

Collaborative Care for Adolescents With Persistent Postconcussive Symptoms: A Randomized Trial

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abstract

BACKGROUND AND OBJECTIVES: Postconcussive and co-occurring psychological symptoms are not uncommon after sports-related concussion and are associated with functional impairment and societal costs. There is no evidence-based treatment targeting postconcussive symptoms in children and adolescents. The goal of this study was to test a collaborative care intervention model with embedded cognitive-behavioral therapy, care management, and psychopharmacological consultation. We hypothesized that patients in collaborative care would demonstrate greater reductions in postconcussive, depressive, and anxiety symptoms and improvement in functioning over the course of 6 months, compared with usual care control.

METHODS: Patients aged 11 to 17 years with persistent symptoms ≥ 1 month after sports-related concussion were randomly assigned to receive collaborative care ($n = 25$) or care as usual ($n = 24$). Patients were assessed before randomization and after 1, 3, and 6 months. Groups were compared over time via linear mixed effects regression models.

RESULTS: Adolescents assigned to collaborative care experienced clinically and statistically significant improvements in postconcussive symptoms in addition to functional gains at 6 months compared with controls. Six months after the baseline assessment, 13.0% of intervention patients and 41.7% of control patients reported high levels of postconcussive symptoms ($P = .03$), and 78% of intervention patients and 45.8% of control patients reported $\geq 50\%$ reduction in depression symptoms ($P = .02$). No changes between groups were demonstrated in anxiety symptoms.

CONCLUSIONS: Orchestrated efforts to systematically implement collaborative care treatment approaches for slow-to-recover adolescents may be useful given the reductions in postconcussive and co-occurring psychological symptoms in addition to improved quality of life.



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WHAT'S KNOWN ON THIS SUBJECT: Persistent postconcussive symptoms confer significant impairment in a subset of youth after concussion. Co-occurring psychological symptoms are common and may prolong recovery. Lack of empirical data in support of treatment of postconcussive symptoms places the clinician in a challenging position.

WHAT THIS STUDY ADDS: Adolescents with persistent postconcussive symptoms who received collaborative care, including integrated care management and cognitive-behavioral therapy, displayed a significant reduction in postconcussive symptoms and functional improvement after 6 months as compared with adolescents in usual care.

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Sports-related concussions have galvanized the American public and represent an important public health problem, especially for children and adolescents. Although symptomatic recovery is typically reached within 2 weeks of concussive injury, an estimated 13.7% of school-aged youth remain symptomatic at 3 months.¹ Over time, refractory headache, fatigue, dizziness, and inattention can confer significant functional impairment including executive dysfunction and poor academic performance.²⁻⁴ Affective symptoms, including depression and anxiety, commonly co-occur with cognitive and somatic symptoms and may prolong recovery from postconcussive symptoms, as has been demonstrated in patients with traumatic brain injury and depressive symptoms.⁵⁻⁹ Although it is widely accepted that a variety of biological, psychological, and social factors together contribute to increased risk of protracted symptom duration, the etiology and trajectory of persistent postconcussive symptoms remain poorly understood.¹⁰ Taken together, the complexities of managing persistent postconcussive symptoms in conjunction with comorbid psychological symptoms create a significant burden for injured children and adolescents, their families, and schools.^{2,3,11}

Current clinical paradigms emphasize education about the symptoms of concussion, anticipatory guidance around a gradual return to cognitive and physical activity, psychoeducation, and reassurance of a projected complete recovery.¹²⁻¹⁵ These clinical strategies may be adequate for children at the time of acute symptom presentations but remain unsubstantiated by rigorous clinical trials.^{12,16} No evidence-based guidelines exist regarding care of youth with persistent symptoms (≥ 1 month) from concussion.¹⁷ This lack of empirical data places the treating clinician in a challenging position

where watchful waiting remains the key component of standard care, leaving a gap in active intervention options.¹⁸

Cognitive-behavioral therapy (CBT) has been recommended as a first-line treatment of persistent postconcussive symptoms based on studies with adults after concussion.^{13,19} Robust evidence has documented that CBT is effective in the treatment of adolescent depression, anxiety, and chronic pain.^{20,21} Psychopharmacological management of co-occurring mood disorders requires close coordination and collaboration between physicians with specialized clinical training and experience in traumatic brain injury and child psychiatry.²² Zatzick et al²³ previously established safety of psychotropic medication provision with proper supervision in adolescents with traumatic brain injury. However, CBT, care coordination, and psychopharmacological treatment have not yet been harnessed within a clinical intervention to target postconcussive symptoms and co-occurring depressive and anxiety symptoms.^{24,25}

Collaborative care is a health care delivery model that integrates medical and behavioral health care for patients with chronic disorders in which both physical and psychological symptoms are present, such as sequelae related to traumatic brain injury.^{26,27} Large-scale randomized clinical trials have established the effectiveness of collaborative care interventions that combine care management, CBT, and evidence-based pharmacotherapy in treating pediatric and adult primary care patients with depressive, anxiety, and posttraumatic stress disorders.²⁷⁻²⁹ Given the constellation of somatic, cognitive, sleep, and postconcussive symptoms, collaborative care may be ideal because it can facilitate linkages and coordination across pediatric

primary care, subspecialist sports medicine and rehabilitation, and school-based service delivery sectors. However, no previous study has examined the efficacy of collaborative care treatment of postconcussive symptoms in adolescents.

The current investigation was a randomized controlled trial conducted among adolescents who reported persistent postconcussive symptoms after sports-related concussion. The study was designed to test whether receiving a CBT intervention embedded in a collaborative care treatment model would reduce postconcussive, anxiety, and depressive symptoms. We also hypothesized that intervention patients would demonstrate improved health-related quality of life. The intervention was designed as a stepped-care model whereby adolescents were first provided with care management and CBT; patients' symptoms were monitored, and for those who remained symptomatic, psychopharmacologic consultation was made available.

METHODS

Design, Setting, and Participants

Participants were adolescents ages 11 to 17 years with sports- or recreation-related concussion. The sample was 65% female, with the following racial distribution: 75.5% white, 14.3% other, 8.2% Asian or Pacific Islander, and 2.0% black. Approximately 8% of the sample identified as Hispanic or Latino. All concussions were diagnosed by sports medicine or rehabilitation medicine specialists trained in concussion diagnosis and management. Informed consent and assent were obtained before data collection, and study procedures were approved by the Seattle Children's Institutional Review Board. Recruitment occurred between October 2014 and July 2015.

During active recruitment, a research associate reviewed upcoming visits for patients with a sports-related concussion in the Sports Medicine and Rehabilitation Medicine Clinics at Seattle Children's and the Sports Concussion Program at Harborview Medical Center, clinics that receive referrals from emergency and primary care physicians for management of postconcussive symptoms. If patients were symptomatic ≥ 1 month after the concussion, a research associate subsequently informed the family of the clinical trial and conducted an eligibility screening by phone. Parents were asked to assess the frequency of postconcussive symptoms their children experienced during the preceding week and the week before the injury by using the Health and Behavior Inventory (HBI).³⁰ Patients were eligible to participate if they experienced an onset or increase in frequency of ≥ 3 postconcussive symptoms after a concussion within the past year compared with preinjury parent report. Patients and ≥ 1 parent or guardian were required to be able to read and speak English and to live within commuting distance of the regional children's hospital where assessments and treatment took place. Patients were excluded if they had sustained more severe brain injuries, as documented by any abnormalities demonstrated on computed tomography or MRI. Patients who were actively suicidal or abusing substances or who reported bipolar or psychotic disorders were also excluded. Patients with other preexisting psychological disorders were considered eligible.

Randomization

Randomization to collaborative or usual care treatment groups occurred in a 1:1 ratio according to random assignments that were computer generated by a study biostatistician. Patients were stratified by the

frequency of postconcussive symptoms (0–21 vs 22–60) reported by their parent within the past week via the 20-item HBI. The cutoff of 21 for stratification purposes was chosen based on a median split of HBI scores from a sample of youth with mild traumatic brain injury who had ≥ 3 symptoms, from data provided by the primary author of measure (K. Yeates, PhD, personal communication, 2014). Research associates conducting baseline and follow-up assessments were blinded to intervention or control group status.³¹ The unblinded care manager called families to inform them of their randomization assignment after the baseline assessment.

Collaborative Care Intervention

Patients randomly assigned to the intervention received care management, CBT, and possible psychopharmacological consultation over the course of the 6-month treatment period. Intervention patients were treated for the duration of their symptoms, and treatment was terminated upon symptom resolution or at the end of the 6-month follow-up. Modular CBT targeting postconcussive depressive and anxiety symptoms was delivered by 1 of 5 study therapists (4 PhD-level psychologists and 1 licensed therapist). CBT focused on techniques to encourage increased appropriate activation, including pacing of activities and the use of coping skills, relaxation strategies, sleep hygiene, and positive thinking in the face of symptoms. Health care coordination needs were carried out by the care manager, who communicated with the consulting psychiatrist, primary care physicians, and subspecialists to ensure that individual physical, psychological health, and health care-related concerns were actively addressed. Care management also included advocacy and coordination with the patient's school regarding accommodations and motivational

interviewing to maintain engagement in treatment. A multidisciplinary case conference included a bachelors-level care manager (E.S.), a supervising CBT interventionist (C.A.M.), a pediatrician (F.P.R.), and a supervising MD psychiatrist skilled in the postinjury collaborative care model (D.Z.); this team met weekly to discuss patients randomly assigned to the intervention condition. An expert in pediatric psychopharmacology (R.H.) provided pharmacologic consultation in cases of severe or recalcitrant symptoms that did not respond to psychotherapy when warranted at any time in treatment.

Usual Care Control Condition

Adolescent patients and their parents in the control condition underwent the baseline and follow-up assessments at 1, 3, and 6 months after enrollment. They received usual care organized by the referring clinic concussion specialist. Usual care in our system consisted of a visit initially to a sports medicine trained physician. For youth who were symptomatic beyond 4 to 6 weeks, patients were referred to pediatric rehabilitation medicine. They also usually underwent MRI, with diffuse tensor imaging sequences, and testing by a neuropsychologist. Patients having difficulty with sleep were usually prescribed a hypnotic medication, and patients may have also been provided with a subthreshold exercise program by a physical therapist. Usual care was documented by reviewing the medical chart and parent report of health care utilization outside the hospital over the course of the 6-month study.

Measures

The following set of measures captured the degree of adolescent physical and psychological impairment present at baseline and

1, 3, and 6 months, based on both youth and parent report.

Primary Outcome Measures

Postconcussive Symptoms

The HBI was administered to both youth and parents to assess the presence of postconcussive symptoms. The HBI is a 20-item questionnaire that assesses postconcussive symptoms on a 4-point scale, ranging from “never” to “often,” and yields total scores in cognitive and somatic domains, with higher scores indicating more symptomatic patients. The scale includes youth-report and parent-report versions with established reliability and validity in youth with sports injury.^{30,32}

Depressive Symptoms

The Patient Health Questionnaire (PHQ-9), which includes 9 questions based on *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition* major depression criteria, was administered to assess depressive symptoms.³³ It has been found to have high sensitivity (89.5%) and acceptable specificity (73%) for the diagnosis of major depression in adolescent populations.³⁴ Anxiety Symptoms

The PROMIS-PA8 (version a) asks about the frequency of 8 anxiety symptoms over the preceding 7 days on a 5-point scale, with higher scores indicating more symptoms. The scale includes youth-reported and parent-reported versions with established validity and reliability among adolescents.^{35–37} Health-Related Quality of Life

The Pediatric Quality of Life Inventory (PedsQL) is a 23-item questionnaire that assesses physical, emotional, social, and school functioning, with higher scores indicating greater quality of life.³⁸ The scale includes youth-reported and parent-reported versions with demonstrated validity and reliability, including good

to excellent internal consistency (Cronbach’s $\alpha = 0.88$ for child and 0.90 for parent report).^{38–41} It has successfully been used in youth traumatic brain injury research previously.⁴² A 4- or 5-point difference is clinically meaningful.³⁹

Secondary Outcome Measure

Satisfaction With Care

An item from the Client Satisfaction Questionnaire assessed satisfaction with care: “In an overall, general sense, how satisfied are you with the care you/your child have received?”⁴³ Other Measures

A medical chart review at the end of the study follow-up period provided demographic and health care utilization information. Additional mental health care utilization throughout the course of enrollment was also assessed in a questionnaire administered to both treatment groups.

Statistical Analyses

Moderate to large effect sizes have been observed in a general sample of youth with mild to severe traumatic brain injury.⁴⁴ We calculated that a sample size of 40 would provide adequate power to observe a large treatment effect (partial $\eta^2 = 0.14$). In the current study, we recruited 49 adolescents to compensate for potential dropouts.

We used *t* tests and χ^2 analyses to compare groups at baseline, using $P < .05$ as our threshold for statistical significance. To determine whether patients in the 2 groups manifested different patterns of change in symptoms and functioning over the 6 months after enrollment, we used linear mixed effects regression models.^{45,46} For all dependent variables, we fit models containing time categories (baseline, 1 month, 3 months, and 6 months), treatment group, and treatment group by time interactions. The final models presented include no covariates given the sample size. All outcome

analyses were intent-to-treat and used continuous variables. Effect sizes were calculated with Cohen’s *d*.⁴⁷ Relative risk ratios were calculated to compare collaborative care and usual care groups with respect to high levels of postconcussive symptoms and depression symptom response. We conducted χ^2 analyses to examine differences between groups in treatment satisfaction.

RESULTS

A total of 49 adolescents (mean age = 15.0 years) enrolled in the study. Adolescents randomly assigned to the intervention and control conditions were not statistically different with regard to demographic variables, preinjury health concerns, or clinical profiles at baseline, as indicated with dichotomized variables (Table 1). A total of 57.5% of the adolescents incurred sports-related concussion, and 42.5% sustained recreation-related concussion (eg, being hit by a ball on the playground, trampoline injury), with a higher proportion of youth assigned to collaborative care sustaining sports concussions ($P = .03$). The investigation attained >98% follow-up of the participants at 1, 3, and 6 months (Fig 1).

Intervention Implementation

Of the 25 patients randomly assigned to the intervention, 23 completed the full course of collaborative care treatment over 6 months (1 withdrew from treatment before initiating treatment and remained in the study, 1 withdrew from the study). The median number of CBT sessions received was 8 (range 0–12); 88% of patients received ≥ 4 sessions. One-third of patients received stepped-up care in the form of psychopharmacologic consultation and subsequent medication. Patients receiving collaborative care on

average had 6.2 (SD = 4.6) outpatient concussion-related visits (ie, sports medicine, rehabilitation medicine, neurology).

Usual Care

Among 24 patients assigned to the control condition, 8% saw a psychiatrist, 33% reported visits with a mental health professional, 58% sought treatment from their primary care physician, and 21% sought treatment from another physician. Patients receiving usual care on average had 5.8 (SD = 2.3) outpatient concussion-related visits, including sports medicine, rehabilitation medicine, neurology, and pain medicine visits (range 2–23 visits).

Treatment Outcomes

Intervention patients had clinically and statistically significant improvements in postconcussive symptoms and health-related quality of life outcomes compared with controls (Fig 2 and Table 2). The overall group × time interaction term indicated more improvement in youth-reported postconcussive symptoms over time among intervention than control adolescents ($d = 0.70$). At 6 months after the baseline assessment 13% of intervention patients and 41.7% of control patients reported high levels (HBI ≥ 22) of postconcussive symptoms (relative risk = 0.03). Statistically significant improvements in health-related quality of life were demonstrated by both child and parent report. For functional status at 6 months, PedsQL child report improved a mean of 27.7 in the intervention group and 17.8 for controls (mean difference, 9.8; 95% confidence interval [CI], 0.9 to 18.8), and by parent report PedsQL improved by 33.3 points in the intervention group and 19.3 in the control group (mean difference, 14.0; 95% CI, 4.6 to 23.1).

TABLE 1 Baseline Adolescent Patient Characteristics

Characteristics	% of Patients		
	All Patients (n = 49)	Collaborative Care (n = 25)	Usual Care (n = 24)
Demographic			
Age, y, mean (SD)	15.0 (1.6)	15.1 (1.6)	14.8 (1.7)
Female	65.3	68.0	62.5
Race			
White	75.5	76.0	75.0
Asian or Pacific Islander	8.2	4.0	12.5
Black	2.0	4.0	0.0
Other	14.3	16.0	12.5
Hispanic	8.2	8.0	8.3
Parent married	79.6	80.0	79.2
Parent education			
High school graduate or less	6.1	4.0	8.3
Some college	26.5	28.0	25.0
College graduate	46.9	52.0	41.7
Graduate school	20.5	16.0	25.0
Annual household income			
≤\$50 000	20.4	20.0	20.8
\$50 000–\$100 000	26.5	28.0	25.0
>\$100 000K	46.9	44.0	50.0
Unknown	6.2	8.0	4.2
Preinjury health concerns			
Previous ADHD or LD diagnosis	18.8	16.7	20.8
History of anxiety or depression	37.5	37.5	37.5
History of previous concussion	52.1	41.7	62.5
History of headache	18.8	16.7	20.8
Injury type			
Sports related	57.5	73.9*	41.7*
Recreation related	42.5	26.1	58.3
Clinical profile at baseline			
Median days since concussion (interquartile range)	66.0 (45.0)	60.0 (38.0)	74.5 (59.5)
High postconcussion symptoms ^a	83.7	84.0	83.3
High depressive symptoms ^b	40.8	40.0	41.7
High anxiety symptoms ^c	8.3	0.0	17.4

ADHD, attention-deficit hyperactivity disorder; LD, learning disability.

^a Scores >22 on the HBI.

^b >10 symptoms on the PHQ-9.⁴⁵

^c T-score >65 on the PROMIS-PA8.

* Statistically significant between groups, $P \leq .05$.

A majority of intervention patients (78.3%) demonstrated >50% reduction in depressive symptoms, a metric used in previous collaborative care trials of treatment of depression in adolescents,²⁹ compared with 45.8% of patients in the usual care group (relative risk 1.71 [1.05–2.79]). Depressive symptom outcomes demonstrated a pattern of symptomatic improvement for adolescents who received the collaborative care intervention compared with controls over time, although differences in frequency of symptoms between the 2 groups at

6 months did not achieve statistical significance.

Adolescents who received collaborative care treatment and their parents reported high levels of satisfaction with care (Table 3). A total of 82.6% of intervention patients were “very satisfied” with their care, as compared with 45.8% of patients in the control group ($\chi^2[1] = 6.9, P = .001$). A total of 87% of parents of intervention patients and 29.2% of parents of patients in the control group were “very satisfied” with care ($\chi^2[1] = 16.0, P < .0001$).

There were no reported adverse events.

DISCUSSION

This study provides evidence of the effectiveness of a collaborative care intervention in reducing postconcussive symptoms in a sample of adolescents with prolonged recovery from sports-related concussion. Although patients in both groups showed symptom reduction in the first 3 months, only those who received collaborative care demonstrated sustained improvements through 6 months of follow-up. The large effect size for postconcussive symptom reduction and quality-of-life improvement reported in the collaborative care group compared with the usual care group was greater than the mean effect size for integrated pediatric medical-behavioral health care interventions according to a recent meta-analysis.⁴⁸ Parents of adolescents randomly assigned to collaborative care reported improvement in their children's health-related quality of life that was concordant with that reported by adolescents. Adolescents who received the collaborative intervention were more satisfied with their treatment than those who received usual care, suggesting that this patient population is amenable to behavioral treatment and coordination services offered through care management.

A clinical profile of adolescents with a prolonged postconcussive recovery course emerged, indicating that on average patients were moderately depressed at baseline while displaying anxiety levels on par with mean population levels. At baseline, 84% of enrolled patients reported high postconcussive symptoms, 41% reported high depressive symptoms, and 8% reported high anxiety levels. Low levels of anxiety symptoms in the adolescent patient

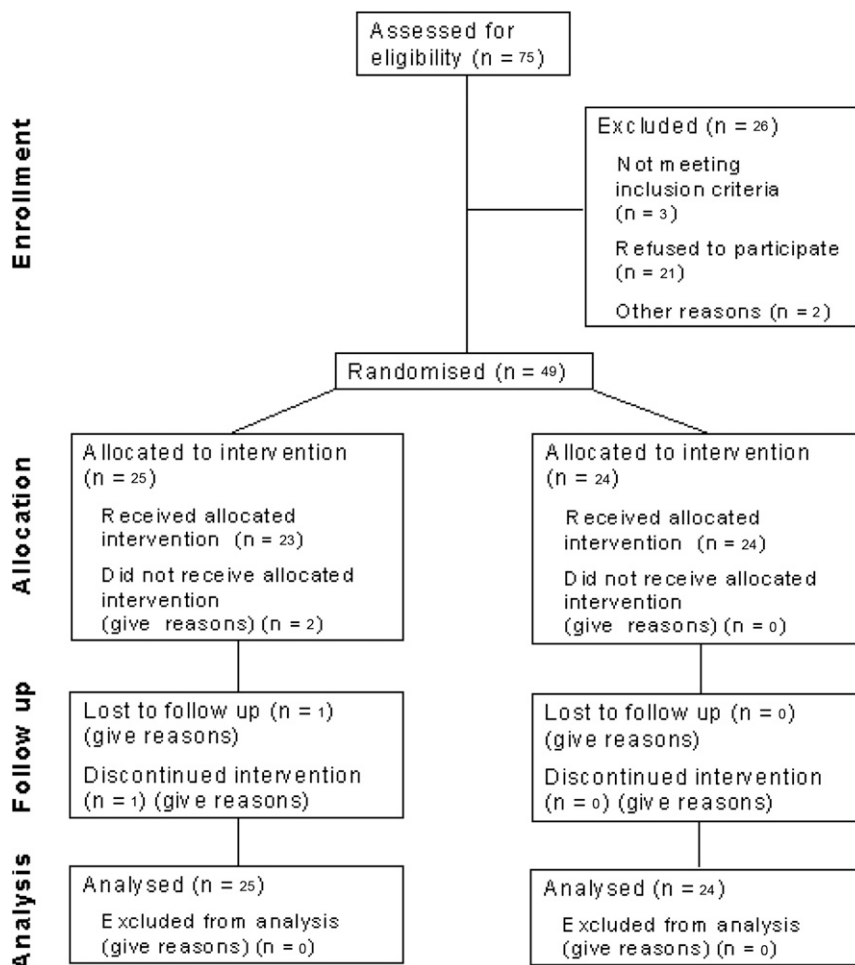


FIGURE 1

Flow of adolescent patients through the randomized clinical trial.

population consistent with the general population may have limited the power to detect significant treatment effects on anxiety outcomes. Clinically significant reduction in depressive symptoms was established at 6 months in the collaborative care intervention group as compared with patients receiving care as usual. No significant group differences were observed over time for anxiety or parental mental health.

This is the first randomized controlled treatment trial of a collaborative care intervention for persistent postconcussive symptoms in the pediatric population. An integrated, personalized treatment approach using a collaborative care model of health care delivery

targeted the full range of postinjury symptoms and comorbidities through CBT and continuous case management services that included advocacy in the school setting as well as stepped-up care coordination and medication consultation to achieve symptom remission. Additional strengths of the study include use of a robust battery of measures that longitudinally tracked symptoms and impairment throughout a 6-month time period, and the high retention of participants.

There were also limitations to the study. The sample was small and drawn from a regional population, including a large proportion of Caucasian girls, which may limit generalizability. Adolescents were

enrolled in the study at variable times since injury, introducing heterogeneity of symptom duration. For this trial, we allowed patients to enroll at any point in their symptom trajectory (≥ 1 month) to reflect a real-world clinical population. Moreover, we used the PHQ-9 to evaluate depressive symptoms, which have some overlap with postconcussive symptoms. We cannot determine which particular components of our intervention were responsible for symptom reduction; nevertheless, a health services approach to providing comprehensive services was intentional and aligned with real-world clinic conditions. Usual care at the regional children's hospital where the study was conducted included multidisciplinary rehabilitative services at pediatric outpatient clinics. It is worth noting that adolescents randomly assigned to the usual care control group displayed symptom reduction over the course of 6 months. However, adolescents who received collaborative care continued to make symptom reduction gains between 3 and 6 months, whereas the symptoms of adolescents in the control group plateaued after 3 months.

Previous studies have established the role of depression in mediating poor outcomes of children with traumatic brain injury.^{10,49} This investigation contributes to an expanding literature on combined medical-behavioral health care in the pediatric setting aimed at improving physical and behavioral health outcomes measured by both symptoms and associated health-related quality of life. Our findings indicate that co-occurrence of depressive symptoms in slow-to-recover adolescents is common and suggests that a continuum of care management, CBT, and pharmacotherapy when necessary is a promising approach for reducing the burden of postconcussive

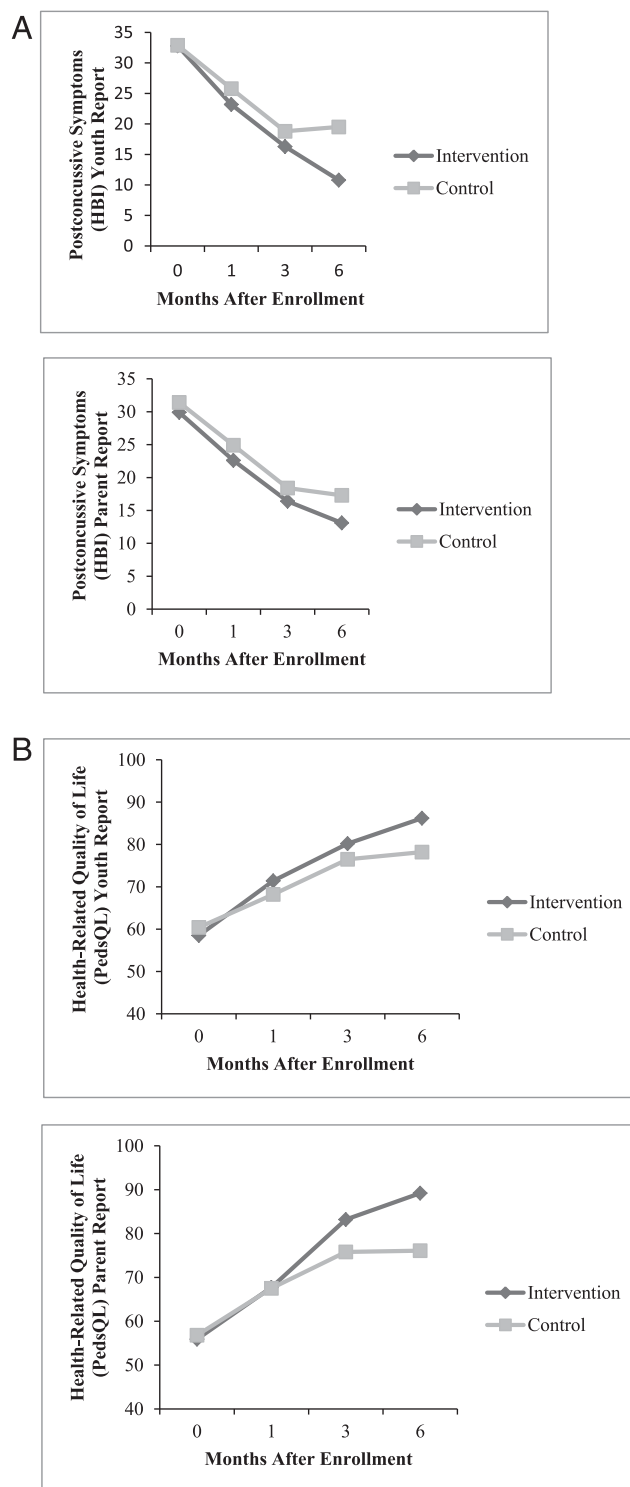


FIGURE 2

Primary outcomes of collaborative care intervention compared with usual care in sample of adolescents with postconcussive symptoms. A, Postconcussive symptoms in collaborative care and usual care group by youth and parent report. B, Health-related quality of life in collaborative care and usual care by youth and parent report.

TABLE 2 Primary Outcomes in Collaborative Care (CC) Versus Usual Care Control (UC) Over Time

Primary Outcomes	Net Mean Difference (95% CI) From Baseline in Intervention Compared With Control Group					
	Baseline Mean (SD)		1 Mo	3 Mo	6 Mo	Effect Size
	CC (n = 25)	UC (n = 24)				
Symptoms						
Postconcussive symptom youth report ^a	32.8 (9.0)	32.9 (12.9)	-2.7 (-9.6 to 4.3)	-2.6 (-9.6 to 4.3)	-8.2 (-15.2 to -1.2)*	0.70
Postconcussive symptom parent report ^a	29.9 (12.5)	31.4 (11.0)	-0.8 (-7.6 to 6.0)	-0.5 (-7.3 to 6.3)	-2.4 (-9.2 to 4.4)	0.20
Depression youth report ^b	9.2 (3.9)	10.4 (6.7)	-0.5 (-3.7 to 2.7)	-0.2 (-3.4 to 3.0)	-2.9 (-6.1 to 0.3)	0.52
Depression parent report ^b	7.8 (4.6)	8.2 (6.7)	-0.2 (-3.2 to 2.8)	-0.7 (-3.6 to 2.3)	-0.7 (-3.6 to 2.3)	0.13
Anxiety youth report ^c	48.4 (8.4)	53.3 (12.5)	3.0 (-2.3 to 8.3)	1.9 (-3.4 to 7.2)	0.3 (-5.0 to 5.7)	-0.04
Anxiety parent report ^c	49.0 (10.2)	52.8 (10.4)	4.1 (-1.9 to 10.1)	1.1 (-4.9 to 7.1)	-0.5 (-6.5 to 5.6)	0.04
Functioning						
Quality of life youth report ^d	58.5 (13.2)	60.4 (15.8)	5.4 (-3.5 to 14.3)	5.9 (-3.0 to 14.8)	9.8 (0.9 to 18.8)*	0.63
Quality of life parent report ^d	55.9 (18.1)	56.8 (17.6)	1.2 (-8.0 to 10.4)	8.4 (-0.9 to 17.6)	13.8 (4.6 to 23.1)*	0.86

^a HBI.^b PHQ-9.^c PROMIS-PAB.^d PedsQL.* *P* < .05.**TABLE 3** Secondary Outcomes in Collaborative Care (CC) Versus Usual Care Control (UC) Over Time

Secondary Outcomes	Net Mean Difference (95% CI) From Baseline in Intervention Compared With Control Group					
	Baseline Mean (SD)		1 Mo	3 Mo	6 Mo	Effect Size
	CC (n = 25)	UC (n = 24)				
Parental depression ^a	4.6(3.6)	3.4 (4.1)	-1.0 (-2.8 to 0.8)	-1.2 (-3.0 to -0.6)	-0.4 (-2.2 to 1.4)	0.13
Parental anxiety ^b	50 (9.9)	54.6 (9.2)	5.7 (0.5 to 10.9)*	1.4 (-3.8 to 6.6)	2.2 (-3.0 to 7.5)	-0.25

^a PHQ-9.^b PROMIS-PAB.* *P* < .05.

symptoms and associated functional impairment. Additional cost analysis is warranted to assess cost savings and health care utilization associated with a collaborative care treatment program for slow-to-recover patients compared with traditional outpatient care. In the absence of empirically based treatment options for this patient population, this study provides evidence for the application of the collaborative care model of integrated care for postconcussive symptoms. In settings where adaptation of the collaborative care model may not be feasible, components of the collaborative care intervention including skill training in behavioral activation, coping, relaxation, or sleep hygiene techniques in

addition to closer coordination with schools might be incorporated into provider visits. Larger-scale randomized clinical trials are needed in this understudied and critical aspect of adolescent medicine. Our findings prompt more investigation into the role of affective symptoms in perpetuating physical symptoms secondary to prolonged recovery from sports-related concussion.

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ABBREVIATIONS

CBT: cognitive-behavioral therapy
CI: confidence interval
HBI: Health and Behavior Inventory
PedsQL: Pediatric Quality of Life Inventory
PHQ-9: Patient Health Questionnaire
PROMIS-PA8: Patient-Reported Outcomes Measurement Information System

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REFERENCES

1. Barlow KM, Crawford S, Stevenson A, Sandhu SS, Belanger F, Dewey D. Epidemiology of postconcussion syndrome in pediatric mild traumatic brain injury. *Pediatrics*. 2010;126(2). Available at: www.pediatrics.org/cgi/content/full/126/2/e374
2. Peterson RL, Kirkwood MW, Taylor HG, Stancin T, Brown TM, Wade SL. Adolescents' internalizing problems following traumatic brain injury are related to parents' psychiatric symptoms. *J Head Trauma Rehabil*. 2013;28(5):E1-E12
3. Institute of Medicine (IOM) and National Research Council. (NRC). *Sports-Related Concussions in Youth: Improving the Science, Changing the Culture*. Washington, DC: The National Academies Press; 2013
4. Lundin A, de Boussard C, Edman G, Borg J. Symptoms and disability until 3 months after mild TBI. *Brain Inj*. 2006;20(8):799-806
5. Hajek CA, Yeates KO, Gerry Taylor H, et al. Relationships among post-concussive symptoms and symptoms of PTSD in children following mild traumatic brain injury. *Brain Inj*. 2010;24(2):100-109
6. Chrisman SP, Richardson LP. Prevalence of diagnosed depression in adolescents with history of concussion. *J Adolesc Health*. 2014;54(5):582-586
7. Vargas G, Rabinowitz A, Meyer J, Arnett PA. Predictors and prevalence of postconcussion depression symptoms in collegiate athletes. *J Athl Train*. 2015;50(3):250-255
8. Ellis MJ, Ritchie LJ, Koltek M, et al. Psychiatric outcomes after pediatric sports-related concussion. *J Neurosurg Pediatr*. 2015;16(6):709-718
9. Fann JR, Hart T, Schomer KG. Treatment for depression after traumatic brain injury: a systematic review. *J Neurotrauma*. 2009;26(12):2383-2402
10. McCrea M, Iverson GL, McAllister TW, et al. An integrated review of recovery after mild traumatic brain injury (MTBI): implications for clinical management. *Clin Neuropsychol*. 2009;23(8):1368-1390
11. Ransom DM, Vaughan CG, Pratson L, Sady MD, McGill CA, Gioia GA. Academic effects of concussion in children and adolescents. *Pediatrics*. 2015;135(6):1043-1050
12. Giza CC, Kutcher JS, Ashwal S, et al. Summary of evidence-based guideline update: evaluation and management of concussion in sports: report of the Guideline Development Subcommittee of the American Academy of Neurology. *Neurology*. 2013;80(24):2250-2257
13. Conder R, Conder AA. Neuropsychological and psychological rehabilitation interventions in refractory sport-related post-concussive syndrome. *Brain Inj*. 2015;29(2):249-262

14. Willer B, Leddy JJ. Management of concussion and post-concussion syndrome. *Curr Treat Options Neurol*. 2006;8(5):415–426
15. Ponsford J, Willmott C, Rothwell A, et al. Impact of early intervention on outcome after mild traumatic brain injury in children. *Pediatrics*. 2001;108(6):1297–1303
16. Pangilinan PH, Giacoletti-Argento A, Shellhaas R, Hurvitz EA, Hornyak JE. Neuropharmacology in pediatric brain injury: a review. *PM R*. 2010;2(12):1127–1140
17. Kaye AJ, Gallagher R, Callahan JM, Nance ML. Mild traumatic brain injury in the pediatric population: the role of the pediatrician in routine follow-up. *J Trauma*. 2010;68(6):1396–1400
18. McCrory P, Meeuwisse W, Johnston K, et al. Consensus statement on concussion in sport: the 3rd International Conference on Concussion in Sport held in Zurich, November 2008. *Br J Sports Med*. 2009;43(suppl 1):i76–i90
19. Mittenberg W, Canyock EM, Condit D, Patton C. Treatment of post-concussion syndrome following mild head injury. *J Clin Exp Neuropsychol*. 2001;23(6):829–836
20. Hopkins K, Crosland P, Elliott N, Bewley S; Clinical Guidelines Update Committee B. Diagnosis and management of depression in children and young people: summary of updated NICE guidance. *BMJ*. 2015;350:h824
21. Fisher E, Law E, Palermo TM, Eccleston C. Psychological therapies (remotely delivered) for the management of chronic and recurrent pain in children and adolescents. *Cochrane Database Syst Rev*. 2015;3(3):CD011118
22. Max JE. Neuropsychiatry of pediatric traumatic brain injury. *Psychiatr Clin North Am*. 2014;37(1):125–140
23. Zatzick D, Russo J, Lord SP, et al. Collaborative care intervention targeting violence risk behaviors, substance use, and posttraumatic stress and depressive symptoms in injured adolescents: a randomized clinical trial. *JAMA Pediatr*. 2014;168(6):532–539
24. Miller LJ, Mittenberg W. Brief cognitive behavioral interventions in mild traumatic brain injury. *Appl Neuropsychol*. 1998;5(4):172–183
25. Silverberg ND, Hallam BJ, Rose A, et al. Cognitive-behavioral prevention of postconcussion syndrome in at-risk patients: a pilot randomized controlled trial. *J Head Trauma Rehabil*. 2013;28(4):313–322
26. Zatzick D, Jurkovich G, Rivara FP, et al. A randomized stepped care intervention trial targeting posttraumatic stress disorder for surgically hospitalized injury survivors. *Ann Surg*. 2013;257(3):390–399
27. Zatzick D, Roy-Byrne P, Russo J, et al. A randomized effectiveness trial of stepped collaborative care for acutely injured trauma survivors. *Arch Gen Psychiatry*. 2004;61(5):498–506
28. Katon WJ, Lin EH, Von Korff M, et al. Collaborative care for patients with depression and chronic illnesses. *N Engl J Med*. 2010;363(27):2611–2620
29. Richardson LP, Ludman E, McCauley E, et al. Collaborative care for adolescents with depression in primary care: a randomized clinical trial. *JAMA*. 2014;312(8):809–816
30. Ayr LK, Yeates KO, Taylor HG, Browne M. Dimensions of postconcussive symptoms in children with mild traumatic brain injuries. *J Int Neuropsychol Soc*. 2009;15(1):19–30
31. Altman DG, Schulz KF, Moher D, et al; CONSORT Group (Consolidated Standards of Reporting Trials). The revised CONSORT statement for reporting randomized trials: explanation and elaboration. *Ann Intern Med*. 2001;134(8):663–694
32. Yeates KO, Luria J, Bartkowski H, Rusin J, Martin L, Bigler ED. Postconcussive symptoms in children with mild closed head injuries. *J Head Trauma Rehabil*. 1999;14(4):337–350
33. Kroenke K, Spitzer RL, Williams JB. The PHQ-9: validity of a brief depression severity measure. *J Gen Intern Med*. 2001;16(9):606–613
34. Richardson LP, McCauley E, McCarty CA, et al. Predictors of persistence after a positive depression screen among adolescents. *Pediatrics*. 2012;130(6). Available at: www.pediatrics.org/cgi/content/full/130/6/e1541
35. Irwin DE, Stucky B, Langer MM, et al. An item response analysis of the pediatric PROMIS anxiety and depressive symptoms scales. *Qual Life Res*. 2010;19(4):595–607
36. Cella D, Yount S, Rothrock N, et al; PROMIS Cooperative Group. The Patient-Reported Outcomes Measurement Information System (PROMIS): progress of an NIH Roadmap cooperative group during its first two years. *Med Care*. 2007;45(5 suppl 1):S3–S11
37. Riley WT, Rothrock N, Bruce B, et al. Patient-Reported Outcomes Measurement Information System (PROMIS) domain names and definitions revisions: further evaluation of content validity in IRT-derived item banks. *Qual Life Res*. 2010;19(9):1311–1321
38. Varni JW, Seid M, Kurtin PS. PedsQL 4.0: reliability and validity of the Pediatric Quality of Life Inventory version 4.0 generic core scales in healthy and patient populations. *Med Care*. 2001;39(8):800–812
39. Varni JW, Limbers CA. The Pediatric Quality of Life Inventory: measuring pediatric health-related quality of life from the perspective of children and their parents. *Pediatr Clin North Am*. 2009;56(4):843–863
40. Varni JW, Burwinkle TM, Seid M, Skarr D. The PedsQL 4.0 as a pediatric population health measure: feasibility, reliability, and validity. *Ambul Pediatr*. 2003;3(6):329–341
41. Varni JW, Burwinkle TM, Seid M. The PedsQL as a pediatric patient-reported outcome: reliability and validity of the PedsQL Measurement Model in 25,000 children. *Expert Rev Pharmacoecon Outcomes Res*. 2005;5(6):705–719
42. Rivara FP, Koepsell TD, Wang J, et al. Disability 3, 12, and 24 months after traumatic brain injury among children and adolescents. *Pediatrics*. 2011;128(5). Available at: www.pediatrics.org/cgi/content/full/128/5/e1129
43. Freed LH, Ellen JM, Irwin CE Jr, Millstein SG. Determinants of adolescents' satisfaction with health care providers and intentions to keep follow-up appointments. *J Adolesc Health*. 1998;22(6):475–479
44. Kurowski BG, Wade SL, Kirkwood MW, Brown TM, Stancin T, Taylor HG. Online problem-solving therapy

- for executive dysfunction after child traumatic brain injury. *Pediatrics*. 2013;132(1). Available at: www.pediatrics.org/cgi/content/full/132/1/e158
45. Zhang J, Yu KF. What's the relative risk? A method of correcting the odds ratio in cohort studies of common outcomes. *JAMA*. 1998;280(19):1690–1691
46. Zou G. A modified Poisson regression approach to prospective studies with binary data. *Am J Epidemiol*. 2004;159(7):702–706
47. Cohen J. *Statistical Power Analysis for the Behavioral Sciences*. Mahwah, NJ: Lawrence Erlbaum Associates; 1988
48. Asarnow JR, Rozenman M, Wiblin J, Zeltzer L. Integrated medical–behavioral care compared with usual primary care for child and adolescent behavioral health: a meta-analysis. *JAMA Pediatr*. 2015;169(10):929–937
49. Snell DL, Siegert RJ, Hay-Smith EJ, Surgenor LJ. Associations between illness perceptions, coping styles and outcome after mild traumatic brain injury: preliminary results from a cohort study. *Brain Inj*. 2011;25(11):1126–1138

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