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Psychological Resilience as a Predictor of Symptom Severity in Adolescents With Poor Recovery Following Concussion

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Abstract

Objectives: Examine the mediating effects of anxiety and depressive symptoms on the relationship between psychological resilience and post-concussive symptoms (PCS) in children with poor recovery following concussion. **Participants and Methods:** Adolescents ($N = 93$), ages 13 to 18 years, were assessed at a neuropsychology screening clinic at a children's hospital. They sustained concussions more than 1 month before the clinic visit (median time since injury = 5.1 months; range = 42–473 days) and were seen on the basis of poor recovery (i.e., presence of persistent PCS and complaints of cognitive problems). Self-reported psychological resilience was measured using the 10-item version of the Connor-Davidson Resilience Scale; self- and parent-reported anxiety and depressive symptoms were measured using the Behaviour Assessment System for Children – Second Edition; and self- and parent-reported PCS were measured using the Post-Concussion Symptom Inventory. All variables were measured concurrently. Regression-based mediation analyses were conducted to examine anxiety and depressive symptoms as mediators of the relationship between psychological resilience and PCS. **Results:** Psychological resilience significantly predicted self-reported PCS. Self-reported anxiety and depressive symptoms significantly mediated the relationship between resilience and self-reported PCS, and parent-reported child depressive symptoms significantly mediated the relationship between resilience and self- and parent-reported PCS. **Conclusions:** Psychological resilience plays an important role in recovery from concussion, and this relationship may be mediated by anxiety and depressive symptoms. These results help shed light on the mechanisms of the role of psychological resilience in predicting PCS in children with prolonged symptom recovery. (*JINS*, 2019, *25*, 346–354)

Keywords: Concussion, Pediatric, Mild traumatic brain injury, Hardiness, Post-concussive symptoms, Child

INTRODUCTION

Concussion is very common among children and adolescents. Over half a million children younger than 14 years of age present to the emergency department with a concussion each year (Bazarian et al., 2005). An array of physical, cognitive, and emotional/behavioral sequelae, known as post-concussive symptoms (PCS), are often present following a concussion. These symptoms are expected to resolve within approximately 1–3 months post-injury in most cases (Barlow et al., 2010); however, 15–30% of children with concussion experience persistent PCS that can last far beyond this expected recovery period (Babcock et al., 2013; Barlow et al., 2010; Grool et al., 2016; Zemek et al., 2016). Prolonged symptom recovery contributes to lower health related quality of life in this population (Fineblit, Selci, Loewen, Ellis, & Russell, 2016). Furthermore, concussion in children and youth accounts for over $1 billion in annual healthcare costs in the United States (Graves, Rivara, & Vavilala, 2015). These costs can be further amplified by additional treatment-seeking for persistent PCS. Thus, understanding factors that help account for persistent symptoms in children and adolescents with concussion has become a critical research focus.

Both injury and non-injury factors are implicated in the persistence of PCS. Injury factors, including mechanism of injury, duration of loss of consciousness, duration of post-traumatic amnesia, and positive neuroimaging findings are important to study in their relation to PCS; however, their contribution to predicting symptoms tends to be significant primarily during the acute phase of recovery (Babcock et al., 2013; McNally et al., 2013, Olsson et al., 2013; Taylor et al., 2010; Yeates et al., 2012). Therefore, non-injury factors (i.e., psychosocial and/or environmental correlates that predate or co-occur with the injury) have received increased attention due to their importance in predicting persistent PCS.

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Such factors include being of female sex or adolescent age at the time of injury, pre-injury learning problems, pre-injury behavioral adjustment and psychiatric problems, and poor coping skills (Ponsford et al., 1999; Taylor et al., 2010; Woodrome et al., 2011; Yeates et al., 2012). An additional non-injury factor gaining increased attention is psychological resilience.

Psychological resilience is conceptualized as interpersonal qualities that enable one to successfully adapt to adverse events, such as illness or injury. It is comprised of factors such as tolerance of negative affect, positive acceptance of change, perceived control, and personal competence (Conner & Davidson, 2003). Recently, the construct of resilience has piqued the interest of researchers wishing to study predictors of the outcomes of medical trauma, including concussion. Several studies in adults have demonstrated high psychological resilience to be related to fewer PCS, fewer depressive symptoms, and less fatigue following concussion in adults (Losoi et al., 2015; Merritt, Lange, & French, 2015; Sullivan, Edmed, Allan, Smith, & Karlsson, 2015), although some research has not supported this relationship (e.g., McCauley et al., 2013).

Recently, resilience has been shown to be related to fewer PCS in children and adolescents long after injury (i.e., 2.5 years; Laliberté Durish, Brooks, & Yeates, 2018). Importantly, psychological resilience has been identified as a dynamic, modifiable construct that is amenable to change through intervention (Johnston et al., 2015; Steinhardt & Doblier, 2008); thus, it seems an important construct to examine to better understand the outcomes of concussion. Given the modifiability of resilience and its relation to outcome in concussion, further study of its role in children with poor recovery following concussion is warranted. However, our understanding of the mechanisms of the relationship of resilience to concussion outcomes remains unclear.

Anxiety and depression are other factors that have been found to predict persistent symptoms in children and adolescents who are slow to recover from concussion (Grubenhoff et al., 2016; Laliberté Durish, Persevereff, & Yeates, 2018; Stazyk et al., 2017; Wood, O'Hagan, Williams, McCabe, & Chadwick, 2014;). For example, the risk for persistent PCS has been found to be associated with increased anxiety before or shortly after injury in children with concussion who were followed longitudinally (Grubenhoff et al., 2016). Furthermore, the role of high resilience in mitigating the development of psychological symptoms, such as anxiety and depression, following adversity is well documented (e.g., Campbell-Sills, Cohan, & Stein, 2006; Pietrzak, Johnson, Goldstein, Malley, & Southwick, 2009; Poole, Dobson, & Pusch, 2017; Rainey, Petrey, Reynolds, Agtarap, & Warren, 2014; Schulz et al., 2014). Given support for the relationship between psychological resilience and both anxiety/depressive symptoms and persistent PCS, as well as the relationship between anxiety/depressive symptoms and persistent PCS, we hypothesized that anxiety/depressive symptoms might act as a mediator of the relationship between resilience and PCS in children with prolonged symptom recovery.

The aim of the current study was to thus elucidate the relationship between psychological resilience and persistent PCS by examining the role of anxiety/depressive symptoms as a potential mediator. We predicted that psychological resilience would be negatively associated with PCS, such that lower self-reported psychological resilience would predict greater self- and parent-reported PCS. We also predicted that both anxiety and depressive symptoms would act as mediators of this relationship, such that lower psychological resilience would predict higher self- and parent-reported anxiety and depressive symptoms, which would correspond with greater self- and parent-reported PCS.

METHODS

Participants

Adolescents ($N = 93$), ages 13–18 years, were consecutively referred to the Alberta Children's Hospital Neuropsychology Service for a neuropsychological screening of their neurocognitive and psychological functioning following a concussion. All participants sustained injuries more than 1 month before assessment and were referred by a nurse practitioner, neurologist, or physiatrist on the basis of poor recovery (i.e., persistent PCS) and complaints of cognitive problems. The diagnosis of concussion (or mild traumatic brain injury [TBI]) was based on the World Health Organization (WHO) definition (Carroll, Cassidy, Holm, Kraus, & Coronado, 2004), and was confirmed by a nurse practitioner at the initial intake clinical assessment *via* review of medical records and/or family report.

Persistent PCS was defined as the presence of one or more symptoms reported to be associated with the concussion that persist for longer than 1 month post-injury, consistent with the International Classification of Diseases for post-concussion syndrome (WHO, 1992). Symptom severity was initially evaluated as part of the intake clinical assessment by a nurse practitioner using the Post-Concussion Symptom Inventory (PCSI), to assess ongoing symptoms for clinical purposes, but that data were not available for research purposes and are not included in analyses. Complaints of cognitive problems were based on child or parent report of problems with attention, thinking speed, memory, or executive functioning post-concussion to the nurse practitioner.

Inclusion criteria for the current study were sustainment of a concussion, diagnosed by a health professional, no less than 1 month before testing. Children with a record of positive neuroimaging findings (i.e., complicated mild TBI) were excluded from analyses. To conform with age restrictions of the measures used, children less than 13 years of age were also excluded from analyses. Children with a history of premorbid learning, attention, or psychological concerns were not excluded from participation due to the high degree of co-occurrence of these problems in this population (Horris, Elmer, & Valovich McLeod, 2017) and to increase generalizability of the findings.

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Measures

Post-concussive symptoms

PCS were measured using the PCSI (Gioia, Janusz, Isquith, & Vincent, 2008; Gioia, Schneider, Vaughan, & Isquith, 2009). The PCSI is a 26-item measure of severity of PCS. Participants are asked rate the severity of current symptoms (i.e., yesterday and today) on a 7-point scale (0 = Not a problem, 3 = Moderate problem, 6 = Severe problem), with total possible scores ranging from 0 to 156 (higher scores are indicative of greater severity of PCS). Children completed the self-report form and their parents completed the parent-report form. The PCSI has been shown to have moderately high test–retest reliability, strong internal consistency, and good convergent validity (Sady et al., 2014). PCS are multidimensional, and include physical, cognitive, emotional, and fatigue related symptoms (Sady et al., 2014).

Given the high correlation between emotional symptom reporting on the PCSI and symptom reporting on the Behaviour Assessment System for Children – Second Edition (BASC-2) Anxiety (self: $r = .71$; $p < .001$; parent: $r = .55$; $p < .001$) and Depression (self: $r = .71$; $p < .001$; parent: $r = .61$; $p < .001$) subscales, emotional symptom scores on the PCSI (i.e., items 13, 14, 15, 16 on the self-report and items 12, 13, 14, 15 on the parent-report) were subtracted from the PCSI total score to minimize overlap between items on the PCSI and on the BASC-2 Anxiety and Depression subscales. Thus, all analyses used total scores minus emotional symptoms from both the self- and parent-report versions of the PCSI.

Resilience

Resilience was measured using the 10-item version of the Connor-Davidson Resilience Scale (CD-RISC; Connor & Davidson, 2003; Campbell-Sills & Stein, 2007). The CD-RISC is a self-report rating scale that measures factors related to resilience, such as personal competence, tenacity, tolerance of negative affect, and positive acceptance of change. Each item is measured on a 5-point scale (0 = Not true at all, 2 = Sometimes true, 4 = True nearly all the time), with total possible scores ranging from 0 to 40 (higher scores indicative of greater resilience). The CD-RISC demonstrates satisfactory reliability and validity in the general population, as well as clinical samples (Connor & Davidson, 2003), and satisfactory validity in a pediatric medical sample (Laliberté Durish, Yeates, & Brooks, 2017). Total raw scores for the CD-RISC were included in the analyses.

Anxiety and depressive symptoms

Anxiety and depressive symptoms were measured using the self- and parent-report versions of the BASC-2 (Reynolds & Kamphaus, 2004). The BASC-2 is a measure of behavioral and psychological symptoms in children and adolescents. Both versions of the BASC-2 contain items measured on a 4-point scale (i.e., Never, Sometimes, Often, Almost Always). The self-report version also contains items rated as true/false. Standardized scores (i.e., age and sex-adjusted T scores with a mean of 50 and *SD* of 10) for the Anxiety and Depression subscales were included in the analyses, with higher scores indicative of greater problems (cutoff for clinical significance = 70). The BASC-2 has demonstrated satisfactory reliability and validity in pediatric populations (Reynolds & Kamphaus, 2004).

Procedure

The measures included in the current study were administered as part of a clinical neuropsychological assessment battery. Participants underwent approximately 90 minutes of neuropsychological testing, completed in a designated testing space in the clinic with a trained psychometrist (under the supervision of a neuropsychologist), and parents completed questionnaires, as well as a demographic and injury information form (e.g., parental education, pre-injury attention/learning concerns, mechanism of injury), in a separate space. All participants provided signed parental consent and child assent for use of their data for research purposes upon consenting to the clinical assessment, as approved by the Research Ethics Board.

Statistical Analyses

Statistical analyses were conducted using IBM SPSS Statistics Software, Version 24 (IBM Corp., 2016). Initial hierarchical regression analyses were conducted to examine the prediction of self- and parent-reported PCS by psychological resilience, over and above the effects of age and sex, to control for the effects of age and sex on PCS (e.g., see Taylor et al., 2010). Thereafter, mediation analyses were conducted using the PROCESS macro (Hayes, 2013) with the CD-RISC entered as the predictor variable, self- and parent-report BASC-2 Anxiety and Depression subscales examined separately as mediator variables, and self- and parent-report PCS examined separately as dependent variables.

Age and sex were also included in each of the mediation models as covariates. Proposed effect size measures for mediation (Preacher & Kelley, 2011) have not been validated for models that contain covariates. Therefore, standardized betas are reported as measures of effect size (i.e., representing change in outcome variable for every 1 *SD* change in the mediator variable), gauging the indirect effect relative to variation in the predictor and outcome variables not accounted for by the covariates.

RESULTS

Descriptive statistics for demographic and injury variables (i.e., age, sex, ethnicity, maternal and paternal education, pre-morbid problems, and injury factors) are presented in Table 1. The sample was composed of 52 females and 41 males who were of primarily Caucasian ethnicity and were,

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Table 1. Demographic characteristics of study sample

Age (years); *M* (*SD*), range	15.6 (1.2), 13–18 years
Sex (% female)	55.9
Ethnicity (% Caucasian)	92.4
Maternal education (years); *M* (*SD*)	14.6 (1.9)
Paternal education (years); *M* (*SD*)	14.0 (2.0)
Pre-injury attention concerns (% yes)	29.3
Pre-injury learning concerns (% yes)	34.8
Pre-injury headaches/migraines (% yes)	28.3
Time since injury (days); *M* (*SD*), median, range	178.8 (106.1), 153, 42–473 days
Loss of consciousness (% yes)	22.7
Post-traumatic amnesia (% yes)	31.8
Mechanism of injury	
% Fall	13.0
% Struck by object	5.4
% Sports	66.3
% Motor vehicle	15.2

on average, from families of higher socioeconomic status (i.e., college-educated mothers). Time since injury ranged from 42 to 473 days, with an average time since injury of approximately 6 months. Descriptive statistics for predictor (i.e., CD-RISC, self- and parent-report BASC-2 Anxiety and Depression subscales), outcome variables (i.e., self- and parent-report PCSI scores), and PCSI domain scores encompassed by the total score (i.e., physical, cognitive, fatigue), as well as analyses of sex differences on each of the variables, are presented in Table 2.

Significant sex differences were present on self-reported depressive symptoms ($t(91) = -2.16$; $p = .034$), self-reported total PCS ($t(91) = -2.78$; $p = .007$), and self-reported physical PCS ($t(90) = -2.41$; $p = .018$) and cognitive PCS ($t(90) = -3.04$; $p = .003$), as well as parent-reported physical PCS ($t(90) = -3.20$; $p = .002$), with females reporting greater depressive symptoms and PCS. Correlations among study measures are presented in Table 3.

Hierarchical regression analyses demonstrated a significant effect of the contribution of age and sex on self-reported PCS ($R^2 = .08$; $p = .024$), with a significant independent contribution of sex ($t(90) = 3.04$; $p = .003$; females reported greater PCS). They also showed a significant effect of psychological resilience on self-reported PCS, over and above the effects of age and sex ($\beta = -0.23$; $\Delta R^2 = .05$; $p = .022$). Similar effects were not found for parent-reported PCS.

Significant mediation analyses are outlined in Figures 1–4. Of the eight models tested, the mediation effect was significant in four, with three of the four involving the same rater for PCS and for anxiety or depressive symptoms. Self-reported anxiety symptoms significantly mediated the relationship between psychological resilience and self-reported PCS ($\beta = -0.20$; 95% CI = −0.33 to −0.10). Self- and parent-reported depressive symptoms significantly mediated the relationship between psychological resilience and self-reported PCS ($\beta = -0.18$; 95% CI = −0.35 to −0.09 and $\beta = -0.11$; CI = −0.23 to −0.03, respectively). Parent-reported depressive symptoms also mediated the relationship between psychological resilience and parent-reported PCS ($\beta = -0.12$; 95% CI = −0.24 to −0.06). The prediction of self-reported PCS by psychological resilience was no longer significant when anxiety or depressive symptoms were entered into the model. In all models, psychological resilience significantly predicted anxiety/depressive symptoms ($p \leq .001$), and in four of eight models, anxiety or depressive symptoms significantly predicted PCS (i.e., self-reported anxiety symptoms to self-reported PCS; self-reported depressive symptoms to self-reported PCS, parent-reported depressive symptoms to self-reported PCS, parent-reported depressive symptoms to parent-reported PCS; $p \leq .005$).

DISCUSSION

Psychological resilience has been found to be an important predictor of persistent PCS in adults following concussion (Losoi et al., 2015; Merritt et al., 2015; Sullivan et al., 2015), but only one other study has examined this relationship in children (Laliberté Durish, Yeates, & Brooks, 2018). This study sought to contribute to the growing body of research regarding the role of psychological resilience in predicting poor outcome of pediatric concussion by elucidating the relationships among psychological resilience, anxiety/depressive symptoms, and PCS, to better understand potential mediators of poor outcome after concussion in adolescents.

Our results indicate that anxiety and depressive symptoms may indeed act as mediators of the relationship between psychological resilience and PCS, such that lower resilience predicted greater anxiety/depressive symptoms, which, in turn, predicted increased PCS in this population. Self-reported depressive symptoms may act as a more important mediator of the relationship between resilience and PCS given their significance in mediating parent-reported PCS, as opposed to self-reported anxiety symptoms, which only mediated child-reported PCS.

Although inclusion criteria for the study required a minimum time since injury of 1 month, the average time since injury was 6 months; thus, the current results are best interpreted as shedding light on the relationship between psychological resilience and *persistent* PCS in children with poor recovery following concussion. Moreover, the exclusion of emotional symptom items from the PCSI total scores minimized the extent to which item overlap may have accounted for significant mediation by anxiety and depressive symptoms. That is, anxiety and depressive symptoms mediated the relationship of psychological resilience to physical, cognitive, and fatigue-related PCS. These findings are in keeping with previous literature indicating that anxiety and depressive symptoms are predictive of physical, cognitive, and sleep symptoms following concussion (e.g., de Koning et al., 2016; Herrmann et al., 2009).

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Table 2. Descriptive statistics of study measures

	Overall sample		Males		Females		Male *Versus* female difference	
	M	*SD*	*M*	*SD*	*M*	*SD*	*t*	*p*
CD-RISC	26.1	6.0	26.85	5.56	25.35	6.29	1.05	.299
BASC-2 SR: Anxiety	56.1	13.7	55.37	12.26	56.41	14.91	–0.44	.660
BASC-2 PR: Anxiety	59.3	15.2	57.22	15.38	60.94	15.06	–1.17	.246
BASC-2 SR: Depression	51.6	11.0	48.88	8.84	53.51	12.08	–2.16*	.034
BASC-2 PR: Depression	55.6	12.0	53.80	12.94	57.08	11.0	–1.31	.193
PCSI Total Self-Report	44.3	26.8	35.93	22.02	50.08	28.12	–2.78*	.007
Physical	14.72	10.01	11.93	9.48	16.87	9.96	–2.41*	.018
Cognitive	15.66	9.07	12.53	7.01	18.08	9.75	–3.04*	.003
Fatigue	6.28	4.15	5.43	3.83	6.94	4.30	–1.76	.082
PCSI Total Parent-Report	40.2	23.2	35.10	22.90	44.35	22.77	–1.93	.056
Physical	13.53	9.75	10.07	8.90	16.31	9.58	–3.20*	.002
Cognitive	12.25	7.31	11.49	7.49	12.86	7.17	–0.90	.373
Fatigue	6.26	4.77	6.0	5.34	6.47	4.31	–0.47	.641

BASC-2 = Behaviour Assessment System for Children – Second Edition (standardized scores for Anxiety and Depression sub-scales; SR = Self-Report, PR = Parent Report), CD-RSIC = Connor-Davidson Resilience Scale (10 item version; total raw score); PCSI = Post-Concussion Symptom Inventory (total raw score minus ratings on emotional symptom items).
*Significant group differences ($p < .05$).

Table 3. Correlations among study measures

	BASC-2 SR: Depression		BASC-2 PR: Depression		BASC-2 SR: Anxiety		BASC-2 PR: Anxiety		PCSI Self-Report		PCSI Parent-Report	
	r	*p*	*r*	*p*	*r*	*p*	*r*	*p*	*r*	*p*	*r*	*p*
CD-RISC	–.44*	<.001	–.39*	<.001	–.46*	<.001	–.49*	<.001	–.26*	.013	–.07	.481
BASC-2 SR: Depression	–	–	.54*	<.001	.76*	<.001	.33*	.001	.46*	<.001	.17	.116
BASC-2 PR: Depression	–	–	–	–	.48*	<.001	.68*	<.001	.39*	.001	.32*	.002
BASC-2 SR: Anxiety	–	–	–	–	–	–	.50*	<.001	.45*	<.001	.12	.247
BASC-2 PR: Anxiety	–	–	–	–	–	–	–	–	.27*	.010	.17	.097
PCSI Self-Report	–	–	–	–	–	–	–	–	–	–	.52*	<.001

BASC-2 = Behaviour Assessment System for Children – Second Edition (standardized scores for Depression and Anxiety sub-scales; SR = Self-Report, PR = Parent-Report); CD-RISC = Connor-Davidson Resilience Scale (10-item version, total raw score); PCSI = Post-Concussion Symptom Inventory (total raw score minus ratings on emotional symptoms).
* Significant ($p < .05$) after controlling for multiple comparisons (false discovery rate).

An interesting finding was the substantial change in the prediction of PCS by psychological resilience when anxiety and depressive symptoms were added to the model. Although psychological resilience significantly predicted self-reported PCS when anxiety and depressive symptoms were not included in the model, this predictive relationship was no longer significant when they were added as mediators. This finding suggests that, while resilience may be an important predictor of PCS, this may be because of the relationship of resilience to psychological distress more generally.

Our results have important implications for intervention research, suggesting that interventions that target anxiety and depressive symptoms may help to alleviate persistent PCS. Psychological resilience, however, may also play an important role in terms of intervention, given its relationship to psychological symptoms. Studies on the effectiveness of psychotherapy have provided empirical support for the importance of resilience factors, such as flexibility and optimism, in achieving positive outcomes (Duncan, Miller, Wampold, & Hubble, 2010). Thus, the current findings provide a more comprehensive understanding of psychological factors implicated in poor recovery following concussion and may help serve as a guide to the best treatment modalities.

Justification for the therapeutic application the current findings is provided by research showing that high resilience is predictive of fewer anxiety and depressive symptoms following exposure to trauma (Campbell-Sills et al., 2006; Pietrzak et al., 2009; Poole et al., 2017; Rainey et al., 2014; Schulz et al., 2014), that anxiety/depressive symptoms are predictive of outcome of concussion (Grubenhoff et al., 2016; Stazyk et al., 2017, Laliberté Durish, Persevereff, & Yeates, 2018; Wood et al., 2014), and that psychological resilience is a predictor of PCS (Laliberté Durish, Yeates, & Brooks, 2018; Losoi et al., 2015; Merritt et al., 2015; Sullivan

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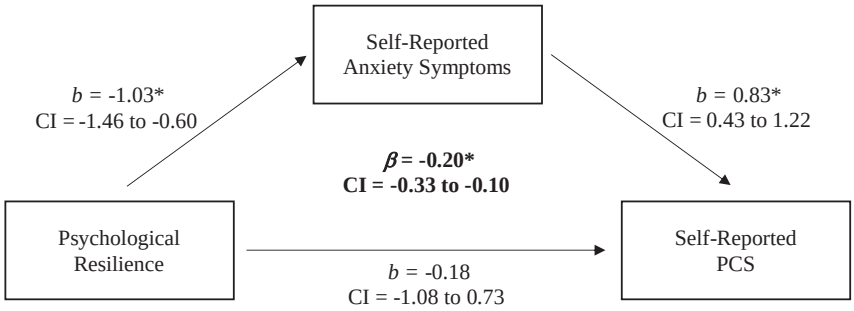

Fig. 1. Mediation model depicting the relationship between psychological resilience and self-reported PCS mediated by self-reported anxiety symptoms, with age (Anxiety Symptoms: $t(89) = 0.44$; $p = .663$; PCS: $t(88) = -0.74$; $p = .458$) and sex (Anxiety Symptoms: $t(89) = -0.05$; $p = .963$; PCS: $t(88) = 2.82$*; $p = .006$) entered as covariates. The standardized beta and confidence interval displayed in the center of the model indicate the indirect effect of psychological resilience on self-reported PCS through self-reported anxiety symptoms. *Significant effect ($p < .05$).

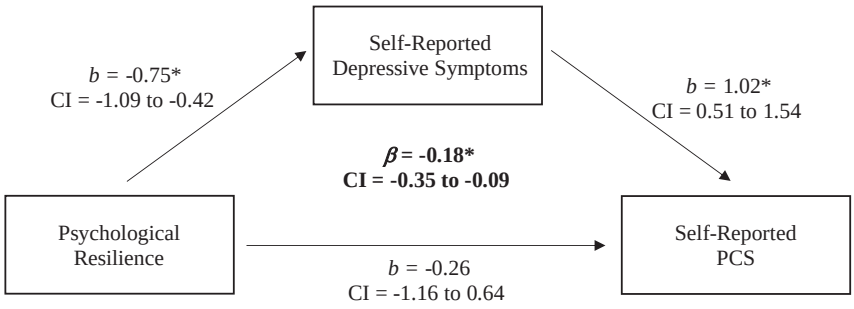

Fig. 2. Mediation model depicting the relationship between psychological resilience and self-reported PCS mediated by self-reported depressive symptoms, with age (Depressive Symptoms: $t(89) = 1.74$; $p = .086$; PCS: $t(88) = -1.26$; $p = .211$) and sex (Depressive Symptoms: $t(89) = 1.85$; $p = .067$; PCS: $t(88) = 1.96$; $p = .053$) entered as covariates. The standardized beta and confidence interval displayed in the center of the model indicate the indirect effect of psychological resilience on self-reported PCS through self-reported depressive symptoms. *Significant effect ($p < .05$).

et al., 2015). However, given that our study did not use a longitudinal design, causal relationships cannot be proven; thus, the possibility of alternative causal relationships among anxiety, depressive symptoms, and PCS (i.e., greater PCS leads to increased anxiety or depressive symptoms) cannot be discounted.

Studies have shown an increased risk of anxiety and depressive symptoms following concussion (Hawley, Ward, Magnay, & Long, 2004; Luis & Mittenberg, 2002), suggesting that increased PCS may lead to greater anxiety/depressive symptomatology rather than the converse. Given the overlap that exists between depression and anxiety, and many PCS (e.g., fatigue), changes in one may affect changes in the other in a bidirectional manner (see Stein et al., 2017). More research is needed to examine the causal relationships among these variables.

The results should be interpreted in light of several study limitations. First, and perhaps most importantly, the study was cross-sectional; thus, causal relationships between the three key variables (i.e., resilience, anxiety/depressive symptoms, and PCS) cannot be determined from the data. Second, only limited retrospective data were available regarding pre-morbid psychological symptoms or PCS, although a high proportion of children were reported to have pre-morbid learning and attention concerns, as well as a history of physical symptoms (i.e., headaches). While inclusion of children with these pre-morbid concerns increases generalizability of the findings, we cannot conclude that all symptoms reported by the participants were linked to their concussions. The limited sample size precluded examining the contribution of these variables in the analyses; however, premorbid factors may account for significant variance in the mediator and outcome variables. Relatedly, pre-injury resilience was not assessed; thus, we cannot assume that the concurrent ratings reflected a stable trait and were unchanged by the injury. Previous research suggests that resilience, while potentially modifiable (Steinhardt & Dolbier, 2008), is unlikely to change as a result of a single injury (Rainey et al., 2014). However, no research to date has examined these relationships prospectively among children with concussion, limiting definitive conclusions in this regard.

Third, information on previous injuries was not collected. Given the potential impact of a history of multiple concussions on severity of PCS (Brooks et al., 2013; Iverson et al., 2017; Laliberté Durish, Yeates, & Brooks, 2018; Rieger et al., 2013), the possibility of previous injuries accounting for variance in anxiety/depressive symptoms and PCS cannot be discounted. Fourth, the mediation effects were not

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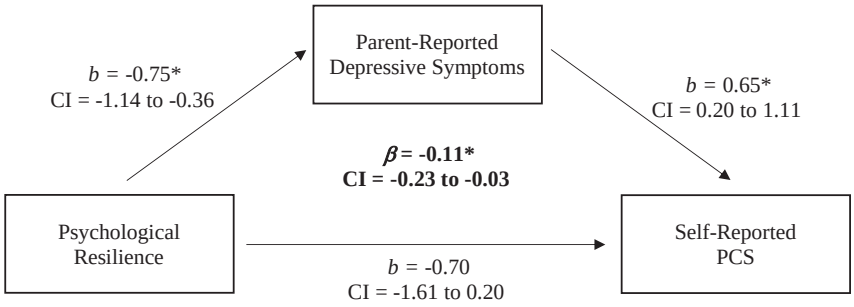

Fig. 3. Mediation model depicting the relationship between psychological resilience and self-reported PCS mediated by parent-reported depressive symptoms, with age (Depressive Symptoms: $t(88) = -0.22$; $p = .823$; PCS: $t(87) = -0.57$; $p = .571$) and sex (Depressive Symptoms: $t(88) = 0.92$; $p = .362$; PCS: $t(87) = 2.18$*; $p = .032$) entered as covariates. The standardized beta and confidence interval displayed in the center of the model indicate the indirect effect of psychological resilience on self-reported PCS through parent-reported depressive symptoms. *Significant effect ($p < .05$).

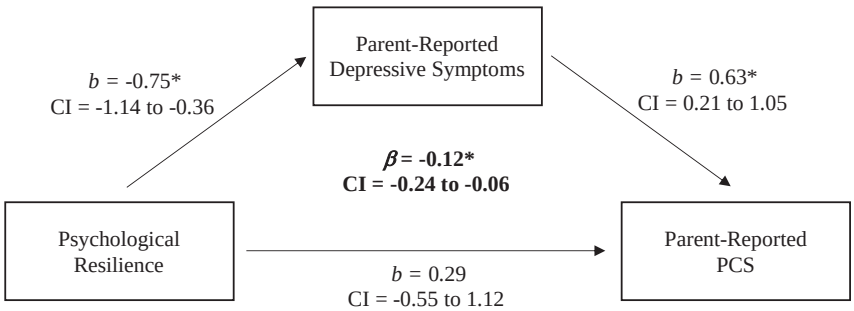

Fig. 4. Mediation model depicting the relationship between psychological resilience and parent-reported PCS mediated by parent-reported depressive symptoms, with age (Depressive Symptoms: $t(88) = -0.23$; $p = .823$; PCS: $t(87) = 0.31$; $p = .758$) and sex (Depressive Symptoms: $t(88) = 0.92$; $p = .362$; PCS: $t(87) = 1.62$; $p = .110$) entered as covariates. The standardized beta and confidence interval displayed in the center of the model indicate the indirect effect of psychological resilience on parent-reported PCS through parent-reported depressive symptoms. *Significant effect ($p < .05$).

significant when models were based on multi-informant ratings (e.g., self-report depressive symptoms mediating the relationship between psychological resilience and parent-reported PCS), except for the model involving parent-reported depressive symptoms and self-reported PCS; thus, shared rater variance may be driving some of the observed mediation effects. Fifth, given the lack of a comparison group (e.g., orthopedic injury), we are limited in interpreting the findings as specific to concussion rather than as potentially reflecting psychological factors related to sustaining an injury in general (e.g., post-traumatic stress disorder following a motor vehicle collision). Finally, the results must be interpreted in the context of a highly selective sample, (i.e., children who were seen in a clinical setting on the basis of poor recovery). Thus, the results cannot be generalized to all youth who sustain concussion, but instead are restricted to those with poor recovery.

In conclusion, the results of this study suggest a potential mechanism underlying the relationship between psychological resilience and PCS. That is, low psychological resilience is associated with greater anxiety and depressive symptoms, which, in turn, predicts a combination of physical, cognitive, and fatigue-related PCS. Future studies should use a longitudinal design to further explore causal relationships among these variables. Additionally, future studies should examine these relationships within specific domains of PCS (i.e., physical, cognitive, sleep, mood) to better parse out the specific symptoms that may be impacted by resilience and anxiety/depressive symptoms. Nonetheless, the current findings have important potential implications for intervention for children suffering from persistent symptoms after concussion.

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