Title of Manuscript: Use of the Sport Concussion Assessment Tools in the Emergency Department to predict persistent post-concussive symptoms in children

Original Article

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Conflicts of interest: GD is an honorary member of the Australian Football League Concussion Working Group and has attended meetings organized by sporting organizations including the National Football League (NFL; USA), National Rugby League (Australia), and FIFA (Switzerland); however, he has not received any payment, research funding, or other monies from these groups other than for travel costs. GD is a member of the International Concussion in Sport group that developed the SCAT3 and ChildSCAT3.

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ABSTRACT

Aim: The Sport Concussion Assessment Tool v3 (SCAT3) and its child version (ChildSCAT3) are composite tools including a symptom scale, a rapid cognitive assessment (Standardized Assessment of Concussion (SAC)) and the modified Balance Error Scoring System (mBESS). It is unclear whether their use for the acute assessment of paediatric concussion in the Emergency Department (ED) may help predict persistent post-concussive symptoms (PPCS). We aimed to assess the predictive value of the main SCAT3/ChildSCAT3 components for PPCS when applied in the ED.

Methods: Single-site prospective longitudinal cohort study of children aged 5-18 years assessed within 48 hours of their concussion at the ED of a state-wide tertiary paediatric hospital and followed up at the affiliated concussion clinic, between November 2013 and August 2017. PPCS was defined as ≥ 2 new or worsening symptoms at 1-month post-injury using the Post Concussive Symptom Inventory.

Results: Of the 370 children enrolled, 213 (57.7% <13 years old) provided complete data. Of these, 34.7% had PPCS at 1-month post-injury (38.2% of children <13 years and 30.0% ≥ 13 years of age, $p=0.272$). The adjusted ORs from multiple logistic regression models for number and severity of symptoms, and for the SAC and mBESS performance in both the ChildSCAT3/SCAT3 were all not significant. The Area Under the Curve of Receiver Operator Characteristic curves for all analysed ChildSCAT3/SCAT3 components was below 0.6.

Conclusions: Although SCAT3/ChildSCAT3 are recommended tools to assist with concussion diagnosis and monitoring of patient recovery, their use in the ED does not seem to help predict PPCS.

Keywords: mild traumatic brain injury, child, SCAT, Emergency Department, post-concussive symptoms

What is already known on this topic:

- A substantial proportion of children and adolescents who sustain a concussion may experience persistent post-concussive symptoms.
- The Sport Concussion Assessment Tool v3 (SCAT3) and its child version (ChildSCAT3) are composite tools for sideline assessment of concussion in children and adolescents.
- It is unclear whether their use in the Emergency Department setting may help predict persistent post-concussive symptoms and prolonged recovery.

What this paper adds:

- The performance on the SCAT3/ChildSCAT3 key components, used for the acute assessment of paediatric concussion in the ED, does not seem to predict which patients develop persistent post-concussive symptoms at 1 month post-injury.

INTRODUCTION

Concussion, at the mild end of the traumatic brain injury (TBI) spectrum, is a complex pathophysiological process affecting the brain that is induced by biomechanical forces.^{1,2} It accounts for up to 90% of all paediatric TBI, with sport injury being one of the most common cause.³ While the majority of children recover quickly following a concussion, a substantial proportion experience persistent post-concussive symptoms (PPCS) at 1 month post-injury. The definition of prolonged recovery varies in the literature with respect to the method used for identifying PPCS (e.g. clinical diagnosis, parent and child ratings), the timing of post-injury evaluation, and the context of assessment (e.g. acute, follow-up clinics). This leads to a variable reported incidence of PPCS, ranging between 11% and 58.5% across different studies.⁴⁻⁹ Nature of symptoms may also vary across time, with prolonged symptoms in any PCS domain (physical, cognitive, emotional, fatigue) limiting return to normal social, school and sports life. These symptoms may result in secondary problems including worse quality of life and mental health symptoms, including anxiety and depression.^{8,10} Only recently, however, have researchers begun to develop paediatric concussion assessment tools.^{8, 11-13}

The Sport Concussion Assessment Tool (SCAT) is a composite testing tool assessing symptoms, cognition and balance.¹⁴ Its third version, SCAT3, was recommended by the Fourth Consensus Statements on Concussion in Sport for sideline acute assessment of sport concussion.¹ A child-specific version, ChildSCAT3, for children under 13 was also conceived.¹ ChildSCAT3 includes a child and parent symptom report, the age-appropriate modification of the standardized assessment of concussion (SAC), and a simpler modified Balance Error Scoring System (mBESS), including only two of the three stances tested in the SCAT3.^{15, 16} Recently, our team demonstrated the concurrent validity of these tools in differentiating concussed from orthopaedic injured and uninjured children assessed in the Emergency Department (ED), in particular in terms of symptom number and severity.¹⁷

Although many clinicians are using the SCAT tools for the acute assessment of concussed children outside the sport field, it is unclear whether their use in the ED may help predict which children will develop PPCS, and thus contribute to post-acute clinical management. Early identification of children with concussion at-risk for PPCS and prolonged recovery has the potential to enable closer follow-ups and earlier clinical interventions. These may shorten symptom duration and improve their health outcome for the important cognitive, physical, emotional and educational development occurring at this age.

We aimed to assess the predictive value of the main SCAT3/ChildSCAT3 components in identifying children with PPCS at 1 month post-injury.

MATERIALS AND METHODS

Study Design and Setting

This study was a secondary analysis of a single-centre prospective longitudinal cohort study, XXX,^{xx} conducted in XXX, Australia, at the XXX. XXX is a state-wide, tertiary, paediatric hospital with an annual ED census of 87,000 children < 18 years of age. This study was approved by the XXX Human Research Ethics Committee (HREC No 33122).

Study Procedures and Population

Children were recruited in the ED between November 2013 and August 2017. Those ≥ 5 and <18 years of age who presented to the ED between 0900 and 2200 hours on weekdays and between 1200 and 2200 hours during weekends, after a concussion sustained in the previous 48 hours, fulfilled inclusion criteria. Concussion was defined according to the Berlin Consensus Statement on Concussion in Sport (Box 1).² Patients were included if all the definition criteria were met. Exclusion criteria were (i) Glasgow Coma Scale <13; (ii) need of neurosurgery or general anesthesia for injury management, (iii) presence of intracranial injury on computed tomography; (iv) clinical evidence of cerebrospinal fluid leak; (v) intellectual

disability; (vi) non-accidental injury; (vii) multiple trauma; (viii) alcohol or drug intoxication; (ix) insufficient understanding of English; (x) presence of fever at time of ED assessment ($T > 37.5^{\circ}\text{C}$); (xi) previous enrollment in the study; (xii) no clear history of trauma as primary event (e.g., trauma following seizure, syncope or migraine).

Eligible patients were identified from the ED Information System after triage, approached by a research assistant following assessment by the treating clinician, and screened against exclusion criteria. Written consent was obtained from a parent or guardian and from participants 13-18 years. Verbal assent was obtained from participants 5-12 years.

The SCAT3/ChildSCAT3 was administered by trained research assistants at the time of initial assessment in the ED. The ChildSCAT3 was administered to participants 5-12 years, with those 13-18 years assessed using the SCAT3 (see Supplementary Information S1 for description of SCAT3/ChildSCAT3). The tandem gait assessment was omitted, as this was deemed not feasible within the ED due to space constraints. SCAT3 and ChildSCAT3 key components used in the current study are the symptom scale, the rapid cognitive assessment using the SAC (and its child version, SAC-C in the ChildSCAT3), and the modified balance assessment (mBESS).¹⁹ Details of these measures are also described in the Zurich Consensus Statement.¹ Key demographic and clinical information was also collected in the ED.

Children were then followed up at the XXX Outpatient Concussion Clinic at 1-4 days following ED assessment, at 2 weeks and 1-month post-injury. Persistent Post-Concussive Symptoms (PPCS) were assessed, at each follow-up visit, with the parent form of the Post-Concussion Symptom Inventory (PCSI)^{12, 20} which includes a set of 20 items within four subscales for physical, cognitive, emotional, and fatigue post-concussive symptoms; higher scores correspond to more severe symptoms (see Supplementary Information S2 for further details). The main outcome of interest were PPCS at 1-month post injury. At the first follow-up, parents retrospectively completed the pre-injury PCSI to collect information on symptoms that were present prior to the injury to establish the patient baseline, in order to identify patients with PPCS.

Participants were classified as having PPCS according to Hearps et al. definition (i.e. two or more individual parent-report PCSI items increased in severity by one point or more from pre-injury to post-injury).⁹

Data Analysis

Summary statistics were used to illustrate differences between groups on demographic and injury-related characteristics. Summary data were presented by SCAT3/ChildSCAT3 participation (i.e. child aged <13 vs 13+), and PPCS presence (i.e. symptomatic vs recovered). Between-group comparisons were assessed using chi-squared tests for categorical variables (or Fisher test where appropriate), and independent samples *t*-tests for continuous variables (parametric variables). Similar tests were carried out between the final analytic sample and those lost to follow up.

To assess the predictive value of SCAT3/ChildSCAT3 key components for PPCS outcome at 1-month post-injury, multiple logistic regression models were employed and adjusted Odds Ratios (aOR) and 95% confidence intervals (CI) were reported.

As a secondary analysis we also planned to investigate the ability of the SCAT3/ChildSCAT3 to predict the presence of post-concussive symptoms also at the 2-week time point, based on Hearps et al.⁹ definition, or using the PPCS definition by Zemek et al.⁷, which required 3 or more items with increased severity at one month compared with baseline.

All multiple logistic regression models were adjusted for clinical risk factors for persistent symptoms, and time between initial assessment and follow-up.

Finally, Receiver Operator Characteristic (ROC) curves visually explored the discriminant ability of SCAT3/ChildSCAT3 results at the time of ED assessment in classifying PPCS. Nonparametric ROC regressions (with 1000 bootstrap replications, adjusting for child age, sex and time between the 1-4 days post-injury assessment and 1 month) were used to estimate the area under the curve (AUC). For ease of interpretation, SAC scores were reversed, so that all SCAT3/ChildSCAT3 scales were all in the same direction (higher = poorer outcomes).

All analyses used a significance level of $p < 0.05$, unless otherwise specified, and were conducted using Stata v14.2.

RESULTS

A total of 213 patients (57.7% <13 years of age) were included in the study (Figure S1; Supporting Information). The demographic and injury characteristics comparisons between patients who were lost to follow up and those included in the final analytic sample are reported in Table S1 (Supporting information). We found a borderline significant difference in age between the final analytic sample and patients lost to follow up (11.9 years versus 11.2 years, $p = 0.048$), and a higher percentage of sport related concussions in the analytic sample (63.9% versus 38.9%, $p = 0.008$). All the other variables were comparable between the two groups”

PPCS at 1 month post-injury was found in 74 patients (34.7%), 47 (38.2%) children < 13 years and 27 (30.0%) $\geq$ 13 years of age, $p = 0.272$. Table 1 shows the demographic and injury-related characteristics of patients with and without PPCS at 1-month post-injury, within the SCAT3/ChildSCAT3 measures.

Performance on the SCAT3/ChildSCAT3 main components was not significantly different between children with and without PPCS for both ChildSCAT3 and SCAT3 (Table 2).

Multiple logistic regression analysis explored the ability of the SCAT3/ChildSCAT3 to predict PPCS at 1-month post-injury, showing that neither the child-reported number, nor severity of items endorsed significantly predicted PPCS for both the SCAT3 and ChildSCAT3. The same result was found for the parent-reported severity and number of endorsed items for the ChildSCAT3. Performance on the SAC and mBESS were found to be non-significant in predicting PPCS in both age groups (Table 3).

Results of the secondary analysis, assessing the ability of the tools to predict PPCS both at the earlier time point of 2 weeks post-injury (using Hearps et al.’s definition⁹) and at 1-month post-injury, using Zemek et al.’s definition⁷, were similarly not significant (Table 4).

As shown by ROC curves all ChildSCAT3/SCAT3 components had quite poor discriminant ability in predicting PPCS at 1 month, with all AUC <0.6 (Figures 1 and 2). ChildSCAT3 child-reported symptoms endorsed (Figure 1a) and severity (Figure 1b), and parent reported symptoms endorsed (Figure 1c) and severity (Figure 1d) performed no better than chance (AUC range 0.47 to 0.53). Similar results were found for the SCAT3 symptoms endorsed (Figure 2a, AUC=0.53) and total severity (Figure 2b, AUC=0.59). The performance on the SAC and mBESS showed poor discriminant ability for both the ChildSCAT3 and the SCAT3 (Figure 1e, AUC=0.44 and Figure 2c, AUC=0.49 for SAC; Figure 1f, AUC=0.43 and Figure 2d, AUC=0.49 for mBESS, respectively).

DISCUSSION

Our study found that using the main components of the SCAT3/ChildSCAT3 for the acute assessment of paediatric concussion in the ED does not assist with the early identification of children who progress to have PPCS at 1-month post-injury. We assessed PPCS outcome based on the recently validated definition by our team.⁹ However, applying the PPCS definition by Zemek et al.⁷ to the data from the current study led to similar results. These strengthened our findings, which were not dependent on the PPCS definition used. Based on the ICD-10 definition of post-concussion syndrome and recent literature⁸ we employed the 1-month cut-off in our definition of PPCS. Nonetheless, we also tested the ability of the ChildSCAT3/SCAT3 tools to predict the presence of PPCS at 2 weeks post-injury, but found similar non-significant results as compared with the 1-month cut-off.

Very few published studies have assessed the ability of SCAT key components to predict, at initial presentation, which children will develop PPCS. A recent large prospective multicenter study of children presenting with concussion to Canadian EDs found that a number of errors above three in the BESS tandem stance was an independent predictor of PPCS at 1 month in children of any age.⁷ In our study, we presented the results on the overall mBESS performance. However, when

analysing the performance on the BESS tandem stance separately we did not find any association with PPCS.

While in our study, acute symptom burden, as measured on the ChildSCAT3/SCAT3 symptom scales, was not predictive of PPCS, previous studies found an association between acute symptom number/severity and prolonged post-concussion recovery. In their retrospective case-control study, Miller et al.²¹ reported on 294 patients (4 to 18 years) cared for at a multidisciplinary concussion clinic, and showed that a SCAT2 symptom severity score > 20, within the first month of injury, was predictive of prolonged recovery (>28 days), OR 8.7 (95%CI 2.4-30.8). The work of Nelson et al.²² reported a significant association of both pre-injury somatisation symptoms and acute (<24h) symptom severity score on SCAT3 with prolonged recovery in high school and collegiate athletes following a sport-related concussion. Another recent study in an adult sample, presenting to a concussion clinic showed that the SCAT3 severity score was the most important predictor for post-concussion recovery, defined as the presence and frequency of post-traumatic headache.²³ Although early self-reported concussive symptoms have been found to be independent predictors of recovery in many studies^{6, 24, 25} this finding has not been ubiquitous and the evidence is at times contradictory.⁶ Differences in study design, characteristics of included patients, time of assessment(s) and outcome measures are most likely responsible for these inconsistent findings.

While research has shown that SCAT3/ChildSCAT3, developed by expert consensus, are helpful tools to assist with child concussion diagnosis and monitoring of patient recovery, the current study showed that application of their main components in the ED did not predict prolonged recovery, independent of patient age and sex. Since completion of our study the updated SCAT5/ChildSCAT5^{26,27} version of the tools has been published and recommended for clinical practice. Whilst the newer SCAT tools differ only slightly in their key components (the symptom scale, the rapid cognitive assessment and the modified balance assessment) from the version used in our study, it is uncertain whether these changes would impact the predictive value of the newer tools for PPCS.

The results of our study need to be interpreted in the context of some limitations. First, the representativeness of the present sample may be influenced by the selection bias due to study enrolment and retainment. Although children with a greater symptom burden may have been more likely to agree to participate in the study and complete the follow up, in order to have access to repeat clinical assessment, it is unclear whether the burden of acute symptoms may influence the rate of PPCS and possibly the results of our study. While the number of potentially eligible patients was large, determination of actual eligibility could only be ascertained by research assistants in approximately two thirds of cases, due to limited day cover of research assistants, as well as ED high-pace clinical activity. Further, more than half of eligible patients refused to give consent to study participation, most commonly citing demanding study procedures as the reason for refusal. Unfortunately, due to federal privacy laws, we could not compare characteristics of study patients with eligible non-participants to assess for group differences. As for patients lost to follow up, their demographic and injury characteristics were similar to the study analytic sample. The slight identified differences in age and the higher proportion of sport-related concussions in the analytic sample are unlikely to have significantly biased our results. Second, our sample is limited and we did not perform an a priori sample size calculation, so that our results may not be definitive. Third, in the absence of a valid concussion biomarker, we are dependent upon symptom scales, such as the PCSI, to identify children with persistent concussion. Fourth, we used the parent-report PCSI form to determine the PPCS outcome in this study. Recent research has shown that retrospective pre-injury rating of symptoms using PCSI have good-to-perfect stability over the first three months following a concussion on the patient age-appropriate versions²⁸ and that parent- and child-report concordance was only moderate ($r = .44-.65$), underscoring the importance of using both the parent- and child-report.²⁰ While the parent- and child-report in the ChildSCAT3 symptom scale did not show any difference in prediction of PPCS, we cannot exclude that our results could have differed if the child-report PCSI was used for outcome assessment. Fifth, we did not assess the tandem gait, as this was deemed not feasible within the

ED due to space constraints. However, based on the SCAT tools this item could be performed in addition or in place of the balance assessment and is no longer part of the Balance Examination section of the newer version of the tools. Last, this was a single centre study of children presenting to a tertiary, paediatric hospital ED within 48 hours of their concussion and results may not be generalizable to other settings.

Further validation in large unbiased prospective studies are warranted to determine if the scores on the SCAT tools, when used for the acute assessment of paediatric concussion in the ED, are predictive of persistent post-concussive symptoms.

CONCLUSIONS

Although the SCAT3/ChildSCAT3 are recommended tools to assist with concussion diagnosis and monitoring patient recovery, the performance on their key components during the acute assessment in the ED does not seem to predict which patients develop PPCS.

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Figure 1. Receiver Operator Characteristic curves, presenting discriminant ability of ChildSCAT3 components for PPCS at 1 month.

AUC = Area Under Curve. ChildSCAT3: a. Symptom number; b. Symptom severity; c. Symptom number [parent]; d. Symptom severity [parent]; e. SAC (Standardized Assessment of Concussion) [reversed]; f. mBESS (Modified Balance Error Scoring System).

Figure 2. Receiver Operator Characteristic curves, presenting discriminant ability of SCAT3 components for PPCS at 1 month.

AUC = Area Under Curve. SCAT3: a. Symptom number; b. Symptom severity; c. SAC (Standardized Assessment of Concussion) [reversed]; d. mBESS (Modified Balance Error Scoring System).

Box 1**Definition of concussion as per Berlin Consensus Statement on Concussion in Sport ²**

Concussion is a traumatic brain injury induced by biomechanical forces. Several common features that may be utilised in clinically defining the nature of a concussive head injury include:

- concussion may be caused either by a direct blow to the head, face, neck or elsewhere on the body with an impulsive force transmitted to the head.*
- concussion typically results in the rapid onset of short-lived impairment of neurological function that resolves spontaneously. However, in some cases, signs and symptoms evolve over a number of minutes to hours.*
- concussion may result in neuropathological changes, but the acute clinical signs and symptoms largely reflect a functional disturbance rather than a structural injury and, as such, no abnormality is seen on standard structural neuroimaging studies.*
- concussion results in a range of clinical signs and symptoms that may or may not involve loss of consciousness. Resolution of the clinical and cognitive features typically follows a sequential course. However, in some cases symptoms may be prolonged.*

The clinical signs and symptoms cannot be explained by drug, alcohol, or medication use, other injuries (such as cervical injuries, peripheral vestibular dysfunction, etc) or other comorbidities (eg, psychological factors or coexisting medical conditions).

Table 1: Sample demographics and injury characteristics, presented by ChildSCAT3/SCAT3, and presence of PPCS at one month post injury.

N	ChildSCAT3					SCAT3				
	Recovered n=76		Symptomatic* n=47		p	Recovered n=63		Symptomatic* n=27		p
Age [years], mean (SD)	9.5	(2.2)	10.3	(2.1)	0.032	14.8	(1.3)	15.4	(1.3)	0.042
Sex [male], n (%)	56	(73.7)	32	(68.1)	0.504	13	(20.6)	9	(33.3)	0.199
<i>Pre-injury data, n (%)</i>										
Hx of depression/anxiety	5	(6.6)	4	(8.5)	0.731**	6	(9.5)	4	(14.8)	0.479**
Hx of migraine/headache	3	(4.0)	4	(8.5)	0.426**	12	(19.1)	6	(22.2)	0.730
Concussion in the past year	18	(23.7)	10	(21.3)	0.757	17	(27.0)	12	(44.4)	0.063
<i>Mechanism of Injury, n (%)</i>										
Falls	48	(63.2)	25	(53.2)	0.274	35	(55.6)	18	(66.7)	0.326
Sport-related	32	(42.1)	31	(66.0)	0.010	50	(79.4)	23	(85.2)	0.518
MVA	2	(2.6)	4	(8.5)	0.201**	4	(6.4)	0	(0.0)	0.312
<i>Acute symptoms, n (%)</i>										
Loss of consciousness	7	(9.2)	12	(25.5)	0.015	20	(31.8)	10	(37.0)	0.626
Amnesia	24	(31.6)	16	(34.0)	0.777	32	(50.8)	10	(37.0)	0.231
Vomiting	36	(47.4)	19	(40.4)	0.452	13	(20.6)	4	(14.8)	0.518
Headache	50	(65.8)	32	(68.1)	0.793	49	(77.8)	23	(85.2)	0.421
GCS in ED <15, n (%)	6	(7.9)	2	(4.3)	0.709**	2	(3.2)	0	(0.0)	1.000**
CT performed in ED, n (%)	13	(17.1)	9	(19.2)	0.774	9	(14.3)	6	(22.2)	0.368**
Admitted to ED observation unit, n (%)	47	(61.8)	30	(63.8)	0.825	38	(60.3)	19	(70.4)	0.364
Admitted to the ward, n (%)	4	(5.3)	1	(2.1)	0.648**	2	(3.2)	1	(3.7)	1.000**
Medications for underlying conditions	6	(7.9)	7	(14.9)	0.240**	6	(9.5)	13	(48.2)	<0.001

* Symptomatic = 2+ new symptoms above baseline at 1 month

** Fisher's exact test; MVA= motor vehicle accident

Table 2. ChildSCAT3/SCAT3 scores on acute assessment in the Emergency Department, by presence of PPCS at one month post injury

	ChildSCAT3							SCAT3						
	Recovered			Symptomatic†			p	Recovered			Symptomatic†			p
	n	M	(SD)	n	M	(SD)		n	M	(SD)	n	M	(SD)	
SCAT3/ChildSCAT3 @ T0														
Child Report Items Endorsed	76	10.6	(4.7)	47	10.8	(5.7)	0.844	63	12.0	(4.9)	27	13.2	(5.5)	0.310
Child Report Severity	76	18.5	(9.8)	47	20.1	(11.5)	0.415	63	29.1	(18.8)	27	36.9	(21.9)	0.092
Parent Report Items Endorsed	76	11.1	(5.5)	46	11.4	(5.5)	0.719							
Parent Report Severity	76	18.7	(11.0)	46	18.4	(10.5)	0.898							
SAC‡	76	9.2	(4.7)	47	8.7	(4.5)	0.580	63	7.3	(5.4)	27	7.7	(5.9)	0.716
mBESS‡	74	5.2	(6.2)	44	4.9	(5.8)	0.811	63	5.8	(5.4)	25	8.0	(9.2)	0.153

†Symptomatic = 2+ new symptoms above baseline at 1 month.

‡Negative binomial distribution, SAC reverse coded for inferential model.

M= mean; SD= standard deviation.

Table 3: Adjusted[†] odds ratios and 95% confidence intervals from multiple logistic regressions, predicting PPCS at one month post-injury

	ChildSCAT3				SCAT3			
	N	aOR	(95%CI)	p	N	aOR	(95%CI)	p
T3, 2+ exacerbated symptoms								
Child Report Items Endorsed	123	0.98	(0.90 - 1.06)	0.575	90	1.04	(0.95 - 1.15)	0.406
Child Report Severity	123	1.01	(0.97 - 1.04)	0.755	90	1.02	(0.99 - 1.04)	0.155
Parent Report Items Endorsed	122	1.00	(0.93 - 1.08)	0.958				
Parent Report Severity	122	1.00	(0.96 - 1.03)	0.791				
SAC [reversed]	123	1.03	(0.94 - 1.13)	0.554	90	1.02	(0.93 - 1.11)	0.678
mBESS	119	1.01	(0.94 - 1.07)	0.878	92	1.04	(0.96 - 1.11)	0.342

[†]Adjusted for child age, gender, time between injury and T3 (1 month post injury), history of migraines/headaches, mental health diagnosis, and prior concussion.

Table 4: Adjusted odds ratios and 95% confidence intervals from multiple logistic regressions, predicting delayed recovery using different PPCS definitions

PPCS defined as ≥ 3 items above baseline at 1 month (Zemek et al. definition ⁷)	ChildSCAT3				SCAT3			
	N	aOR	(95%CI)	p	N	aOR	(95%CI)	p
T3, 3+ exacerbated symptoms								
Child Report Items Endorsed	123	0.98	(0.90 - 1.07)	0.632	90	1.04	(0.94 - 1.15)	0.453
Child Report Severity	123	1.02	(0.98 - 1.06)	0.423	90	1.02	(0.99 - 1.04)	0.138
Parent Report Items Endorsed	122	1.04	(0.95 - 1.12)	0.405				
Parent Report Severity	122	1.01	(0.97 - 1.05)	0.531				
SAC [reversed]	123	1.04	(0.93 - 1.15)	0.494	90	1.00	(0.91 - 1.10)	0.978
mBESS	119	1.03	(0.95 - 1.10)	0.500	92	1.04	(0.96 - 1.12)	0.338

Adjusted for child age, gender, time between injury and T3, and history of migraines/headaches, mental health diagnosis, and prior concussion.

PPCS defined as ≥ 2 items above baseline at 2 weeks (Hearps et al. definition ⁹)	ChildSCAT3				SCAT3			
	N	aOR	(95%CI)	p	N	aOR	(95%CI)	p
T2, 2+ exacerbated symptoms								
Child Report Items Endorsed	121	1.02	(0.95 - 1.11)	0.563	87	1.02	(0.93 - 1.12)	0.705
Child Report Severity	121	1.02	(0.98 - 1.06)	0.292	87	1.01	(0.98 - 1.03)	0.531
Parent Report Items Endorsed	120	1.05	(0.98 - 1.12)	0.187				
Parent Report Severity	120	1.02	(0.98 - 1.06)	0.296				
SAC [reversed]	121	1.06	(0.97 - 1.16)	0.199	87	0.98	(0.89 - 1.07)	0.644
mBESS	117	1.05	(0.99 - 1.13)	0.116	89	0.99	(0.92 - 1.08)	0.881

Adjusted for child age, gender, time between injury and T3, and history of migraines/headaches, mental health diagnosis, and prior concussion.

JPC_14910_Figure 1.jpg

JPC_14910_Figure 2.jpg

Title of Manuscript: Use of the Sport Concussion Assessment Tools in the Emergency Department to predict persistent post-concussive symptoms in children

Original Article

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Conflicts of interest: GD is an honorary member of the Australian Football League Concussion Working Group and has attended meetings organized by sporting organizations including the National Football League (NFL; USA), National Rugby League (Australia), and FIFA (Switzerland); however, he has not received any payment, research funding, or other monies from these groups other than for travel costs. GD is a member of the International Concussion in Sport group that developed the SCAT3 and ChildSCAT3.

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