over time, a generalized linear mixed model was run with time as a fixed effect and subjects as a random effect. We covaried for sex as a fixed effect and interactions between sex and group, group and time, and sex and time were also included in the model. To determine the appropriate covariance structure the Baysian Information Criterion (BIC) was examined. For significant interactions, a simple effects analysis using sequential Bonferroni correction was used to identify location of differences.

Additionally, bivariate correlations were run to explore the relationship between GPA and total symptom presence. Correction for multiple comparison was done ($p = 0.05/3 = 0.017$). Further probing of significant regressions would be done using simple linear regressions.

### Results

A total of 56 participants were included in this study and GPA data for both concussed and control participants is presented in Table 3. Preliminary analysis revealed a sex effect on GPA. In the control group, there were significant differences in GPA at all time-points between males and females such that females had higher GPA; however, there were no significant differences in sex in the concussed group at any time-point (Table 4). Therefore, sex was used as a covariate in subsequent analyses.

Generalized linear mixed model analysis revealed significant interaction of group (concussion vs. control) by time and a significant main effect for sex (Table 5). Estimated marginal means for fixed effects were calculated with sequential Bonferroni correction for the group by time interaction (Figure 1). The control group had non-significant changes in GPA ($p > 0.05$) while the concussed group had a significant decrease in GPA.
GPA only from before the semester of injury to the semester of injury (t = 2.60, p = 0.021).

Bivariate correlation analysis revealed no significant relationship between total symptom presence and GPA Before Injury (r(22) = 0.31, p = 0.16); GPA During Injury (r(26) = 0.17, p = 0.42); or GPA After Injury (r(18) = 0.30, p = 0.23). Therefore, no further linear regression analysis was completed.

Discussion

This study allowed us to study GPA effects surrounding concussive injury in Division I collegiate athletes. Our study revealed a significant effect of concussion on GPA in the semester of injury compared with the semester before injury. Specifically, whereas concussed athletes showed a significant decline in GPA from the semester prior to their injury to the semester during their injury, controls showed no change from one semester to the next. Cognitive demands of academics can potentially exacerbate symptomology of concussion and many students return to academics before complete symptom recovery. This can create a great burden on students, potentially affecting their academic outcomes. This study begins to identify a link between GPA performance and concussion. Identifying students who may suffer academic difficulties post-injury is critical.

Additionally, we saw significant sex differences in GPA in the healthy controls, with females having higher GPAs. This is consistent with previous literatures showing that females tend to have higher GPAs compared to males, supporting our use of sex in the statistical analyses. In fact, electroencephalography (EEG) studies have shown some sex differences in brain activation patterns, especially throughout development. Specifically, girls seem to have a maturational lag in EEG compared to boys, however, this seems to disappear around the time of adolescence. However, concussed males and females did not differ in GPA change in response to concussion. The potential link between the normal trajectory of brain activation patterns in different sex and academic issues arising due to concussion warrant future exploration as well as sex differences in response to concussive injury.

Offering proper support and accommodations for these students, including cognitive rest, extension of deadlines, different academic settings or a note takers, among other possibilities, could potentially assist students and prevent academic disturbances from happening in the semester of injury. Adverse academic effects with no support may even be linked to the onset of depression and anxiety or the loss of scholarship. Academic demands, particularly at the collegiate level at a Division I university, are great, so proper support needs to be offered.

Further work is needed to explore the potential link between these GPA findings, psychosocial influences, and neurobiological processes using more advanced technologies including magnetic resonance imaging (MRI) or EEG. One potential hypothesis for these GPA differences linked to concussion findings is the neural efficiency concept. This hypothesis claims that more intelligent individuals show more efficient brain functioning than less intelligent individuals, and this brain functioning is a function of both intelligence and task demands. This study is not without limitations. It is a relatively small sample size with a variety of sports included. Additionally, when searching medical records, only limited information about the participants was available to us (age, sex, sport, date of first injury).

Table 4. Sex differences in GPA at three timepoints.

|                | Control         | Concussed       |
|----------------|-----------------|-----------------|
|                | N   | Mean  | t   | p    | N   | Mean  | t   | p    |
| GPA Before     |     |       |     |      |     |       |     |      |
| Male           | 12  | 2.755 | −2.449 | 0.026 | 11  | 3.177 | −0.286 | 0.779 |
| Female         | 18  | 3.296 | 11   | 3.226 |
| GPA During     |     |       |     |      |     |       |     |      |
| Male           | 12  | 2.710 | −3.488 | 0.003 | 12  | 2.689 | −0.612 | 0.547 |
| Female         | 18  | 3.467 |       |       | 14  | 3.019 |
| GPA After      |     |       |     |      |     |       |     |      |
| Male           | 12  | 2.873 | −2.507 | 0.024 | 6   | 2.815 | −1.571 | 0.154 |
| Female         | 18  | 3.439 |       |       | 12  | 3.252 |

*Significant at p < 0.05

Table 5. Mixed effect model for changes in GPA between groups over time.

| Parameter                 | F     | p     | df1, df2 |
|---------------------------|-------|-------|----------|
| Group                     | 0.047 | 0.828 | 1, 146   |
| Sex                       | 10.269| 0.002 | 1, 146   |
| Time                      | 1.139 | 0.323 | 2, 146   |
| Group by sex interaction  | 3.616 | 0.059 | 1, 146   |
| Group by time interaction | 3.340 | 0.038 | 2, 146   |
| Sex by time interaction   | 0.707 | 0.495 | 2, 146   |

*p < 0.05
concussion). This introduces potential confounding variables that cannot be examined at this time and limits the generalizability of these findings. Future studies should include more detailed background and concussion medical history to examine potential factors or variables that could be interacting with or mediating the differences in GPA seen here. Additionally, further work should be conducted to monitor athletes in both the short term and the long term to examine the effects of concussion on GPA.

Data availability statement
Data is available upon reasonable request to the authors.

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References
1. Langlois JA, Rutland-Brown W and Wald MM. The epidemiology and impact of traumatic brain injury: a brief overview. *J Head Trauma Rehabil* 2006; 21: 375–378.
2. Hall EE, Ketcham CJ, Crenshaw CR, et al. Concussion management in collegiate student-athletes: return-to-academics recommendations. *Clin J Sport Med* 2015; 25: 291–296.
3. Ransom DM, Vaughan CG, Pratson L, et al. Academic effects of concussion in children and adolescents. *Pediatrics* 2015; 135: 1043–1050.
4. NCAA.org – the official site of the NCAA, www.ncaa.org (accessed 18 October 2017).
5. Halstead ME, McAvoy K, Devore CD, et al.; Council on School Health. Returning to learning following a concussion. *Pediatrics* 2013; 132: 948–957.
6. McLeod TCV, Lewis JH, Whelihan K, et al. Rest and return to activity after sport-related concussion: a systematic review of the literature. *J Athl Train* 2017; 52: 262–287.
7. Gibson S, Nigrovic LE, O’Brien M, et al. The effect of recommending cognitive rest on recovery from sport-related concussion. *Brain Inj* 2013; 27: 839–842.
8. Majerske CW, Mihalik JP, Ren D, et al. Concussion in sports: postconcussive activity levels, symptoms, and neurocognitive performance. *J Athl Train* 2008; 43: 265–274.
9. Moser RS, Glatts C and Schatz P. Efficacy of immediate and delayed cognitive and physical rest for treatment of sports-related concussion. *J Pediatr* 2012; 161: 922–926.
10. McCrory P, Meeuwisse W, Dvorák J, et al. Consensus statement on concussion in sport-the 5th international conference on concussion in sport held in Berlin. *Br J Sports Med* October 2016; 51: 838–847.
11. Concussion Diagnosis and Management Best Practices. NCAA.org – the official site of the NCAA, www.ncaa.org/sport-science-institute/concussion-diagnosis-and-management-best-practices (2014, accessed 28 September 2017).
12. Davis GA and Purcell LK. The evaluation and management of acute concussion differs in young children. *Br J Sports Med* 2014; 48: 98–101.
13. Brown NJ, Mannix RC, O’Brien MJ, et al. Effect of cognitive activity level on duration of post-concussion symptoms. *Pediatrics* 2014; 133: e299-304-e304.

14. Iverson GL, Echemendia RJ, Lamarre AK, et al. Possible lingering effects of multiple past concussions. *Rehabil Res Pract* 2012; 2012: 316575.

15. Trinidad KJ, Schmidt JD, Register-Mihalik JK, et al. Predicting clinical concussion measures at baseline based on motivation and academic profile. *Clin J Sport Med* 2013; 23: 462–469.

16. St Clair-Thompson HL and Gathercole SE. Executive functions and achievements in school: shifting, updating, inhibition, and working memory. *Q J Exp Psychol (Hove)* 2006; 59: 745–759.

17. Ransom DM, Burns AR, Youngstrom EA, et al. Applying an evidence-based assessment model to identify students at risk for perceived academic problems following concussion. *J Int Neuropsychol Soc* 2016; 22: 1038–1049.

18. Swanson MW, Weise KK, Dreer LE, et al. Academic difficulty and vision symptoms in children with concussion. *Optom Vis Sci* 2017; 94: 60–67.

19. Iadevaia C, Roiger T and Zwart MB. Qualitative examination of adolescent health-related quality of life at 1 year postconcussion. *J Athl Train* 2015; 50: 1182–1189.

20. Rozbacher A, Selci E, Leiter J, et al. The effect of concussion or mild traumatic brain injury on school grades, national examination scores, and school attendance: a systematic review. *J Neurotrauma* 2017; 34: 2195–2203.

21. Russell K, Hutchison MG, Selci E, et al. Academic outcomes in high-school students after a concussion: a retrospective population-based analysis. *PLoS ONE* 2016; 11: e0165116.

22. Duckworth AL, Shulman EP, Mastronarde AJ, et al. Will not want: self-control rather than motivation explains the female advantage in report card grades. *Learn Individ Differ* 2015; 39: 13–23.

23. Clarke AR, Barry RJ, McCarthy R, et al. Age and sex effects in the EEG: development of the normal child. *Clin Neurophysiol* 2001; 112: 806–814.

24. Olympia RP, Ritter JT, Brady J, et al. Return to learning after a concussion and compliance with recommendations for cognitive rest. *Clin J Sport Med* 2016; 26: 115–119.

25. Haier RJ, Siegel BV, Nuechterlein KH, et al. Cortical glucose metabolic rate correlates of abstract reasoning and attention studied with positron emission tomography. *Intelligence* 1988; 12: 199–217.