

Physician recommended school accommodations and student outcomes following a mild traumatic brain injury among youth with persistent post-concussive symptoms

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Abstract.

BACKGROUND: Post-concussion return-to-learn (RTL) guidelines include implementation of school accommodations. Yet, little is known about physician recommendations for school accommodations and their impact, particularly among youth experiencing persistent post-concussive symptoms (PPCS).

OBJECTIVE: We examined the association between physician recommended school accommodations and student outcomes among youth experiencing PPCS.

METHODS: Data from a randomized comparative effectiveness trial was used. Physician recommended school accommodations (≤ 90 days post-injury) were collected via chart abstraction. Grade point average was extracted from school records. Reports of problems at school, concussion symptoms, health-related quality of life (HRQOL), anxiety symptoms, and depressive symptoms were collected by survey (at baseline, three months, and 12 months post study entry).

RESULTS: Of 200 participants ($M_{\text{age}} = 14.7$, 62% female), 86% were recommended school accommodations. Number of recommended school accommodations was positively associated with number of school problems at three months (aRR 1.18, 95% CI:1.12–1.24) and 12 months (aRR 1.11, 95% CI:1.05–1.18). No significant associations were found between recommended school accommodations and GPA, HRQOL, anxiety symptoms, or depressive symptoms.

CONCLUSIONS: Physicians recommend more school accommodations for students experiencing more school problems post-concussion. Appropriate implementation of RTL recommendations made by physicians by fostering partnerships among physicians, students, and schools may be needed to achieve student-centered RTL.

Keywords: Traumatic brain injury, concussion, school accommodations, physician recommendations, return to learn

1. Background

Each year, an estimated 1.1 million to 1.9 million sports- and recreation-related concussions (SRC) occur among children in the United States (US)

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(Bryan, Rowhani-Rahbar, Comstock, & Rivara, 2016). Mild traumatic brain injury, including concussions, are associated with emotional, physical, and cognitive symptoms (McCrary et al., 2017). Although concussion symptoms typically resolve within two to four weeks after injury, some youth experience persistent post-concussive symptoms (PPCS) for months (Graham, Rivara, Ford, & Spicer, 2014).

Best practices in concussion focus on symptom identification and management with the goal of facilitating a safe resumption of activities, including return-to-learn (RTL) or return-to-school (Lumba-Brown et al., 2018; McCrary et al., 2017). However, RTL may be negatively affected by post-concussive symptoms (Neelakantan et al., 2020), and students with more numerous or severe symptoms, including those with persistent symptoms, may experience symptom exacerbation with RTL (Silverberg et al., 2016). Current guidelines also suggest minimizing absence from school, as prolonged rest lengthens recovery time (Thomas, Apps, Hoffmann, McCrea, & Hammeke, 2015). The importance of finding a balance for students between rest and activity is reflected in the 2018 Center for Disease Control and Prevention Guideline, which provides a strategy for assisting students in a gradual return to full school activities while monitoring symptoms and implementing appropriate school accommodations (Lumba-Brown et al., 2018).

Healthcare providers can play an important role in guiding students back to RTL and advising on needed accommodations following concussion. School accommodations may include attendance modifications (no school, half-day), providing breaks as needed, decreasing student workload (reducing homework, extra assistance), addressing visual and auditory stimuli (allowing sunglasses/earplugs, additional time for transition between classes), or implementing a 504 Plan (Halstead et al., 2013; Howland, Hackman, Torres, Campbell, & Olshaker, 2021). A 504 plan is a formal process carried out by publicly funded schools, as part of a United States Rehabilitation Act of 1973, to provide appropriate aids and services designed to meet the needs of students with disabilities (Halstead et al., 2013). Factors considered for recommendations may include symptoms, age, history of concussion, and prior learning difficulties (Lumba-Brown et al., 2018). With a wide variation in state-level RTL legislation and school-level compliance to national RTL recommendations (Olympia, Ritter, Brady, & Bramley, 2016; Thompson et al., 2016), physician recommendations may

offer an opportunity to intervene with appropriate RTL protocols.

Students with concussion are at risk for unfavorable short (<3 months) and long (≥ 12 months) term academic performance outcomes (Neelakantan et al., 2020), and cognitive demand with RTL may worsen symptoms (Silverberg et al., 2016). Students may also experience psychological impairments such as depression and anxiety immediately or after RTL (Yrondi, Brauge, LeMen, Arbus, & Pariente, 2017). However, a 2019 study found that students with concussion who returned to school find reduced attendance requirements, excused non-participation in physical education classes, and open communication with teachers to be very helpful in their RTL (Russell, Selci, Black, Cochrane, & Ellis, 2019). Hence, short- and long-term academic, symptomatic, and psychological outcomes following school accommodations are interests of study. Appropriate accommodations supporting students may modify the extent of impairments. However, studies supporting the ideal management of RTL are limited (Lumba-Brown et al., 2018), and the effectiveness of school accommodations on concussive symptoms and student outcomes, particularly among youth experiencing PPCS, is understudied (DeMatteo, Bednar, Randall, & Falla, 2020). The purpose of this study was to examine physician recommendations for academic accommodations and associations with short- and long-term student outcomes among youth experiencing PPCS.

2. Methods

2.1. Overview and study population

This study used data from the CARE4PCS II study, a randomized comparative effectiveness trial to assess whether adolescents aged 11–18 years with PPCS following a sports injury demonstrate better outcomes when receiving a collaborative care intervention versus usual care (McCarty et al., 2019). Parent-child dyads were recruited from subspecialty clinics (sports medicine, neurology, rehabilitation medicine) in Western Washington from March 2017–May 2019, with follow-up for 12 months after study entry. Adolescents with at least three PPCS persisting for ≥ 1 and < 9 months after injury were eligible if they and a parent could read and speak English. Youth were ineligible if they had a diagnosis of schizophrenia or psychosis, presented with active

and acute suicidal ideation, or suffered spinal cord or other severe injuries that prevented participation. Adolescents were not excluded if they reported prior concussions.

Assent and consent were collected from the youth and parent, respectively, at study entry. Follow-up surveys at three and 12 months after study enrollment were collected by research staff using online or telephone surveys of parents and children. Data were collected using Research Electronic Data Capture (REDCap), a secure, web-based application. More information on study methods is available elsewhere (McCarty et al., 2019). All CARE4PCS II study procedures were approved by the Seattle Children's Hospital Institutional Review Board (IRB; protocol number STUDY00000437).

2.2. Measures

2.2.1. School accommodations

Physician recommended school accommodations were collected via medical chart abstraction. Data were abstracted for initial and, if applicable, return visits at the index clinic for the index injury. Data were collected on any visits that may have occurred prior to study enrollment up to the 12 month assessment. Visits that occurred ≤ 90 days post-injury were included

Table 1

Categorization of school accommodations noted in clinical charts of youth with concussions

Accommodation category	Definition/specific accommodations noted in clinical chart
Non-specific	"non-specific", "meet with school counselor"
Limited academic adjustment	"breaks as needed", "access to water and snacks", "accommodation for PE", "early or late transition between classes", "limit in class screen time", "allow for sunglasses or earplugs"
Expanded academic adjustment	"alternative method for obtaining class notes or taking tests", "extra time on assignments and/or tests"
Academic accommodation	"change in assignments and/or homework expectations", "alternative method for grading or showing mastery of concepts"
Academic schedule modification	"excused absences", "no school", "part-time school days", "plan to slowly resume full-time school"
504 plan	The 504 plan provides a formal plan for a student who is not eligible for special education under an IEP but who requires accommodations in regular education on the basis of medical need

in the present study. Chart data included information on whether and which school accommodations were recommended by what medical specialty at the clinic visit. As seen in Table 1, the 17 potential recommendations that were recommended by physicians were divided into six separate categories based on prior definitions (Halstead et al., 2013; Howland, Hackman, Torres, Campbell, & Olshaker, 2021): 1) non-specific, 2) limited academic adjustment, 3) expanded academic adjustment, 4) academic accommodation, 5) academic schedule modification, and 6) 504 plan.

Both the number and categories of recommended school accommodations were examined in these analyses. The number of school accommodations was also categorized into a dichotomous variable (0–3, >4) based on a data-driven cutoff using the median recommended number of accommodations (four).

2.2.2. Health behavior inventory (HBI)

The 20-item HBI was used to assess adolescent symptoms on a four-point scale (0 = never; 3 = often) at baseline and three and 12 months after study entry. HBI items contribute to two subscales (cognitive, somatic) and a total score, with higher scores indicating a higher degree of symptoms. This study used a youth-report version with established validity and reliability among adolescents with sports injuries (Ayr, Yeates, Taylor, & Browne, 2009).

2.2.3. Patient health questionnaire-9 (PHQ-9)

The nine-item PHQ-9 was used to assess depressive symptom severity using a four-point scale (0 = not at all; 3 = nearly all the time) at baseline, three months, and 12 months after study entry, with higher scores indicating a higher degree of depressive symptoms (Kroenke, Spitzer, & Williams, 2001). This study used a youth-report version with established validity and reliability in pediatric populations (Richardson et al., 2010).

2.2.4. Pediatric quality of life inventory™ (PedsQL™)

The PedsQL™ was used to examine health-related quality of life (HRQOL) at baseline, three months, and 12 months after study entry. The PedsQL™ includes 23 items that contribute to four subscales (physical, emotional, social, and school functioning) and a total score (Varni, Burwinkle, Seid, & Skarr, 2003). This study used a youth-report version. Items on the PedsQL™ are reverse-scored and linearly

transformed (0 = 100, 1 = 75, 2 = 50, 3 = 25, 4 = 0). Higher scores indicate better HRQOL. The validity and reliability of the PedsQL™ is well-established (Varni, Seid, & Kurtin, 2001).

2.2.5. Generalized Anxiety Disorder-7 (GAD-7)

The seven-item GAD-7 was used to examine adolescents' self-reported anxiety symptoms during the past two weeks using a four-point scale (0 = not at all; 3 = nearly every day) at baseline, three months, and 12 months after study entry, with higher scores indicating greater symptoms or severity (Löwe et al., 2008).

2.2.6. Grade point average (GPA)

School records, including GPA, were obtained at baseline, six months, and 12 months after injury using mail and email initially, followed by phone calls and text messages. At baseline, school records were obtained for 163 participants (79 intervention group, 84 usual care group). At 12 months, school records were obtained for 170 participants (85 in each group). For all students, GPA was recorded from report cards and school transcripts using a 0.0 to 4.0-point grading scale (e.g., A+ or A = 4.0, A- = 3.7, B+ = 3.3, B = 3.0). For elementary school students, GPA was based on three possible subjects: Social Studies/History, English/Language Arts, and Math. In cases where grading scales included adjectives as a measure of academic performance, criteria were converted to a 4.0-point grading scale. For example, "Outstanding/Exceeding grade-level expectations" = 4.0, "Good/Meeting grade-level expectations" = 3.0, "Satisfactory/Approaching grade-level expectations" = 2.0, and "Needs Improvement/Below grade-level expectations" = 1.0. For middle and high school students, all subjects in the grading period were combined for the GPA calculations.

2.2.7. School problems

New or worsening school problems were assessed as part of the Concussion Learning Assessment and School Survey (CLASS) questionnaire (Gioia et al., 2020) at baseline, three months, and 12 months after study entry. The CLASS was completed by parents to assess the youth's academic functioning following concussion. New or worsening school problems included 14 possible items such as difficulty studying for tests, difficulty taking notes, easily distracted during class, headaches interfering classwork, easily

tiring during school day, difficulty understanding material, and homework is taking longer.

2.2.8. Baseline demographics and medical history

At study entry, parents reported on adolescent age, sex (male, female), race, ethnicity, grade (elementary, middle, or high school), and whether they had attention deficit hyperactivity disorder (ADHD), a prior learning disability, history of concussion, type of sport being played at time of most recent concussion injury (if applicable) or had received special education services (IEP or 504 plan). Parents also reported on their own education level, household income, and insurance type (Medicaid or CHIP, Medicare, private insurance, self-pay/none, other).

2.3. Statistical analysis

Differences between adolescents who were recommended 0–3 accommodations and those who were recommended four or more were examined for baseline demographic, prior concussion/learning disability, and pre-injury functioning variables using chi-square tests for categorical variables and *t*-tests for continuous variables.

Next, the categories of recommended school accommodations and the number of recommended school accommodation categories were evaluated for all participants, and for each sequential visit within the first 90 days post-injury.

We assessed the associations between recommended school accommodations and student outcomes. Student GPA was examined at six months and 12 months post-concussion. Survey data including the reported number of problems at school and functional outcomes (HBI, PHQ-9, GAD-7, PedsQL™), were examined at three and 12 months post study enrollment. Outcomes were assessed using multivariable linear regression models for continuous outcomes or Poisson regression models for count outcomes, while adjusting for school grade, prior utilization of special education services, intervention status, prior learning disability/ADHD, days between injury to study entry, and baseline HBI score. Adjusted coefficients or relative risk and their 95% confidence intervals were presented.

All analyses were conducted using SAS Software Version 9.4 (SAS Institute Inc., Cary, NC, USA) and Stata Statistical Software Release 16 (StataCorp LLC, College Station, TX, USA).

3. Results

Of the 200 adolescents, 62.0% were female and 82.0% were White (Table 2). The mean age was 14.7 years (SD = 1.7) and approximately two-thirds were high school students. Sixty eight percent of the adolescents had parents who completed a bachelor's degree or higher and 84% carried private medical insurance.

Days from injury to study entry was significantly and negatively associated with the number of recommended accommodation categories (0–3 versus ≥ 4 categories) within 90 days after the injury ($p < 0.001$). Most evaluations were conducted by Sports Medicine clinicians (84%). Analysis across medical specialties was not conducted due to overlap of specialties that the adolescents consulted. No other significant differences by number of accommodation categories were detected.

Among the adolescents experiencing PPCS, 14% ($n = 28$) did not receive recommendations for school accommodations by a physician within 90 days post-injury: either by not visiting a clinic within the first 90 days of injury or not receiving recommendations at clinic visits. However, among those who were recommended for school accommodations, a majority (70%) received recommendations across four or more categories of accommodations (Table 3). The mean number of recommended accommodation categories was 3.7 (SD = 1.8) at the first visit, and generally decreased as the number of visits increased (Table 3). The number of adolescents visiting the clinic also decreased with increasing visits. Among the school accommodation recommendations made at the first visit, the most frequent were non-specific (83.8%; physician recommended “non-specific” and/or “meet with school counselor”) and the least frequent were 504 plans (10.3%). However, the proportion of participants with recommendations for 504 plans increased for those who continued to have clinic visits.

Table 4 presents the associations between recommended school accommodations within 90 days post-injury and student outcomes at three months after study entry, adjusted for school grade, group assignment, prior learning disability/ADHD, prior utilization of special education services, days from injury to study entry, and baseline HBI scores. More school accommodation recommendations were associated with increased count of school problems as reported on the CLASS questionnaire at three months after study entry (aRR 1.18, 95% CI: 1.12–1.24). Adolescents who received ≥ 4 recommendations also

experienced more school problems compared to those who received 0–3 recommendations for school accommodations at three months after study entry (aRR 1.98, 95% CI: 1.59–2.47). Recommendations for all six categories of accommodations were positively associated with the number of problems at school reported at the three month time point. No significant associations were found between the recommended school accommodations and student evaluations of concussion-related symptoms, depression, anxiety, and HRQOL at three months post study entry.

Table 5 presents the adjusted associations between recommended school accommodations within 90 days post-concussion and student outcomes at 12 months after study entry. The number of recommended accommodations was positively associated with the count of reported problems at school (aRR 1.11, 95% CI: 1.05–1.18). Adolescents who received ≥ 4 recommendations for accommodations also reported more problems at school at 12 months post study entry compared to those who received 0–3 recommendations (aRR 1.40, 95% CI: 1.08–1.80). Recommendation categories were significantly associated with the number of reported problems at school for “Expanded academic adjustments” (aRR 1.79, 95% CI: 1.34–2.38), “Academic accommodation” (aRR 1.72, 95% CI: 1.29–2.30), and “Academic schedule modifications” (aRR 1.57, 95% CI: 1.21–2.02). Receiving recommendations across ≥ 4 (vs. 0–3) accommodation categories was positively associated with HBI scores reported at 12 months post study entry (adj coeff 3.43, 95% CI: 0.08–6.78). No significant associations were detected between recommended school accommodations and student evaluations of depression, anxiety, and HRQOL.

Recommended accommodations within 90 days of concussion were not significantly associated with student GPA at six or 12 months post-concussion (adj coeff = -0.04, 95% CI: -0.09–0.01; adj coeff = -0.03, 95% CI: -0.08–0.02).

4. Discussion

This study demonstrated a positive association between the number of physician recommended school accommodations and the number of reported school problems at three and 12 months after study entry among adolescents with PPCS. During the first 90 days after concussion, the number of adoles-

Table 2
Participant characteristics by number of recommended accommodation categories (0–3, ≥4) within 90 days post-concussion

Participant characteristics at baseline	All n = 200 (%)	0–3 categories n = 60 (%)	≥4 categories n = 140 (%)
Age			
Age(years), Mean(SD ^a)	14.7(1.7)	15.0(1.8)	14.6(1.7)
Sex			
Female	124(62.0)	35(58.3)	89(63.6)
Male	76(38.0)	25(41.7)	51(36.4)
School status			
Highschool	131(65.5)	40(66.7)	91(65.0)
Elementary or middle school	69(34.5)	20(33.3)	49(35.0)
Race			
White	164(82.0)	47(78.3)	117(83.6)
More than one race	17(8.5)	7(11.7)	10(7.1)
Asian, Native Hawaiian, or other Pacific Islander	8(4.0)	3(5.0)	5(3.6)
Black or African American	5(2.5)	1(1.7)	4(2.9)
Other/Unknown	6(3.0)	2(3.3)	4(2.9)
Ethnicity			
Non-Hispanic	177(88.5)	51(85.0)	126(90.0)
Hispanic	17(8.5)	6(10.0)	11(7.9)
Other	6(3.0)	3(5.0)	3(2.1)
Student health scores			
HBI ^b baseline total score, Mean(SD ^a)	31.0(11.4)	31.7(12.6)	30.7(10.9)
PHQ-9 ^c baseline total score, Mean(SD ^a)	9.7(5.8)	10.1(6.3)	9.5(5.5)
PedsQL ^{TMd} baseline total score, Mean(SD ^a)	66.6(15.3)	65.8(16.2)	66.9(14.9)
GAD-7 ^e baseline total score, Mean(SD ^a)	7.2(5.1)	7.6(5.2)	7.1(5.1)
Intervention group assignment			
Intervention	101(50.5)	29(48.3)	72(51.4)
Usual care	99(49.5)	31(51.7)	68(48.6)
Days from injury to study entry			
Days from injury to study entry, Mean(SD ^a)***	70.1(48.6)	95.1(65.5)	59.4(34.2)
Household income (in US dollars)			
< 50,000	17(8.5)	6(10.0)	11(7.9)
50,000–150,000	88(44.0)	28(46.7)	60(42.9)
> 150,000	83(41.5)	26(43.3)	57(40.7)
Unknown	12(6.0)	0(0.0)	12(8.6)
Parent's highest education			
High school/GED	6(3.0)	2(3.3)	4(2.9)
Some college	21(10.5)	7(11.7)	14(10.0)
Associate's degree	36(18.0)	8(13.3)	28(20.0)
Bachelor's degree	65(32.5)	21(35.0)	44(31.4)
Master's degree	54(27.0)	17(28.3)	37(26.4)
Professional degree	17(8.5)	5(8.3)	12(8.6)
Unknown	1(0.5)	0(0.0)	1(0.7)
Insurance status			
Private	168(84.0)	53(88.3)	115(82.1)
Medicaid	25(12.5)	7(11.7)	18(12.9)
Other	7(3.5)	0(0.0)	7(5.0)
History of concussion			
No	97(48.5)	29(48.3)	68(48.6)
Yes	103(51.5)	31(51.7)	72(51.4)
Prior learning disability/ADHD ^f			
No	173(86.5)	49(81.7)	124(88.6)
Yes	27(13.5)	11(18.3)	16(11.4)
Site of care within 90 days of injury			
Orthopedic/sport medicine	168(84.0)	39(65.0)	129(92.1)
Rehabilitation medicine	20(10.0)	10(16.7)	10(7.1)
Neurology	6(3.0)	6(10.0)	0(0.0)
Adolescent medicine	3(1.5)	3(5.0)	0(0.0)
Other	27(13.5)	17(28.3)	10(7.1)

Notes. ^a“SD”–Standard Deviation. ^b“HBI”–Health Behavior Inventory measures concussion symptom severity; maximum score is 60. ^c“PHQ-9”–Patient Health Questionnaire 9 is a depressive symptom severity module; maximum score is 27. ^d“PedsQLTM”–Pediatric Quality of Life Inventory measures health-related quality of life in children and adolescents; maximum score is 100. ^e“GAD-7”–General Anxiety Disorder 7 measures levels of anxiety; maximum score is 21. ^f“ADHD”–attention deficit hyperactivity disorder. ****p* < 0.001 for categorical number of recommended accommodations.

Table 3
Number of recommended school accommodations and type within 90 days post-concussion

Recommendations for school accommodations	All visits N=200 n(%)	Visit 1 N=185 n(%)	Visit 2 N=157 n(%)	Visit 3 N=97 n(%)	Visit 4 N=46 n(%)	Visit 5 N=13 n(%)	Visit 6 N=4 n(%)
Mean number of accommodation categories recommended							
Mean (SD ^a)	4.0(2.0)	3.7 (1.8)	2(2.2)	1.4(2.0)	1.2(2.0)	0.5(0.9)	1.5(2.4)
Number of visits by number of recommended accommodations							
0-3	60(30.0)	63(34.1)	108(68.8)	79(81.4)	39(84.8)	13(100.0)	3(75.0)
>=4	140(70.0)	122(65.9)	49(31.2)	18(18.6)	7(15.2)	0(0.0)	1(25.0)
Count of categorical accommodations recommended							
Non-specific	162(81.0)	155(83.8)	70(44.6)	38(39.2)	11(23.9)	1(7.7)	0(0.0)
Limited academic adjustment	149(74.5)	135(73.0)	54(34.4)	15(15.5)	9(19.6)	0(0.0)	1(25.0)
Expanded academic adjustment	147(73.5)	130(70.3)	56(35.7)	20(20.6)	9(19.6)	0(0.0)	1(25.0)
Academic accommodation	150(75.0)	131(70.8)	56(35.7)	24(24.7)	8(17.4)	0(0.0)	1(25.0)
Academic modification	133(66.5)	119(64.3)	48(30.6)	25(25.8)	6(13.0)	1(7.7)	1(25.0)
504 plan	54(27.0)	19(10.3)	29(18.5)	18(18.6)	10(21.7)	4(30.8)	2(50.0)

Notes. ^a“SD” - Standard Deviation.

Table 4

Adjusted^a associations of recommended school accommodations within 90 days post-concussion and student outcomes at 3 months after study entry (N = 200)

Recommendations for school accommodations	Numbers of school problems adj RR ^f (95% CI)	HBI ^b adj coeff ^g (95% CI)	PHQ-9 ^c adj coeff ^g (95% CI)	GAD-7 ^d adj coeff ^g (95% CI)	PedsQL TM ^e adj coeff ^g (95% CI)
Number of accommodation categories recommended					
Continuous	1.18(1.12,1.24)*	0.34(-0.43,1.11)	0.04(-0.33,0.42)	-0.01(-0.33,0.32)	-0.31(-1.34,0.72)
0-3	reference	reference	reference	reference	reference
>=4	1.98(1.59,2.47)*	1.79(-1.83,5.41)	0.50(-1.15,2.15)	-0.13(-1.47,1.21)	-2.28(-6.81,2.25)
Categories of recommended accommodations					
Non-specific	2.01(1.54,2.62)*	-0.67(-4.71,3.37)	-0.51(-2.45,1.44)	-0.42(-1.92,1.08)	-1.96(-6.92,2.99)
Limited academic adjustment	1.67(1.33,2.09)*	0.91(-3.05,4.88)	0.52(-1.21,2.25)	0.12(-1.24,1.48)	-2.87(-7.50,1.76)
Expanded academic adjustment	1.70(1.36,2.13)*	2.40(-1.05,5.85)	0.72(-0.90,2.34)	0.05(-1.31,1.40)	-1.11(-5.71,3.49)
Academic accommodation	1.81(1.44,2.27)*	1.47(-2.15,5.09)	0.57(-1.10,2.24)	-0.46(-1.92,1.00)	-0.24(-5.04,4.55)
Academic schedule modification	1.61(1.31,1.98)*	1.36(-1.87,4.59)	-0.05(-1.63,1.53)	0.03(-1.31,1.38)	-1.15(-5.37,3.07)
504 plan	1.81(1.49,2.20)*	1.24(-2.29,4.77)	-0.38(-2.05,1.30)	0.45(-1.01,1.92)	0.52(-3.96,5.00)

Notes. ^aAdjusted for school grade, intervention group assignment, prior learning disability/ADHD, prior utilization of special education services, days from injury to study entry, and baseline HBI scores. ^b“HBI”–Health Behavior Inventory quantifies concussion symptom severity. ^c“PHQ9”–Patient Health Questionnaire 9 is a major depressive disorder module. ^d“GAD7”–General Anxiety Disorder 7 measures levels of anxiety. ^e“PedsQLTM”–Pediatric Quality of Life Inventory measure health-related quality of life in children and adolescents. ^f“adj RR”–adjusted relative risk for count variables. ^g“adj coeff”–adjusted coefficient from linear regression for continuous variables. **p* < 0.05.

cents with repeat visits decreased and adolescents received progressively fewer school accommodation recommendations, but the proportion of recommendations for formal 504 plans increased for students who continued to have clinic visits. There was no relationship between recommendations for school accommodations made by physicians and GPA, concussion symptoms, depression, anxiety, and HRQOL outcomes. Collectively, these findings support a role for physicians in supporting RTL efforts and suggest the need for future work examining how physician recommendations are implemented in schools.

Research indicates that adolescents who RTL without the needed rest or RTL accommodations take

longer to recover and experience exacerbated symptoms after concussion (Brown et al., 2014, Silverberg et al., 2016). Therefore, our finding that adolescents who report more problems post-concussion received more physician recommendations for RTL accommodations suggests that students who need more accommodations were recommended to receive them. Since there is large variation in concussion guidelines for RTL accommodations and few schools have formal RTL policies, teachers often rely on physician recommendations for RTL (Bevilacqua et al., 2021; Howland, Hackman, Torres, Campbell, & Olshaker, 2021). Physician assessments and recommendations are also needed for students with

Table 5

Adjusted^a associations of recommended school accommodations within 90 days post-concussion and student outcomes at 12 months after study entry (*N* = 200)

Recommendations for school accommodations	Number of school problems adj RR ^f (95% CI)	HBI ^b adj coeff ^g (95% CI)	PHQ-9 ^c adj coeff ^g (95% CI)	GAD-7 ^d adj coeff ^g (95% CI)	PedsQL TM ^e adj coeff ^g (95% CI)
Number of accommodation categories recommended					
Continuous	1.11(1.05,1.18)*	0.40(-0.40,1.20)	-0.05(-0.45,0.36)	0.10(-0.26,0.45)	-0.20(-1.27,0.88)
0-3	reference	reference	reference	reference	reference
>= 4	1.40(1.08,1.80)*	3.43(0.08,6.78)*	0.60(-1.04,2.24)	0.86(-0.57,2.29)	-2.47(-6.85,1.91)
Categories of recommended accommodations					
Non-specific	1.32(0.99,1.78)	-0.12(-4.25,4.01)	-1.14(-3.22,0.95)	-0.60(-2.26,1.06)	1.00(-4.47,6.46)
Limited academic adjustment	1.10(0.85,1.42)	1.16(-2.62,4.93)	-0.33(-2.11,1.45)	0.31(-1.15,1.77)	-0.59(-5.30,4.11)
Expanded academic adjustment	1.79(1.34,2.38)*	2.22(-1.25,5.70)	0.46(-1.17,2.08)	0.58(-0.84,1.99)	-1.81(-6.21,2.60)
Academic accommodation	1.72(1.29,2.30)*	1.76(-1.76,5.28)	0.31(-1.40,2.03)	0.72(-0.82,2.26)	-0.69(-5.32,3.93)
Academic schedule modification	1.57(1.21,2.02)*	1.07(-2.55,4.69)	-0.17(-1.85,1.50)	0.46(-1.07,1.99)	-0.33(-4.87,4.20)
504 plan	1.28(0.997,1.63)	1.99(-1.97,5.96)	-0.25(-2.11,1.61)	0.36(-1.56,2.28)	-1.34(-6.67,4.00)

Notes. ^aAdjusted for school grade, intervention group assignment, prior learning disability/ADHD, prior utilization of special education services, days from injury to study entry, and baseline HBI scores. ^b"HBI"—Health Behavior Inventory quantifies concussion symptom severity. ^c"PHQ9"—Patient Health Questionnaire 9 is a major depressive disorder module. ^d"GAD7"—General Anxiety Disorder 7 measures levels of anxiety. ^e"PedsQLTM"—Pediatric Quality of Life Inventory measure health-related quality of life in children and adolescents. ^f"adj RR"—adjusted relative risk for count variables. ^g"adj coeff"—adjusted coefficient from linear regression for continuous variables. **p* < 0.05.

concussion because students may underestimate symptoms they are experiencing compared to those who receive formal examinations by physicians (Post, Snedden, Snedaker, Bouton, & Wang, 2021).

We observed no significant associations between categories of recommended accommodations and three month student outcomes including post-concussive symptoms, anxiety symptoms, depressive symptoms, and HRQOL. These results were also reflected in the 12 month outcomes. This may indicate the need to examine how physicians make RTL recommendations, and how recommended RTL accommodations are implemented at schools, both of which were beyond the scope of this study. In the absence of formal RTL school policies, stronger engagement between adolescents, parents, and physicians may be needed to support implementation of concussion related RLT accommodations.

While our sample lacked diversity, our study indicated that the number of school accommodations recommendations did not significantly differ by socioeconomic factors such as parent education, insurance status, race, ethnicity, and household income. However, disparities of post-concussion outcomes across socioeconomic factors are documented in literature (see, e.g., Holmes et al., 2016). This discrepancy may be indicative of a disparity in implementation of recommended accommodations for concussion that result from disparities of resources at the school level (Kroshus, Rivara, Whitlock, Herring, & Chrisman,

2017). Although this study showed that adolescents who accessed physician care received recommendations equally across socioeconomic lines, the implementations of these recommendations may not be equitable across schools. Again, future studies on implementation of school accommodations are needed. A combination of physician involvement, better communication between schools and physicians, and strengthening school implementation of RTL recommendations, particularly at schools with less resources are likely needed to reduce concussion outcome disparities.

This study has both strengths and weaknesses. For instance, the parent study did not limit access to medical specialties for concussion care, which strengthens the study by offering generalizability across medical specialties. Further, we examined six outcomes to understand the effect of physician RTL recommendations on the whole student by including academic, symptomatic, and psychological outcomes. A limitation of the study is that the study lacked student diversity, with the sample of predominately White and high income, which reflects participants in the parent study. Further, the inclusion criterion of at least three PPCS lasting between ≥ 1 and < 9 months after injury resulted in considerable variation in the time between injury and study entry for the sampled youth. The heterogeneity of enrollment time after the injury may have impacted the ability to detect associations of outcomes with recommendations

made ≤ 90 days post-injury. The clinic visits ≤ 90 days post-injury may not have occurred at the same time as the three month post study entry survey measures, making the interpretation of associations difficult. An additional limitation is the lack of data on interdisciplinary rehabilitation approaches where a student with a concussion receives coordinated guidance from a variety of care providers. Finally, recommendations for accommodations made by non-physicians such as athletic trainers and school nurses were not captured in this study, limiting generalizability.

5. Conclusion

Physician recommendations for academic accommodations within 90 days following concussion reflected adolescent needs. However, GPA, concussion symptoms, depression, anxiety, and HRQOL outcomes were not associated with recommended accommodations, suggesting a potential gap between physician recommendations and school implementation. Ensuring appropriate implementation of RTL recommendations through partnerships between physicians, students, and school systems may be needed to achieve student centered RTL and academic achievement following concussion.

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Conflict of interest

The authors have no conflicts of interests to disclose.

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