ORIGINAL ARTICLE

Clinical Outcomes of Pediatric Acute Sport- and Non-Sport-Related Concussions

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ABSTRACT: ***Objectives:*** The objectives were to examine clinical characteristics, length of recovery, and the prevalence of delayed physician-documented recovery, compare clinical outcomes among those with sport-related concussion (SRC) and non-sport-related concussion (nSRC), and identify risk factors for delayed recovery. ***Methods:*** Included patients (8–18 years) were assessed ≤14 days post-injury at a multidisciplinary concussion program and diagnosed with an acute SRC or nSRC. Physician-documented clinical recovery was defined as returning to pre-injury symptom status, attending full-time school without symptoms, completing Return-to-Sport strategy as needed, and normal physical examination. Delayed physician-documented recovery was defined as >28 days post-injury. ***Results:*** Four hundred and fifteen patients were included (77.8% SRC). There was no difference in loss of consciousness (SRC: 9.9% vs nSRC: 13.0%, $p = 0.39$) or post-traumatic amnesia (SRC: 24.1% vs SRC: 31.5%, $p = 0.15$) at the time of injury or any differences in median Post-Concussion Symptom Scale scores (SRC: 20 vs nSRC: 23, $p = 0.15$) at initial assessment. Among those with complete clinical follow-up, the median physician-documented clinical recovery was 20 days (SRC: 19 vs nSRC: 23; $p = 0.37$). There was no difference in the proportion of patients who developed delayed physician-documented recovery (SRC: 27.7% vs nSRC: 36.1%; $p = 0.19$). Higher initial symptom score increased the risk of delayed physician-documented recovery (IRR: 1.39; 95% CI: 1.29, 1.49). Greater material deprivation and social deprivation were associated with an increased risk of delayed physician-documented recovery. ***Conclusions:*** Most pediatric concussion patients who undergo early medical assessment and complete follow-up appear to make a complete clinical recovery within 4 weeks, regardless of mechanism.

RÉSUMÉ : L'évolution clinique des commotions en phase aiguë, liées ou non au sport chez les enfants. ***Objectifs*** **:** L'étude visait, d'une part, à examiner les caractéristiques cliniques de l'ébranlement, le temps nécessaire au rétablissement et la prévalence du rétablissement tardif objectivé par le médecin (RTOM) et, d'autre part, à comparer l'évolution clinique des commotions liées au sport (CLS) avec celle des commotions non liées au sport (CNLS) et à cerner les facteurs de risque de rétablissement tardif. ***Méthode*** **:** Ont participé à l'étude des patients (8-18 ans) qui avaient été examinés ≤ 14 jours après le trauma, dans le cadre d'un programme pluridisciplinaire de prise en charge des commotions, et chez qui avaient été posé un diagnostic de CLS ou de CNLS en phase aiguë. Le rétablissement clinique objectivé par le médecin a été défini comme le retour à l'état de santé tel qu'il était avant la blessure; le retour à l'école à temps plein, sans manifestation de symptômes; l'application de l'ensemble de la stratégie de retour au sport, selon le cas; et un examen physique normal. Quant au rétablissement tardif objectivé par le médecin, il s'observe > 28 jours après la blessure. ***Résultats*** **:** Au total, 415 patients ont été retenus (CLS : 77,8 %). Aucune différence quant à la perte de connaissance (CLS : 9,9 % contre [c.] CNLS : 13,0 %, $p = 0,39$) ou à l'amnésie post-traumatique (CLS : 24,1 % c. CLS : 31,5 %; $p = 0,15$) n'a été observée au moment de l'accident, pas plus qu'il n'y avait de différence de résultats médians sur l'échelle Post Concussion Symptom Scale (CLS : 20 c. CNLS : 23; $p = 0,15$) à la consultation initiale. Le temps médian nécessaire au rétablissement clinique objectivé par le médecin parmi les sujets qui ont fait l'objet d'un suivi clinique complet était de 20 jours (CLS : 19 c. CNLS : 23; p = 0,37). Aucune différence n'a été relevée non plus en ce qui concerne la proportion de patients qui a connu un RTOM (CLS : 27,7 % c. non-CLS : 36,1 %; $p = 0,19$). Toutefois, des résultats initiaux élevés sur l'échelle des symptômes comportaient un risque accru de RTOM (ratio des taux d'incidence : 1,39; IC à 95 % : 1,29-1,49). En outre, une pauvreté matérielle importante et un manque sérieux de relations sociales étaient associés à une augmentation du risque de RTOM. ***Conclusions*** **:** La plupart des enfants ébranlés par une commotion qui sont soumis à un examen médical précoce et qui font l'objet d'un suivi complet semblent connaître un rétablissement clinique complet au cours des 4 semaines suivant la blessure, et ce, indépendamment du mécanisme incriminé.

Keywords: Concussion, Sport, Non-sport, Pediatrics

doi:10.1017/cjn.2021.82 Can J Neurol Sci. 2022; 49: 263–269

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Received September 21, 2020. Final Revisions Submitted March 23, 2021. Date of Acceptance April 16, 2021.

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Introduction

Concussion is the most common form of traumatic brain injury (TBI) and is characterized by clinical manifestations that are thought to reflect a functional rather than a structural injury to the brain.[1] Despite increasing research attention focused on this condition, the natural history and expected clinical outcomes following pediatric concussion remain poorly understood. Most studies of pediatric concussion have consisted of modest samples of patients with sport-related injuries evaluated at tertiary concussion clinics and larger studies of more heterogeneous populations initially evaluated in the emergency department but who went on to receive non-uniform follow-up care, were assessed largely with surveys, and for whom the length of recovery was not assessed using current clinical standards.[2–4] A recent systematic review focusing on sport-related concussion (SRC) suggests that the majority of children and adolescents are expected to recover within 1–4 weeks post-injury with a small but important proportion developing symptoms that persist beyond 1 month.[3] To date, few studies have examined clinical outcomes among a general sample of pediatric concussion patients who underwent comprehensive medical assessment and were followed to physician-documented clinical recovery.

Therefore, the primary objective of this study was to examine clinical characteristics, length of recovery, and the prevalence of delayed physician-documented recovery among pediatric sport- and non-sport-related concussion (nSRC) patients who underwent comprehensive management through a multidisciplinary pediatric concussion program. The secondary objectives were to compare clinical outcomes among those with sport- and non-sport-related injuries and identify risk factors for delayed recovery for the entire cohort.

Methods

Research Design and Inclusion Criteria

We completed a retrospective chart review of pediatric patients who underwent initial assessment at the Pan Am Concussion Program in Winnipeg, Manitoba, Canada between May 15th, 2017 and April 13th, 2018. The Pan Am Concussion Program is a provincial government-funded multidisciplinary program that receives referrals from emergency departments and primary care providers and through sport-specific concussion protocols. All patients undergo initial medical assessment, follow-up, and medical clearance by a single neurosurgeon. Patients aged 8–18 years who underwent initial assessment within 14 days of injury and were diagnosed with a concussion were included in the study. Patients excluded from the study were those who: 1) were assessed greater than 14 days post-injury; 2) did not have a confirmed date of injury; 3) were not diagnosed with a concussion; 4) did not live in Manitoba; 5) sustained a new injury while symptomatic from a previous injury or who sustained a second suspected injury before recovering from their initial injury; 6) sustained a co-existing orthopedic injury; 7) sustained a co-existing spinal cord injury (e.g., spinal cord injury without radiographic abnormality); or 8) had evidence of structural brain injury on diagnostic imaging. Patients who were managed exclusively through telemedicine and who underwent initial in-person assessment but lived in remote regions that presented a barrier to frequent clinical follow-up were also excluded.

Medical Assessment and Management

At their initial visit, patients completed a standardized intake form documenting demographic characteristics, self-reported past medical history, and mechanism of injury. They also completed the Post-Concussion Symptom Scale (PCSS), a validated symptom inventory composed of 22 symptoms encompassing physical, cognitive, sleep, and emotional domains of functioning that were ranked on a 7-point Likert scale (0–6; maximum score 132).[5] The medical assessment performed by the neurosurgeon consisted of a clinical history, review of completed symptom inventory, and previous diagnostic imaging as well as a physical examination that evaluated cranial nerve, motor, sensory, cerebellar, balance, vestibulo-ocular, and cervical spine functioning.

Follow-up appointments were typically scheduled based on the patient's rate of recovery and sport schedules where applicable. In general, patients were classified as clinically recovered when they were symptom-free or had returned to their pre-injury symptom status, were tolerating physical activity and full-time school without limitations, and had a normal physical examination including the absence of cervical spine or vestibulo-ocular dysfunction (VOD). Those returning to sports were required to have satisfied the appropriate requirements of their sport-specific Return-to-Sport protocol.[1]

Definitions

Concussion

Concussion was defined according to the Berlin Consensus Statement on Concussion in Sport and was medically diagnosed in patients who reported sustaining a traumatic impulsive force to the head or body and presented with new onset concussion-like symptoms such as headaches, dizziness, photosensitivity, fatigue, or memory difficulties that could not be attributed to an alternative medical diagnosis.[1] SRC was defined as an injury occurring during a sporting activity (training or organized game/competition) or during physical education class at school. All other concussions were classified as nSRC.

Vestibulo-Ocular Dysfunction

Similar to our previous work,[6,7] VOD was diagnosed among patients who reported vestibulo-ocular symptoms (i.e., blurred vision, double vision, dizziness, difficulty concentrating) and demonstrated more than one abnormality on initial focused vestibulo-ocular examination, including near point of convergence >6 cm, abnormal smooth pursuits, or abnormal or symptomatic (leading to new or worsening symptoms or discomfort) testing of horizontal or vertical saccades or gaze stabilization.

Cervical Spine Dysfunction (CSD)

Similar to our previous work,[8] CSD was diagnosed among patients who reported neck pain, headache, or dizziness and who demonstrated cervical spine tenderness and/or decreased cervical spine range of motion on initial physical examination.

Length of Physician-Documented Clinical Recovery

This was defined as the number of days between the date of the initial injury and the date of physician-documented clinical recovery.

https://doi.org/10.1017/cjn.2021.82 Published online by Cambridge University Press

Delayed Physician-Documented Recovery

Given that the current literature suggests that the majority of pediatric concussion patients make a complete recovery within 4 weeks,[3] we defined delayed physician-documented recovery as clinical recovery documented by the physician greater than 28 days post-injury.

Data Collection

The following data were extracted from each patient's chart: demographic characteristics (age, sex, self-reported history of previous concussion, mental health disorders, and migraine and/or non-specific headaches), injury characteristics (date of injury, injury mechanism or sport, presence of self-reported loss of consciousness (LOC), or post-traumatic amnesia (PTA) at the time of injury), and clinical outcomes (initial PCSS score, presence of VOD and CSD at initial medical assessment, days until physician-documented clinical recovery). Postal code was extracted as an indicator of socioeconomic status (SES). SES was classified by linking participants' postal code to their respective dissemination areas (DAs) according to Statistics Canada. One DA represents approximately 400–700 people within a stable geographic neighborhood. Two indicators of SES were examined: material deprivation and social deprivation.[9] Material deprivation is a score composed of average household income, proportion without a high school diploma, and the unemployment rate. Social deprivation is composed of proportion of people who are separated, divorced, or widowed, proportion of people living alone, and proportion of people who had moved in the previous 5 years. Patients were classified based on quintiles representative of the Prairie Zone as defined by Statistics Canada (Manitoba, Saskatchewan, and Alberta).[10] Quintile 5 represents the highest deprivation or lowest SES.

For baseline characteristics, the dichotomous and polychotomous characteristics for SRC and nSRC patients were reported as a proportion and compared using a chi-squared test. Normally distributed continuous characteristics were reported as a mean with standard deviation and compared using the unpaired *t*-test. Continuous characteristics that were not normally distributed were reported as a median with interquartile ranges (IQRs) and compared using the rank-sum test.

The median days to physician-documented recovery were compared using the Wilcoxon rank-sum test for non-parametric data. Days to physician-documented recovery between SRC and nSRC were tested using purposeful backwards elimination Cox regression and the proportional hazards assumption was assessed. The following potential confounders were assessed: age, sex, initial PCSS score (squared to correct for the skewed nature of the scores), past medical history of mental health disorder, previous concussion, LOC or PTA at the time of injury, the presence of VOD or CSD at initial assessment, social deprivation quintiles, and material deprivation quintiles. The confounders remained in the final model if the effect estimate changed by 15% or more compared to the effect estimate without the confounder.

The proportion of patients with delayed physician-documented recovery was compared using a chi-squared test. Purposeful backwards elimination poison regression was conducted to identify risk factors for developing delayed physician-documented recovery. Characteristics that were not significant risk factors were then assessed as potential confounders.

Statistical analysis was completed using Stata version 16. A two-sided p-value <0.05 was interpreted as statistically significant. Approval for this study was obtained from the institutional review ethics board at the University of Manitoba.

Results

Patient Characteristics

A total of 415 patients, 323 (77.8%) with SRC and 92 (22.2%) with nSRC, were included in the study. The median days from injury to initial medical assessment were 5 (IQR: 3, 7) for the entire cohort but were significantly shorter for SRC (4; IQR: 3, 7) versus nSRC (5; IQR: 3, 8) patients ($p = 0.0373$). Patients with SRC were significantly older and more likely to be male compared to patients with nSRC (Table 1). There were no group differences in the proportion of patients who experienced LOC or PTA at the time of injury nor any differences in PCSS scores or the presence of CSD or VOD at initial assessment between SRC and nSRC patients. SES data were available for 374 patients. There was no difference in the distribution across the quintiles for material deprivation ($p = 0.222$) or social deprivation ($p = 0.053$) between the SRC and nSRC groups. Among those with a SRC, the most common sports were ice hockey (48.6%), football (14.7%), and soccer (9.0%) (Table 2). For those with an nSRC, the most common mechanisms of injury were having been struck by or having struck an object (37.0%), falls (30.4%), or motor vehicle collisions (21.7%).

Length of Physician-Documented Clinical Recovery

In this study, 339 (81.7%) patients met the criteria for physician-documented clinical recovery and one patient remained in treatment. Overall, the median length of recovery for the entire cohort with complete follow-up was 20 days (IQR: 13, 32). There was no difference in length of physician-documented clinical recovery between SRC and nSRC patients (Figure 1). Among those with complete follow-up, the median length of physician-documented recovery was 19 days (IQR: 13, 30.25 days) for SRC and 23 days (IQR: 12.5, 39 days) for nSRC patients ($p = 0.37$). There was no significant difference in time to physician-documented recovery between groups (crude hazard ratio (HR): 1.31; 95% CI: 0.99, 1.75) and the proportional hazards assumption was not violated ($p = 0.146$). There was no evidence of confounding by age, sex, initial PCSS, previous history of concussion, previous history of psychiatric history, previous history of migraine or non-specific headache, social deprivation, material deprivation, self-reported LOC or PTA at the time of injury, or presentation with VOD or CSD at initial assessment (adjusted HR: 1.19; 95% CI: 0.82, 1.72).

Overall, 75 patients included in this study were lost to follow-up (18.1%). Patients with an nSRC were significantly more likely to be lost to follow-up than those with an SRC (33.0% vs 13.9%, $p < 0.001$).

Delayed Physician-documented Clinical Recovery

Among the 339 youths with complete medical follow-up, 99 (29.2%) patients in the entire cohort experienced delayed

https://doi.org/10.1017/cjn.2021.82 Published online by Cambridge University Press

Table 1: Characteristics at initial presentation among youth who sustained a sport- or non-sport-related concussion

	All concussions $n = 415$ (%)	SRC $n = 323$ (%)	nSRC $n = 92$ (%)	*p*-value
Pre-injury characteristics				
Males	272 (65.5%)	219 (67.8)	53 (57.6)	0.07
Mean age (years; SD)	14.0 (2.4)	14.2 (2.2)	13.1 (3.0)	<0.0001
History of previous concussion(s)	158 (38.4)	129 (40.3)	29 (31.5)	0.13
History of psychiatric history	23 (5.5)	17 (5.3)	6 (6.5)	0.64
History of non-specific or migraine headache	26 (6.3)	21 (6.5)	5 (5.4)	0.71
Material deprivation quintiles				0.22
1 (lowest deprivation)	96 (23.1)	79 (29.5)	17 (18.5)	
2	61 (14.7)	45 (16.8)	16 (17.4)	
3	65 (15.7)	50 (18.7)	15 (16.3)	
4	64 (15.4)	55 (20.5)	9 (9.8)	
5 (highest deprivation)	55 (13.3)	39 (14.5)	16 (20.7)	
Missing	74 (17.8)	55 (17.0)	19 (20.7)	
Social deprivation quintiles				0.05
1 (lowest deprivation)	123 (29.6)	105 (32.5)	18 (19.6)	
2	73 (17.6)	60 (18.6)	13 (14.1)	
3	52 (12.5)	36 (11.2)	16 (17.4)	
4	64 (15.4)	45 (13.9)	19 (20.7))	
5 (highest deprivation)	29 (7.0)	22 (6.8)	7 (7.6)	
Missing	74 (17.8)	55 (17.0)	19 (20.7)	
Injury characteristics at initial presentation				
Days to initial presentation (median; IQR)	5 (3.7)	4 (3.7)	5 (3.8)	0.04
Initial PCSS score (median; IQR)	20 (6-37)	20 (6-35)	23 (5-42.75)	0.15
Loss of consciousness	44 (10.6)	32 (9.9)	12 (13.0)	0.39
Post-traumatic amnesia	106 (25.7)	77 (24.1)	29 (31.5)	0.15
Cervical spine dysfunction	173 (41.7)	132 (40.9)	41 (44.6)	0.53
Vestibulo-ocular dysfunction	101 (24.3)	81 (25.1)	20 (21.7)	0.51

SD = standard deviation; PCSS = Post-Concussion Symptom Score; IQR = inter-quartile range; CT = computed tomography; SRC=sport-related concussion; nSRC = non-sport-related concussion.

Table 2: Mechanism of concussion

SRC ($n = 323$)	Frequency (%)	nSRC ($n = 92$)	Frequency (%)
Ice hockey	157 (48.6)	Struck by object/struck head on object	34 (37.0)
Football	48 (14.7)	Fall	28 (30.4)
Soccer	29 (9.0)	MVC (driver or passenger)	20 (21.7)
Basketball	18 (5.6)	Assault	7 (7.6)
Ringette	12 (3.7)	MVC (pedestrian)	4 (4.3)
Volleyball	10 (3.1)		
Rugby	7 (2.2)		
Cheer	4 (1.2)		
Water polo	4 (1.2)		
Other (<4 each)	34 (10.5)		

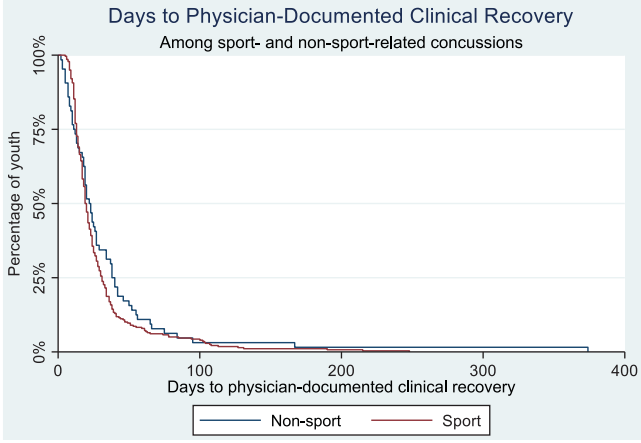

Figure 1: *Kaplan–Meier curve of days to physician-documented clinical recovery.*

https://doi.org/10.1017/cjn.2021.82 Published online by Cambridge University Press

Table 3: Clinical outcomes for sport- and non-sport-related concussions

	All concussions	SRC	nSRC	*p*-value
Achieved physician diagnosed recovery (*n* %)	339 (81.7)	278 (86.1)	61 (66.3)	<0.0001
Days to physician diagnosed clinical recovery (median IQR)	20 (13, 32)	19 (13, 30.25)	23 (12.5, 39)	0.37
Delayed physician-documented clinical recovery (*n* %)	99 (29.2)	77 (27.7)	22 (36.1)	0.19

SRC = sport-related concussion; nSRC = non-sport-related concussion; IQR = inter-quartile range.

physician-documented clinical recovery (Table 3). There was no difference in the proportion of patients who developed delayed physician-documented recovery: nSRC: 36.1% versus SRC: 27.7% ($p = 0.193$). For the entire cohort, the risk of developing physician-documented clinical recovery significantly increased with higher squared PCSS score at initial medical assessment (IRR: 1.39; 95% CI: 1.29, 1.49). Compared to youth in the lowest material deprivation quintile (highest SES; quintile 1), youth in next quintile (high SES, quintile 2) had an increased risk of developing delayed physician-documented recovery (IRR: 1.87; 95% CI: 1.23, 2.84). Youth experiencing the highest level of material deprivation (lowest SES, quintile 5) were also at a significantly higher risk of physician-documented recovery (IRR: 1.66; 95% CI: 1.01, 2.73) compared to youth with the lowest level of material deprivation.

Discussion

This is one of the few studies in the published literature that examines clinical outcomes among a generalized sample of pediatric acute concussion patients who underwent comprehensive medical assessment and complete follow-up to physician-documented clinical recovery. It is also one of the very few studies in the reported literature that compared clinical outcomes among pediatric patients who sustained acute sport- and non-sport-related injuries. This study included 415 patients who underwent initial medical assessment a median of 5 days post-injury, 77.8% of whom sustained injuries during sport-related activities. Among studies that have included general populations of pediatric concussion patients, the proportion of injuries caused by sport-and non-sport-related injuries varies significantly depending on the sample and the healthcare settings in which they were evaluated (e.g. emergency department, primary care, specialized concussion clinics).[11–15] Here, the most common causes of injury among the nSRC patients were being struck by or striking their head on an object, falls, and vehicle occupied motor vehicle collisions which is consistent with the previous epidemiological literature.[11–15] We found that the SRC patients were significantly older and male. This aligns with previous research that has demonstrated that the proportion of concussions caused by sport and recreational injuries within the pediatric population increases with age and males sustaining a greater proportion of sport-related injuries compared to females.[11]

In this study, we found that clinical characteristics such as the presence of LOC and PTA at the time of injury were similar between those with SRC and nSRC. We also found no significant differences in initial symptom burden between the two groups. This is in contrast to one previous study that found that patients with an nSRC evaluated at a pediatric out-patient clinic had a higher symptom burden at initial presentation compared to those with SRC.[16] Consistent with our previous work,[6–8] we found that an important proportion of pediatric concussion patients demonstrated clinical evidence of VOD and CSD on initial assessment, but there were no differences in the proportion of patients who exhibited these features between SRC and nSRC groups.

Among all pediatric concussion patients who underwent complete medical follow-up, the median length of clinical recovery was 20 days and 29.2% experienced delayed physician-documented clinical recovery. Among those with complete medical follow-up, we did not observe any differences in the median length of clinical recovery or the proportion of patients who experienced delayed physician-documented clinical recovery between SRC and nSRC patients. Overall, these findings are in keeping with a large Canadian multi-institutional study of pediatric concussion patients who were evaluated in the emergency department and underwent non-uniform clinical care in which 31% developed persistent post-concussion symptoms (three or more new or worsening symptoms compared to baseline at 28 days post-injury evaluated by electronic or telephone follow-up survey).[14]

When examining the entire cohort, a higher initial PCSS was associated with increased risk of experiencing delayed physician-documented recovery. This aligns with a recent systematic review of pediatric and adult SRC that concluded that the most consistent predictor of slower recovery following concussion was the severity of symptoms in the acute and subacute phases of the injury.[17] One notable finding of the present study was that indicators of lower SES were significantly associated with an increased risk of experiencing delayed recovery following pediatric concussion. To date, the limited studies that have examined the impact of SES on clinical outcomes and the development of persistent symptoms following pediatric concussion and mild TBI have demonstrated mixed results.[18–20] Therefore, more comprehensive studies are needed to clarify the effect of SES and the social determinants of health on clinical outcomes following pediatric concussion.

The results of this study have important clinical implications for primary care and sub-specialty physicians caring for pediatric concussion patients. Overall, the results suggest that the vast majority of pediatric concussion patients who undergo comprehensive medical assessment and follow-up will make a complete clinical recovery and return to school and sport activities within 4 weeks of injury. These findings suggest that pediatric patients with both sport- and non-sport-related injuries should be managed on an individualized basis and according to existing evidence-based pediatric concussion guidelines.[21] However, physicians and healthcare professionals should be aware that socioeconomic factors might have a modifying impact on clinical outcomes in this population. In some instances, there may be a role for other multidisciplinary healthcare professionals, such as

https://doi.org/10.1017/cjn.2021.82 Published online by Cambridge University Press

social workers, to help support selected pediatric concussion patients throughout their recovery

This study has some important limitations. First, this study was performed at a tertiary concussion clinic. Although the results compare favorably to previous studies evaluating patients evaluated through the emergency department and tertiary concussion clinics, the findings may not be representative of patient populations presenting to primary care facilities. Second, relative to larger previous studies including pediatric concussion patients evaluated in the emergency department, the sample size included in our study is small. However, we believe this limitation is offset by the ability to evaluate a sample of pediatric concussion patients who underwent comprehensive medical assessment and who were followed to physician-documented clinical recovery rather than assessing patients with symptom inventories and other measures interpreted without any clinical context. Third, in this study we set out to examine the impact of SES on clinical outcomes following pediatric concussion; however, our measure of SES was based on dissemination data from the 2011 Canadian census. A large number of new neighborhoods have been created in Winnipeg, Manitoba since 2011 and newer communities tend to be more affluent. They were also more likely to have missing data. More recent census data may have impacted the analysis regarding the effect of SES on clinical outcomes. Other social factors such as race, family household income, parental education and occupation, and indicators of family functioning were not independently examined and should be considered in future studies. Fourth, a notable proportion of patients included in this study were lost to follow-up, which was more common among those with nSRC versus SRC. The factors underlying this difference remain unclear; however, those patients who are active in sports and sustained SRC may have been more likely to undergo complete medical follow-up due to the need to obtain medical clearance to return to competitive sports. This limitation is common among studies performed at tertiary pediatric concussion clinics and may have impacted the findings of the study and resulted in insufficient power to identify a significant difference between the SRC and nSRC groups.

Despite the limitations discussed above, our study suggests that most pediatric concussion patients who seek early medical assessment and undergo complete medical follow-up appear to make a complete clinical recovery within 4 weeks post-injury regardless of whether they sustain an injury during a sport- or non-sport-related activity. A small but important proportion of patients will experience delayed recovery that is predicted by higher symptom burden at initial assessment and may be modified by SES. Future research should prioritize obtaining complete follow-up data as well as elucidate the injury and non-injury factors that contribute to risk of delayed recovery following pediatric SRC and nSRC.

Acknowledgements

This work was supported by Dr Russell's Establishment Grant from Manitoba Health Research Council (now Research Manitoba).

Statement of Authorship

MJE conceptualized and designed the study, carried out data collection, critically reviewed and revised the manuscript, and approved the final manuscript as submitted. KR conceptualized and designed the study, conducted the analysis, critically reviewed and revised the manuscript, and approved the final manuscript as submitted. KB carried out data collection, conducted the analysis, drafted the manuscript, and approved the final manuscript as submitted. DM, RG, and LZ carried out data collection and analysis, critically reviewed and revised the manuscript, and approved the final manuscript as submitted. All authors agree to be accountable for all aspects of the work ensuring that questions related to the accuracy and integrity of any part of the work are appropriately investigated and resolved.

Disclosures

None.

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https://doi.org/10.1017/cjn.2021.82 Published online by Cambridge University Press