

# Effects of a Single Concussion During the School Year on the Academic Performance and Neuropsychological Functioning of High School Athletes

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## Abstract

*There are very few studies examining the effects of sports-related concussion (SRC) on objective measures of school performance, such as grades or test scores. In this research, the grade point averages (GPAs) and scores of the Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT) of athletes who sustained an SRC during the school year were compared with those of athletes who did not have an SRC. Multivariate analysis of variance (MANOVA) revealed a significant linear decline in GPA of both groups across the school year, but indicated no difference in the GPA decline between the concussion and no concussion groups. The GPAs of the concussion and no concussion groups were not significantly different across the school year. Finally, no differences were found between the pre- and post-concussion ImPACT scores of the concussed athletes. This study found that an SRC during the school year did not affect the academic performance or neurocognitive test scores of high school athletes.*

## Keywords

*sports-related concussion, academic, neuropsychological, high school*

## Abbreviations

ADHD = attention-deficit/hyperactivity disorder

GPA = grade point average

HCAMP = Hawai'i Concussion Awareness and Management Program

ImPACT = Immediate Postconcussion Assessment and Cognitive Testing

M = mean

MANOVA = multivariate analysis of variance

n = number

P = probability

SD = standard deviation

SRC = sports-related concussion

## Introduction

The past 2 decades have witnessed the increased incidences of concussion in high school sports with growing concern over the proper management of athletes who sustain a sports-related concussion (SRC).<sup>1,2</sup> The treatment of SRC in young athletes is of concern because post-concussive symptoms, including somatic, cognitive and behavioral difficulties, not only impact return-to-

play decisions for the student-athlete, but can also affect their school performance at this period of their educational development.<sup>3</sup> Some reports suggest that post-concussion symptoms, such as headache and sleep disturbance, may lead to deficits in concentration and school performance. However, these reports offer insufficient evidence to support these claims.<sup>4,5</sup> Other studies observe that those with post-concussion symptoms may suffer difficulties in verbal communication, multitasking, and completing assignments, accompanied with a reported decline in test grades, and class attendance.<sup>6,7</sup> But these assertions suffer from methodological problems, eg, lack of a comparison group or reliance on parent and self reports.

Despite the widespread concerns about the influence of SRCs on the academic functioning of high school athletes, a literature review suggests that studies examining the effects of SRC on objective measures of school performance, such as grades or test scores, are limited.<sup>8</sup> An investigation of high school athletes found that recently concussed athletes as well as those with a history of 2 or more SRCs had significantly lower grade point averages (GPAs) than youth athletes with no concussion history.<sup>9</sup> Researchers collected school grades over 2 years from secondary rugby players in South Africa and found statistically significant decrease in academic performance in the subject of Afrikaans language in students with very mild traumatic brain injury (vmTBI) and mild traumatic brain injury (mTBI), but not among no-contact controls.<sup>10</sup> However, no academic grade differences were found in mathematics, science, or English. The authors of this study acknowledged the limitations of the small sample size of participants (26 vmTBI, 9 mTBI, 10 controls).

In contrast to the paucity of studies of SRC effects on academic performance of high school athletes, there is a substantial body of research that has examined the effects of non-sports-related mTBI on school performance, with multiple reviews concluding that there are minimal or insignificant adverse long-term academic outcomes following mTBI. Review papers include (1) an early comprehensive review of 40 studies (1970-1995) of the relationship between mild head injuries in children and adolescents and academic performance;<sup>11</sup> (2) an addendum review of studies from 1995-1998 of the effects of mild head injury on cognitive, academic, or psychosocial functioning;<sup>12</sup> (3) a review of 428 studies related to prognosis in school performance after mTBI;<sup>13</sup> (4) a meta-analytic review of the

literature (1988 to 2007) on the neurocognitive outcomes after pediatric traumatic brain injury;<sup>14</sup> (5) a review of pediatric studies aimed at the clinical management of mTBI;<sup>15</sup> and (6) a review of studies that examined school grades and national examination scores.<sup>8</sup>

The relationship between neuropsychological functioning and school readiness and performance have been reported with both sports and non-sports head injuries.<sup>8,12,16</sup> However, distinctions between non-sports mTBI and SRC should not be ignored.<sup>17</sup> SRC research typically employ brief neurocognitive instruments, such as the Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT), that provide prompt test results to quickly determine whether an athlete can return to competition. In contrast, with non-sports mTBI, comprehensive neuropsychological test batteries are administered to direct long-term neuro-rehabilitation. Because of these differences, research regarding the effects of non-sports mTBI injury high school students may vary from studies of the consequences of SRC on school performance.

In view of the small number of existing empirical studies of the relation between SRC and academic performance, the present study was designed to provide further objective measures to assess the extent to which an athlete's school functioning, as well as neurocognitive abilities, may be impacted by an SRC during the academic year. The findings generated by this research contribute to the understanding of how an SRC affects an athlete's academic performance.

## Methods

This study used data collected by the Hawai'i Concussion Awareness and Management Program (HCAMP)<sup>18</sup> and the Hawai'i State Department of Education as part of a multi-faceted research effort to examine the effects of SRC on the academic functioning of high school athletes. Approval for the use of the research data was granted by the Hawai'i State Department of Education. This retrospective study was evaluated by the Hawai'i Pacific Health Research Institute's institutional review board and was determined to be exempt.

## Measures

To assess the effects of an SRC on the academic functioning of high school athletes, GPAs, obtained from official school transcripts and provided by the Hawai'i State Department of Education, were employed as a measure of the athlete's school functioning. GPA has long been known as a useful indicator of classroom performances,<sup>19,20</sup> however is rarely found in sports neuropsychological studies. GPAs in this study were obtained from official school transcripts and provided by the Hawai'i State Department of Education. In addition to GPA, the study employed ImPACT,<sup>21</sup> which is a web-based computerized

neuropsychological test battery widely used for the assessment of SRC in high school, collegiate, and professional athletes.<sup>22</sup> ImPACT, collected as part of the HCAMP program, takes approximately 30 minutes to complete and yields five Composite scores, including Verbal Memory, Visual Memory, Visual Motor Speed, Reaction Time, and Impulse Control. ImPACT provides a Total Symptom score based on the Post-Concussion Symptom Scale that consists of 22 commonly reported symptoms (eg, headache, dizziness) rated on a 7-point Likert scale. The ImPACT examination also includes self-reported demographic and health information, such as age, sex, years of education, native language, sport played, prior concussion, history of learning disability, attention deficit disorder, psychiatric illness, and seizures. A more complete description of ImPACT can be found elsewhere.<sup>23</sup>

## Participants

The participants for this study came from a pool of 946 boy and 684 girl athletes from seven high schools randomly selected by the Hawai'i State Department of Education in the 2012-2013 school year. There were 80 participants included in this study (55 boys, 25 girls). Those in the concussion group were 39 athletes (31 boys, 8 girls) who had a single SRC during the school year and who had pre- and post-concussion ImPACT testing. The no concussion group of 41 athletes (24 boys, 17 girls) was selected using a Stat Trek random numbers generator to pull from a large group of athletes who did not sustain a concussion during the school year. SRCs were typically observed in practice or competition by the team staff and directly evaluated by a certified athletic trainer, adhering to the concussion criteria provided by the consensus statement on concussion.<sup>24</sup> A small minority of athletes experienced concussion symptoms sometime after a practice or game. They reported their conditions and were subsequently assessed and diagnosed by the athletic trainer. The athletes participated in various sports, including football, basketball, softball, wrestling, cheerleading, soccer, volleyball, and track and field. The demographic characteristics of the concussion and no concussion groups are shown in Table 1.

Table 1. Demographic Characteristics of the Concussion and No Concussion Groups		
	Concussion	No Concussion
Age	14.92 (SD = 1.27)	15.00 (SD = 1.18)
Boys	31	24
Girls	8	17
Prior SRC history	4	0
ADHD history	5	1
Special education history	1	0

## Procedure

The GPAs of the concussion and no concussion groups were obtained for each of the 4 quarters of the entire school year. Online ImPACT baseline testing was administered prior to the athlete's season in small group settings by certified athletic trainers who conducted the standard administration of the examination. In addition to the baseline testing, ImPACT was again administered soon after the SRC. The average days between the injury and post-injury testing was 3.56 ( $SD=1.93$ ), though it should be noted that the post-injury days data were available for only 16 of the 39 athletes who sustained an SRC. The average days between baseline testing and post-concussion testing was 45.70 ( $SD=29.39$ ), based on 30 of the 39 athletes.

## Statistical Analyses

The ages and sex ratios of the concussion and no concussion groups were compared. The dependent variables were the GPA, the 5 ImPACT Composite scores (Verbal Memory, Visual Memory, Visual Motor Speed, Reaction Time, and ImPulse Control), and the Total Symptom score of the participants. MANOVAs were used to compare the GPAs and of the ImPACT measures for within-group to examine any change across time, and between-group differences to compare the GPAs and ImPACT scores of the 2 groups. A MANOVA was calculated to assess pre- and post-SRC ImPACT scores. For the comparisons of GPAs across 4 quarters, an *a priori* statistical significance level was set with Bonferroni correction at  $.05/4 = P < .01$ . For the multiple comparisons of the 6 ImPACT scores, a statisti-

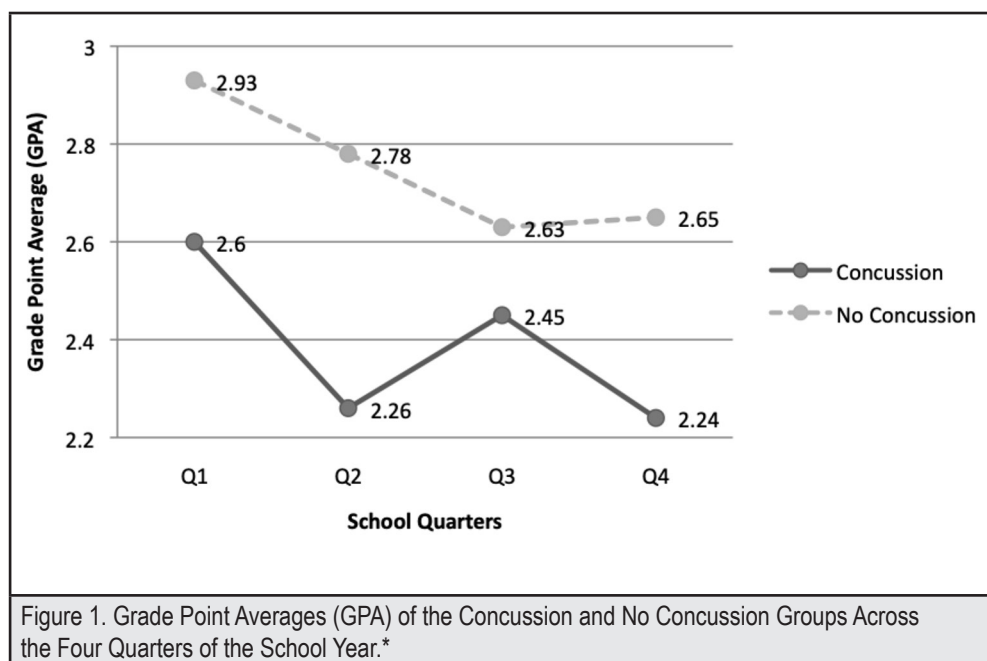
cal significance level was set at  $.05/6 = P < .008$ . The statistical analyses were done with the SPSS Data Analysis Software, IBM Corporation, Armonk, New York.

## Results

Among the 39 athletes in the concussion group, 5 reported a history of attention-deficit/hyperactivity disorder (ADHD), 1 reported a history of special education, and 4 reported a history of a prior SRC. In the no concussion group, 1 reported a history of ADHD, and none reported a history of special education or prior SRC. The difference between the concussion and no concussion group in terms of ADHD history was not significant, ( $\chi^2[1] = 3.80, P > .05$ ).

The mean ages of the 2 groups were as follows: concussion group 14.92 years ( $SD=1.27$ ), and no concussion group 15.00 years ( $SD=1.18$ ). The age difference between the 2 groups was not significant,  $t = .28, df = 78, P = .78$ . The difference in the sex ratios of the 2 groups was statistically significant ( $\chi^2[1] = 4.08, P = .04$ ). Among the concussion group, 4 had a prior history of concussion, while those in the no concussion group had no previous SRC.

MANOVA, using Pillai's trace, indicated no significant between-group GPA difference,  $F(6,73) = 4.26, P = .04$ , across the 4 quarters. MANOVA results, on the other hand revealed significant within-group GPA difference,  $V = .18, F(6,73) = 5.63, P = .002$ , with no interaction effect between groups across the 4 quarters of the school year. (See Figure 1 for GPA data.) Post-hoc tests of



\* The linear decline across time was statistically significant  $F(6,73) = 7.48, P < .001$ . The difference in the GPA decline of the two groups was not significant  $V = .09, F(6,73) = 2.47, P = .007$ .

within-subjects effects indicated a significant linear decline in GPA across time,  $F(6,73)=7.48$ ,  $P<.001$ , with lower grades as the school year progressed. The effect size,  $partial \eta^2=.09$ , was medium.<sup>23</sup> MANOVA, using Pillai's trace, showed no difference between the concussion and no concussion athletes in the decline of GPA across the school year,  $V=.09$ ,  $F(6,73)=2.47$ ,  $P=.007$ . The linear GPA declines of the Concussion and No Concussion groups are shown in Figure 1. MANOVA, using Pillai's trace, indicated no significant between-group difference in baseline ImPACT scores,  $V=.18$ ,  $F(6,73)=2.72$ ,  $P=.02$ . Finally, no differences were found between the pre- and post-SRC ImPACT scores,  $V=.01$ ,  $F(1,37)=.39$ ,  $P=.54$ , of the Concussion athletes. The means and standard deviations of the pre- and post-SRC ImPACT scores appear in Table 2.

## Discussion

This study provided objective measures of academic performance in high school athletes following an SRC, by utilizing the student athlete's GPA. The results revealed (1) no difference between the two groups in GPAs across the school year; (2) a significant linear decline in within-group GPA across time for both the concussion and no concussion groups, with lower grades as the school year progressed; (3) no difference between the 2 groups in the decline of GPA across the school year; and (4) no difference between pre- and post-concussion ImPACT scores of the concussion athletes.

Across the school year, the GPAs among the concussion group and the no concussion group were not significantly different. A previous study similarly found that the GPAs of a concussion and a control group of high school athletes did not differ significantly.<sup>25</sup> These results concur with the vast research literature on non-sports-related mTBI that indicated insignificant effects on school learning.<sup>8,14,15</sup> Nonetheless, the absence of differences in the academic and neuropsychological performances in this group of athletes should not imply that SRCs are benign and do not result in lasting neuropsychological sequelae. A small subset of athletes may exhibit persistent learning and neurocognitive effects due to their head injury, as the recovery pattern from a concussion can vary from individual to individual.<sup>2</sup>

This study revealed a significant within-group linear decline in GPA across the school year, while showing no differences in the decline over time between the concussion and no concussion groups. These data were consistent with a large-scale non-sports mTBI study in Canada that found that both concussion and non-concussion matched students had lower adjusted GPA over time, i.e., from one year to the next; and that there was no significant difference in GPA change between the concussed and non-concussed students.<sup>16</sup>

The GPA is a global index of school performance but does not provide grades in specific subjects, such as mathematics or language arts. Thus, the overall GPA index may conceal specific

Table 2. Pre- and Post-SRC ImPACT Scores of the Concussion Group\*

	Pre-SRC n = 39	Post-SRC n = 39
Score Category	Mean (SD)	Mean (SD)
Verbal Memory	80.41 (9.13)	76.85 (14.79)
Visual Memory	73.13 (12.08)	68.67 (13.73)
Visual Motor Speed	33.54 (6.26)	33.87 (7.95)
Reaction Time	0.62 (0.10)	0.68 (0.18)
Impulse Control	9.13 (6.26)	8.87 (5.62)
Total Symptom	12.46 (17.29)	18.23 (14.71)

Abbreviations: SRC = Sports-related Concussion, ImPACT = Immediate Post-Concussion Assessment and Cognitive Testing

\* MANOVA indicated no statistical significance between the pre- and post-SRC ImPACT scores,  $V=.01$ ,  $F(1,38)=.23$ ,  $P=.63$ .

academic dysfunctions. A recent large-scale non-sports-related research of 8240 high school students (1709 concussed, 6531 non-concussed) found that concussion did not have deleterious effects on GPA, although small but statistically significant reductions were seen in social studies grades among students following a concussion.<sup>16</sup> Grades in specific school subjects were not obtained in this study.

## Limitations

Limitations with this study include the following: (1) The relatively small sample size of high school athletes was a serious shortcoming that probably resulted in lower statistical power with an inability to discern subtle academic consequences following a concussion. (2) Individual quarterly GPAs that were most proximate to an athlete's SRC were not analyzed, which could have provided a more sensitive measure of a student athlete's concurrent performance in the classroom. (3) While GPAs present a valuable index of academic functioning, other measures of school functioning, such as school achievement test scores, aptitude test results, and teacher ratings of classroom performance, can offer additional insight into the possible consequences of concussion on the student athletes. (4) It is not known if all of the reported concussions occurred during a sports activity. A few may have been sustained outside the sports setting and were not SRCs. (5) ImPACT was administered, on the average, 3.56 days after the SRC, but the post-injury duration data were available for only 16 of the 39 athletes. It is conceivable that several of the cohort of concussion athletes were tested a week or longer after the head injury and, thus, would not be expected to display the acute evidence of SRC sequelae.<sup>26</sup> This may have affected the pre- and post-concussion ImPACT comparisons in this study. (6) Although the identification of an SRC was made by athletic trainers adhering to standard concussion protocol, there was no formal checklist or recording of pertinent symptoms. Thus, some variability in the application of diagnostic criteria could not be avoided or ascertained.



## Conclusion

The effect of SRCs on the school learning of high school athletes is a major concern for the athletes, parents, school teachers and administrators, and sports staff. The present findings suggested that an SRC did not affect the GPAs or neurocognitive test scores of athletes during the school year. This is one of the few SRC studies to date that employed an objective measure of academic performance, the GPA of athletes, to assess the effect of an SRC, encouraging future research to examine other measures of academic performance, such as grades in specific subjects, school achievement test scores, and aptitude test results.

## Conflict of Interest

None of the authors identify a conflict of interest.

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