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Return to sports after pediatric traumatic brain injury: An expert panel survey

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Abstract

Background: There are no evidence based guidelines for clinicians to follow in advising pediatric patients with traumatic brain injury (TBI) on return to play (RTP).

Objective: To understand practice patterns of experts in pediatric traumatic brain injury (TBI) in relation to how they assess severity of TBI and guide return to play (RTP) decisions with their patients who sustain complicated mild, moderate, or severe TBI.

Design: Cross-sectional web-based survey.

Setting: Not applicable.

Participants: Thirty experts (defined by attesting to their clinical management of children with TBI and demonstrating a history of publication in the area of pediatric TBI including mild TBI) represented by physical medicine and rehabilitation, neurology, neurosurgery, sports medicine, and neuropsychology. Fifty-five candidates were invited, 37 responded (67% response rate), and 30 were eligible to participate.

Interventions: Not applicable.

Main Outcome Measure(s): Ratings of agreement as to the relative importance of a variety of factors used to assess initial severity of injury as well as to measure recovery. RTP timelines were measured for different scenarios (adjusted by level of risk of activity returned to and the severity of initial injury sustained). Finally, ratings of agreement with various factors that could influence their RTP decision making as well as a free text option.

Results: Recommendations on RTP timing varied significantly based on risk of activity returned to for all levels of TBI severity ($p < .05$). There was large variability of RTP timeline for any given level of injury severity. There was no significant association between medical specialty and RTP recommendations. Experts also noted a variety of factors which may inform their RTP decision making, many with high agreement.

Conclusions: These results can inform clinicians who care for these patients in their own RTP decision making. The description of these RTP trends, in combination with the variability seen in both severity determination and recovery assessment, highlight the importance of further study of outcomes related to RTP and the eventual development of standardized guidelines for this patient population.

INTRODUCTION

Multiple guidelines describe the assessment, management and return to play (RTP) parameters of mild traumatic brain injury (mTBI) in children.[1–4] Although these guidelines have evolved to emphasize the importance of a holistic view of recovery in children, such as their emphasis on ensuring that successful return to school precedes RTP,

these guidelines exclude a subgroup of patients with mTBI, those categorized as mTBI with neuroimaging evidence of structural intracranial injury, historically referred to as complicated mTBI (C-mTBI), and those with moderate and severe traumatic brain injury (TBI). These are important groups of patients, with an estimated 7.5% of all pediatric mTBI being C-mTBI[2] and up to 15% of hospitalized children seeking care for TBI having moderate or severe TBI.[5] The lack of RTP guidance for those with more severe injury has been highlighted in a Centers for Disease Control and Prevention report to Congress.[6] In the authors' collective clinical experience, many children with complicated mild, moderate, and severe TBI recover well and desire to return to sports participation. In a previous study observing sport participation patterns in children with a prior C-mTBI, greater than 90% of children return to sports participation, many involved in contact or high-risk activities.[7]

As far back as 1998, Cantu posited that an athlete who had sustained a life-threatening head injury could potentially RTP, provided they had made a complete neurologic recovery and likely after at least 1 year.[8] Over the years, however, very little has been studied in this unique population, and the literature is largely limited to case reports and small case series. In 2021, Zuckerman et al. published a systematic review of these cases, identifying 128 cases over 27 studies where sport was implicated in a structural brain injury.[9] Only 33% of these studies included any information on RTP.[9] In a 2023 study, Jo et al. described the outcomes of nine adolescent and college-age athletes with C-mTBI compared to mTBI controls. Those with C-mTBI had similar symptom resolution patterns but did take longer to return to learn and RTP.[10] Additional authors have discussed considerations in allowing sport participation among those with nontraumatic structural brain abnormalities.[11] Although clinicians have discussed potential risks regarding RTP (e.g. persistent symptoms, heightened risk of reinjury, and the possibility of a new injury more severe than a concussion), few empiric data exist to confirm these concerns. For example, in the case of chiari malformations, in a cohort of 147 patients who collectively participated in 1627 athletic seasons, there was no catastrophic injury sustained in sport participation.[12] Zuckerman further studied neurosurgical expert opinions regarding RTP in the setting of sport-related structural brain injury. Key findings from this important work were that surgeons are significantly more conservative in their RTP recommendations for high school athletes compared to collegiate or professional athletes.[9]

Although some literature exists describing RTP safety in patients with nontraumatic and traumatic structural brain lesions, RTP as viewed through the lens of categorizing patients from C-mTBI to severe TBI has not been specifically studied.[6,9,11] There is a lack of clear direction regarding who should make RTP decisions for patients with C-mTBI to severe TBI, whether the existing guidelines for RTP in uncomplicated mTBI can be applied to this population, and whether the increased severity of injury should affect clinical decision making. Data are needed to describe the current practices for those making RTP decisions for patients with C-mTBI to severe TBI and how they are determining the timeline for RTP in these patients.

This survey study aimed to describe how experts in the field of pediatric TBI judge severity of injury, measure recovery, and make subsequent RTP decisions in pediatric populations (age ≤ 18 years) with C-mTBI to severe TBI. We hypothesized that RTP timelines would vary based on injury severity and the level of risk of the activity returned to.

METHODS

Based on the authors' collective clinical experience of greater than 15 years in pediatric TBI management including RTP decisions, the following medical specialties were identified as likely evaluators for children with TBI and making RTP decisions: Neurology, neurosurgery, physical medicine and rehabilitation (PM&R), neuropsychology, sports medicine, and emergency medicine. The authors contacted colleagues in the field via email to generate a list of potential expert candidates; additional candidates were identified from a review of relevant pediatric TBI literature. We aimed to identify approximately 30 experts, consistent with other expert panel surveys in the areas of mild TBI and structural brain injury.[9,13] Candidates were considered experts if they could attest to being clinically active in the care of children with TBI, to making RTP decisions for children with TBI, and to having a history of publication in the general topic of pediatric TBI, including pediatric mTBI.

Between January and April of 2022, emails were sent to each of the physicians and neuropsychologists identified, inviting them to participate in the study. Participants provided informed consent by accessing and completing the survey. Inclusion criteria to participate in the survey required an attestation from the potential participant confirming they are currently clinically active in the care of children with complicated mild, moderate, or severe TBI, make RTP decisions, and have a history of publication within the last 5 years in pediatric TBI, including pediatric mTBI. Participants were excluded from participation if they had not yet completed clinical training. This survey study was approved by the local institutional review board.

Survey design and content

To develop the survey, we used an iterative process to revise and refine items that reflected the aims of the

study and to ensure clarity and used guidelines for good question writing to reduce the likelihood of measurement error.[14] For example, we included fully labeled, construct-specific scales.[15] The relative importance of various clinical data used to determine TBI severity was assessed. Participants were asked to identify what clinical factors, tests, or instruments they use in measuring recovery in children with TBI in order to assist with RTP decisions. Participants were then asked to identify RTP timelines in hypothetical patients who had made a complete recovery (by how they judge recovery) from their TBI and had successfully progressed through a standard graduated RTP program up to the stage of tolerating high-intensity, sport-specific noncontact drills (but not yet participated in regular contact activities in a practice or competitive environment). The cases included a variety of severities from C-mTBI using standard parameters for defining severity,[16] further differentiating by level of contact/risk (low, medium, and high) of various activities in each scenario. Level of contact/risk was suggested to participants utilizing a risk classification scheme based on Rice et al. and published injury rates in youth sports.[17,18] Finally, participants rated their agreement with various factors that could influence their RTP decision making as well as a free text option. The survey instrument was generated in Qualtrics XM (Provo, UT). See Appendix S1 for the full survey.

Data analysis

Survey responses were summarized descriptively using counts and percentages. Participants' recommendations for time to RTP were stratified by severity of TBI, risk of activity, and participants' medical specialty using cross-tabulations. We used Fisher's exact tests with Monte Carlo approximation to assess these associations and report the associated *p* values. Fisher exact was selected due to small cell counts and the ordinal nature of the data. The responses to the 12 items rating level of importance of clinical factors used in TBI severity assessment were summarized by median and interquartile range (IQR) values and displayed in a vertical box plot. *p* values <.05 were considered statistically significant. Analyses were conducted using SAS 9.4 (SAS Institute, Cary, NC). Free text responses to the question "Are there any other factors that alter your decision making and subsequent recommendations on return to sports and physical activities for children with TBI (anything from complicated mTBI through severe TBI)?" were summarized qualitatively using thematic analysis.[19,20] Responses were read by 2 authors (N.G. and C.H.) to identify key themes. Codes were identified from the data, and responses were then coded and grouped by themes derived from the responses. Any discrepancies between coders were discussed to achieve resolution. These themes, along with example quotations, are provided in table format.

RESULTS

Participant characteristics

The characteristics of the survey participants are reported in Table 1. Fifty-five potential candidates were contacted. Thirty-seven responses were received (response rate 67%). Thirty eligible respondents completed the survey represented by PM&R, neurology, neurosurgery, sports medicine, and neuropsychology. Seven participants did not meet inclusion criteria. The majority of respondents had been in practice for >5 years (93%) and most reported making return to play decisions 13–50 times per year (43%).

Criteria used to determine injury severity

The most common variables used to determine injury severity were imaging findings (90%), initial Glasgow Coma Scale (GCS) score (80%), posttraumatic amnesia (PTA) duration (77%), and loss of consciousness (LOC) duration (77%). All variables, including those provided by free text response, are shown in Table 2. Regarding the relative importance of specific variables on a scale from 1 (not at all important) to 10 (extremely important), those deemed most important included LOC duration (median 8, IQR 7–10), presence of imaging findings including traumatic axonal/shear injury (median 9, IQR 8–10), intraparenchymal hemorrhage (median 8.5, IQR 7–10), extra-axial hemorrhage (median 8.5, IQR 7–10), subarachnoid hemorrhage (median 8, IQR 7–10), and cerebral edema (median 8, IQR 7–10). The requirement for surgery (median 7.5, IQR 6–9) and initial GCS (median 7.5, IQR 7–10) were rated as slightly less important. See Figure 1 for all rated variables.

Variables used to measure recovery

In assessing variables used to measure recovery, neurologic exam findings (93%) comprehensive neuropsychologic evaluation scores (90%), balance testing (83%), and child-(73%) and parent-reported (69%) symptom scores were most commonly used. Follow-up computed tomography (28%) and magnetic resonance imaging (53%) were less frequently used in recovery determination. Of those who use balance testing to help determine recovery, the Romberg (57%) and Modified Balance Error Scoring System (47%) were the most used balance tests. A variety of other factors were used at varying frequencies to measure recovery; see Table 3 for further details.

TABLE 1 Characteristics of respondents.

Characteristic	Survey response	Frequency	Percentage
Medical specialty	PM&R	7	23%
	Neurology	7	23%
	Neurosurgery	7	23%
	Sports medicine	1	3%
	Emergency medicine	0	0%
	Neuropsychology	8	27%
Region of practice	United States Northeast	11	37%
	United States South	5	17%
	United States West	9	30%
	United States Midwest	3	10%
	Canada	1	3%
	Europe	1	3%
	Australia/New Zealand	0	0%
Gender identity	Male	21	70%
	Female	8	27%
	Transgender	0	0%
	Non-binary/non-conforming	0	0%
	Prefer not to say	1	3%
Years of independent clinical practice	Less than 5 years	2	7%
	5 or more years	28	93%
Frequency of return to play recommendations/decisions for children with C-mTBI, moderate TBI, or severe TBI	0 times per year	0	0%
	1–2 times per year (at least annually)	0	0%
	3–5 times per year (at least once every 4 months)	7	23%
	6–12 times per year (at least once every other month)	3	10%
	13–50 (at least monthly)	13	43%
	51 or more (at least weekly)	7	23%

Abbreviations: C-mTBI, complicated mild traumatic brain injury; PM&R, physical medicine and rehabilitation; TBI, traumatic brain injury.

RTP timing, stratification by injury severity and risk of activity

Regarding timing assessments for RTP stratified by injury severity, recommendations varied significantly by risk of activity for all injury types.

For C-mTBI (no surgery) the largest number of respondents recommended RTP as soon as clinically recovered for noncontact/low-risk activities (48%), 2–3 months for medium-contact/risk activities (34%), and 2–3 months for high-contact/risk activities (31%) ($p = .028$). For those patients with C-mTBI who require surgery, the largest number of respondents recommended RTP at 2–3 months for noncontact/low-risk activities (36%), 4–6 months for medium-contact/risk activities (33%), and were split between 4–6 and 7–12 months for high-contact/risk activities (26% each respectively) ($p = .008$).

For moderate TBI (no surgery) the largest number of respondents recommended RTP as soon as clinically recovered for noncontact/low-risk activities (32%), 2–3 months for medium-contact/risk activities (37%), and 13–18 months for high-contact/risk activities (30%) ($p = .003$). For moderate TBI requiring surgery respondents were split between 0 and 1 month, 2–3 months, and 4–6 months for noncontact/low-risk activities (25% each respectively); between 2–3 and 4–6 months for medium-contact/risk activities (30% each respectively); and 13–18 months for high-contact/risk activities (33%) ($p < .001$).

For severe TBI (no surgery) the largest number of respondents recommended RTP at 4–6 months for non-contact/low-risk activities (27%), 4–6 months for medium-contact/risk activities (31%), and 31% reporting recommending patients never RTP for high-contact/risk activities ($p < .001$). For severe TBI requiring surgery respondents were split between 0–1 month and 4–6 months for noncontact/low-risk activities (22% each respectively), 7–12 months for medium-contact/risk activities (33%), and 37% reporting recommending patients never RTP for high-contact/risk activities ($p < .001$). A complete description of the response distribution for these scenarios is shown in Table 4.

We examined whether RTP timing varied when stratified by risk of activity. There were no significant

TABLE 2 Variables used to determine TBI severity.

Assuming all of the following data are available to you, which of the following components do you typically use to grade the initial severity of a TBI?	Frequency (%)[a]
Initial GCS score	24 (80%)
24 h GCS score	7 (23%)
Worst GCS score in first 24 h	13 (43%)
Best GCS score in first 24 h	10 (33%)
PTA duration	23 (77%)
LOC duration	23 (77%)
Imaging findings	27 (90%)
Surgery requirement	14 (47%)
Free text responses	
EEG/seizures	2 (7%)
Premorbid status	1 (3%)
Symptom number and severity	1 (3%)
Time to follow commands	1 (3%)
Paroxysmal sympathetic hyperactivity	1 (3%)
Specific neurologic deficits	1 (3%)
Clinical trend over time	1 (3%)

[a]Question asked to select all that apply, percentages will not sum to 100%.
Abbreviations: GCS, Glasgow Coma Scale; LOC, loss of consciousness; PTA, posttraumatic amnesia; TBI, traumatic brain injury.

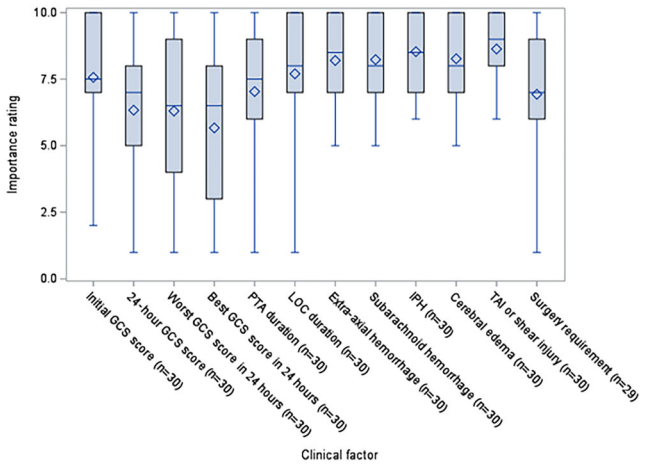

FIGURE 1 Relative importance of clinical factors in determining injury severity. The importance rating (from 1 = not at all important to 10 = extremely important) for several different clinical factors in determining injury severity is shown with box plots showing mean, median, interquartile range, minimum and maximum scores. Abbreviations: GCS, Glasgow Coma Scale; IPH, intraparenchymal hemorrhage; LOC, loss of consciousness; PTA, posttraumatic amnesia; TAI, traumatic axonal injury.

associations between injury severity and RTP recommendations for low-risk/contact activities or medium-risk/contact activities. There was a statistically significant association between TBI type and RTP suggestion for high-contact/risk sports ($p = .001$).

TABLE 3 Variables used to measure recovery.

Which of the following do you use to measure recovery in children with anything more complicated than mild TBI in order to assist with return-to-play decisions?	Frequency (%)[a]
General neurologic exam	28 (93%)
Comprehensive neuropsychologic evaluation scores	27 (90%)
Balance testing	25 (83%)
Symptom scores from the child	22 (73%)
Symptom scores from the parent	20 (67%)
Vestibular ocular motor screen	17 (57%)
Follow-up MRI brain imaging	16 (53%)
ImPACT testing or other abbreviated computer-based tests	11 (37%)
Glasgow outcome scale extended	9 (30%)
Follow-up CT brain imaging	8 (27%)
Timed tandem gait single task	8 (27%)
Timed tandem gait dual task	7 (23%)
Disability rating scale	5 (17%)
Free text responses	
Input from other disciplines (therapies, neurosurgery, PM&R, etc. as applicable)	3 (10%)
More comprehensive assessment of vision, oculomotor, and vestibular functioning (not the VOMS)	2 (7%)
Evaluation of mood/behavior	1 (3%)
Reaction time	1 (3%)
Clinical interview (eg, how they are functioning at school, etc.; are they symptomatic with exercise or other activities)	1 (3%)
Gait evaluation	1 (3%)
Coordination evaluation	1 (3%)

[a]Question asked to select all that apply, percentages will not sum to 100%.
Abbreviations: CT, computed tomography; MRI, magnetic resonance imaging; PM&R, physical medicine and rehabilitation; TBI, traumatic brain injury; VOMS, Vestibular Ocular Motor Screening.

Medical specialty variability

We examined whether RTP recommendations varied by reported medical specialty (PM&R, neurology, neurosurgery, neuropsychology). Sports medicine and emergency medicine were excluded from this analysis due to small sample sizes ($n = 1$ and $n = 0$, respectively). No significant association existed between medical specialty and RTP recommendations.

Factors that influence RTP decision making

Factors necessitating a longer duration before allowing RTP and that received 80% or greater agreement (noted agree or strongly agree) included degree of

TABLE 4 Return to play timelines stratified by injury severity.

	As soon as fully clinically recovered	0–1 month	2–3 months	4–6 months	7–12 months	13–18 months	19+ months	Never	*p* value[a]
Complicated mTBI (no surgery)									.028
Noncontact sports and low-risk activities	14 (48%)	7 (24%)	6 (21%)	2 (7%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
Medium-contact/risk sports	6 (21%)	4 (14%)	10 (34%)	5 (17%)	4 (14%)	0 (0%)	0 (0%)	0 (0%)	
High-contact/risk sports	6 (21%)	2 (7%)	9 (31%)	3 (10%)	6 (21%)	2 (7%)	0 (0%)	1 (3%)	
Complicated mTBI (surgery)									.008
Noncontact sports and low risk activities	6 (21%)	7 (25%)	10 (36%)	4 (14%)	0 (0%)	1 (4%)	0 (0%)	0 (0%)	
Medium-contact/risk sports	2 (7%)	1 (4%)	8 (30%)	9 (33%)	4 (15%)	2 (7%)	0 (0%)	1 (4%)	
High-contact/risk sports	2 (7%)	1 (4%)	4 (15%)	7 (26%)	7 (26%)	3 (11%)	1 (4%)	2 (7%)	
Moderate TBI (no surgery)									.003
Noncontact sports and low risk activities	9 (32%)	4 (14%)	9 (32%)	4 (14%)	2 (7%)	0 (0%)	0 (0%)	0 (0%)	
Medium-contact/risk sports	1 (4%)	1 (4%)	10 (37%)	7 (26%)	4 (15%)	3 (11%)	0 (0%)	1 (4%)	
High-contact/risk sports	1 (4%)	0 (0%)	6 (22%)	7 (26%)	4 (15%)	8 (30%)	0 (0%)	1 (4%)	
Moderate TBI (surgery)									<.001
Noncontact sports and low-risk activities	4 (14%)	7 (25%)	7 (25%)	7 (25%)	2 (7%)	1 (4%)	0 (0%)	0 (0%)	
Medium-contact/risk sports	0 (0%)	0 (0%)	8 (30%)	8 (30%)	6 (22%)	4 (15%)	0 (0%)	1 (4%)	
High-contact/risk sports	0 (0%)	0 (0%)	4 (15%)	7 (26%)	3 (11%)	9 (33%)	0 (0%)	4 (15%)	
Severe TBI (no surgery)									<.001
Noncontact sports and low-risk activities	6 (23%)	4 (15%)	4 (15%)	7 (27%)	4 (15%)	1 (4%)	0 (0%)	0 (0%)	
Medium-contact/risk sports	0 (0%)	0 (0%)	5 (19%)	8 (31%)	6 (23%)	5 (19%)	0 (0%)	2 (8%)	
High-contact/risk sports	0 (0%)	0 (0%)	2 (8%)	4 (15%)	6 (23%)	4 (15%)	2 (8%)	8 (31%)	
Severe TBI (surgery)									<.001
Noncontact sports and low-risk activities	3 (11%)	6 (22%)	5 (19%)	6 (22%)	5 (19%)	2 (7%)	0 (0%)	0 (0%)	
Medium-contact/risk sports	0 (0%)	0 (0%)	4 (15%)	7 (26%)	9 (33%)	4 (15%)	1 (4%)	2 (7%)	
High-contact/risk sports	0 (0%)	0 (0%)	2 (7%)	3 (11%)	6 (22%)	5 (19%)	1 (4%)	10 (37%)	

[a]*p* values obtained from Monte Carlo simulation of Fisher's exact test.
Abbreviations: mTBI, mild traumatic brain injury; TBI, traumatic brain injury.

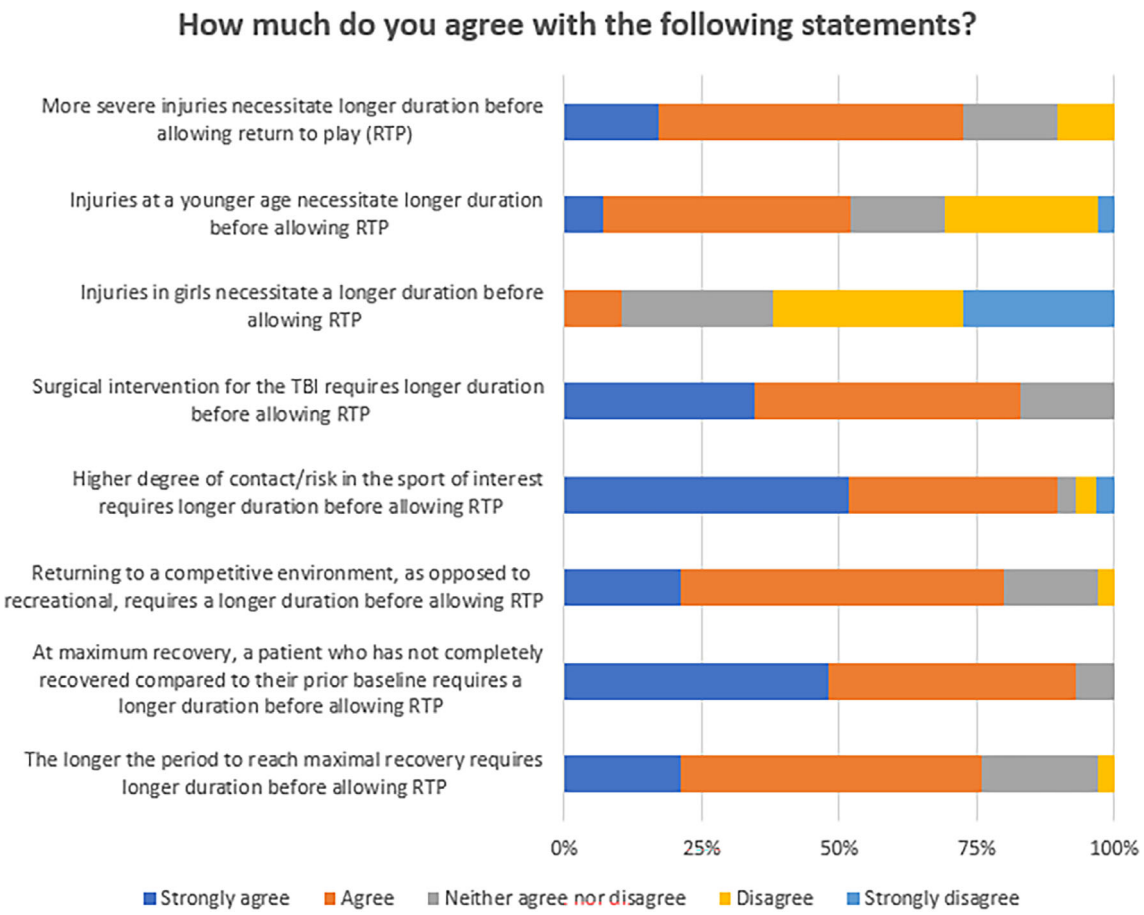

FIGURE 2 Factors that influence return to play decision making. Survey respondent levels of agreement on a Likert scale from strongly agree to strongly disagree for several statements about making return to play decisions in children with TBI are illustrated. Each category of agreement is illustrated as a percentage of total survey respondents. Abbreviation: TBI, traumatic brain injury.

recovery that does not reach preinjury baseline (93%), higher degree of contact/risk in the sport of interest (90%), the requirement of surgical intervention (82%), and returning to a competitive as opposed to a recreational playing environment (80%). All queried factors and the participants level of agreement are illustrated in Figure 2.

In a free text response option, respondents identified several other considerations used when making RTP decisions for children with TBI. The core themes that emerged included family support/values, patient goals, surgical history/needs, follow-up imaging findings, and the presence or absence of medical complications and/or comorbidities including a history of prior TBIs. Examples of responses illustrating these themes are shown in Table 5.

DISCUSSION

This study uniquely describes RTP timelines in hypothetical scenarios where patients with TBI had completely recovered from their injury and considerations to inform the RTP decision making process from a group of experts representing multiple medical specialties for children with C-mTBI through severe TBI from any cause. Given that current RTP guidelines in children exclude anything more severe than mTBI,[1,3,4] these findings offer a framework for clinicians in making RTP decisions for a broader population of patients recovering from TBI.

When asked about classifying injury severity, imaging findings, initial GCS, PTA, and LOC duration were cited as factors considered in severity determination, which is consistent with Veterans Affairs/Department of Defense guidelines,[16] However, the importance given to any one of these severity criteria was variable. The authors attribute this to the lack of uniform agreement regarding which indicators are most important in varying clinical contexts (ie, predicting mortality as opposed to predicting functional recovery).[21–23] There was more consistency across respondents in the variables used to measure recovery. Patients' neurologic exam findings, comprehensive neuropsychologic evaluation scores, balance testing, and child- and parent-reported symptom scores were uniformly cited as important measures of recovery. The number of cited variables

TABLE 5 Qualitative summary of other themes that may affect RTP decision making.

Theme	Example quotations
Family support/ values	Family values, including importance of the sport for child's overall well-being
	Family support/adherence to recommendations
	Each family must come to a decision based on their understanding and valuation of the benefits of the specific activity for that child compared to the potential risks
Patient goals	Athletic identity importance of sports for the youth
	Individual child interests, goals, and socioemotional factors
	Periodically we see a young person for whom return to sport is enormously important psychologically/emotionally
History of prior TBI	Multiple diagnosed TBIs may prolong RTP recommendations
	Total prior brain injuries, especially if long duration of symptoms and proximity to prior head injury
Imaging	Results of the MRI may influence my return to play decision and recommendations for types of sports to consider.
	Presence of skull fracture, particularly displaced or depressed skull fracture may add time to a milder injury to ensure bone healing
	Vascular injury (head or neck) would delay return to sports and physical activities.
Surgical history	External ventricular drain placement versus hemicraniectomy—I would react differently depending on type of surgery
	Ongoing surgical issues (ie, craniectomy)
Cognitive/ behavioral symptoms	Cognitive, emotional, and self-control capacities of the patient to follow appropriate safety guidelines within the sports
	Persistent symptoms and deficits (eg, motor, sensory, cognitive) compared to baseline functioning
	Mental health and recovery; behavioral health and behavioral skill recovery
Seizure history	The risk for seizures with any new head trauma
	Presence of seizure disorder

Abbreviations: MRI, magnetic resonance imaging; RTP, return to play; TBI, traumatic brain injury.

highlights the multifaceted nature of defining TBI recovery.

Although the authors hypothesized initial injury severity would significantly affect RTP decisions, the responses suggest the severity classification given to a patient's injury was less important in RTP decision making when compared to clinical factors. For example, for each injury severity, there is a statistically significant association between risk of activity and RTP timeline recommendation. RTP timeline recommendations are longer for increasing risk of the activity returned to. However, for low- and moderate-risk activities, severity of injury was not significantly associated with RTP timelines. Only for high-risk activities was there a significant association with injury severity classification and RTP timeline. Level of activity returned to, then, appears to be more influential than injury severity. Still, there is a noticeable increase in RTP timeline from one injury severity category to another (ie, the timeline to RTP is longer for severe TBI than for lower severities of injury). However, we acknowledge the significant variability within expert opinions for any given injury severity. For example, when considering a return to high-risk sports for children with C-mTBI, the expert responses ranged from "as soon as clinically recovered" to "never." Zuckerman similarly noted great heterogeneity in RTP recommendations in sport-related structural brain injury.[9] This heterogeneity highlights the critical need for robust data that describes RTP outcomes for these patients.

Besides injury severity and the risk of the activity returned to, the two variables studied in our RTP timeline scenarios, several additional variables should be considered when making RTP decisions for children with TBI. The expert panel noted with strong agreement that surgical intervention for the TBI, the nature of the sport environment (ie, competitive vs. recreational), and whether or not a patient had recovered to their previous baseline should all affect RTP decisions. There was less strong agreement on factors such as duration of recovery and age at time of injury. Few (10%) felt that gender should affect RTP decision making. Upon review of the literature, there are no other analogous studies from which to directly compare the importance of these considerations, though Zuckerman did note that RTP became more lenient for professional athletes than for high school athletes.[9]

Recognizing that many clinical factors are used simultaneously to determine recovery and subsequent RTP, including those themes identified in Table 5, is perhaps the most important finding of this study and is concordant with the existing pediatric RTP and return-to-learn literature.[3,4,24,25] Although the current study focused specifically on RTP decisions, the authors acknowledge the importance of addressing a patient's ability to return to learn as paramount to resumption of sports activities. Notably, RTP decisions are made by a variety of medical specialties, and recommendations did not vary significantly by medical specialty in this group of experts. Prior reports addressing RTP after structural brain injury have been limited to neurosurgeons only.[9] For any future work to create a clinical practice guideline, broad representation should be encouraged.

In making RTP decisions for patients, we encourage clinicians to consider the potential risks versus benefits

of RTP, which was not explicitly investigated in this report. Even though there is a lack of empirical evidence to inform the likelihood of such risks (which may include the risk of repeat head injury, either concussion or more severe TBI, and the exacerbation or reemergence of prior TBI symptoms) occurring by returning to play, we feel it is important to at least acknowledge these in shared decision-making processes with patients and their families. Some cross-sectional data in children with mTBI and C-mTBI suggest that the risk for repeat concussion may actually be less in children with complicated mTBI,[7] thus clinicians need to be careful about assuming these risks are greater in children with more severe injuries without empiric data to inform such assumptions. As for benefits of sport participation (which include improved physical fitness[26] and its downstream health benefits,[27] improved quality of life,[28] and improved mental health[29]), it is equally important to acknowledge these possibilities while understanding the limits of what empiric data exist for this specific context and ultimately engage in a shared decision-making process with patients and their families.

These data offer important insights into the practice patterns of a group of experts who make RTP decisions for pediatric patients on a regular basis. Given the paucity of data describing outcomes in children with C-mTBI, moderate, and severe TBI who return to sport, the current study findings offer an important starting point for clinicians to use to inform their own shared decision-making processes with patients. Although having an algorithm to follow to determine a safe RTP timeline for children with TBI sounds attractive, the reality appears that there are several clinical variables that should be weighed by both the clinician and the patient/patient's family on an individualized basis. Thus, until actual evidence emerges of the outcomes of children with TBI who return to sport, clinicians will need to assimilate their values, their patients' values, while considering expert opinion to guide a shared decision-making process.

Study limitations

There are limitations to this survey study. Although the investigators made efforts to include a diverse group of experts in the field of pediatric brain injury medicine, this process was subject to selection bias. It is possible that some experts appropriate for this study may have been excluded (ie, general pediatricians). This sample of experts heavily represented the United States (94%) and most identified as male (70%). Other factors including participants' culture, race or ethnicity, or more specific details about the participants' patient populations were not gathered. Our inclusion criteria for an ''expert'' required publications in pediatric TBI and the authors acknowledge this narrows the pool of participants; excellent clinicians may not publish for various reasons. Given these demographics, the current group may not represent all practitioners and therefore these findings may not be generalizable to all circumstances. Furthermore, we acknowledge that the hypothetical scenario presented to participants required them to consider a patient who had experienced a complete recovery. Many patients with moderate to severe TBI will not experience this ideal—complete recovery. Thus, the RTP timelines noted by this expert panel in those scenarios, if used as a benchmark for clinicians, would need to be accounted for in other scenarios a clinician may face, such as the decision to return to play in new modified adaptive sports settings. Lastly, there may be yet other important variables which could affect RTP decision making that we did not account for in this survey, nor which emerged in our free text response, such as how to advise young children with TBI (ie, infants and toddlers) who, as they age, may desire to participate in sports.

CONCLUSION

The current survey study is the first of the authors' knowledge to assess expert opinions in RTP decision making for pediatric C-mTBI through severe TBI. Although no consistent formula was found, respondents generally recommended a longer length of time before RTP for patients returning to higher risk activities and with severe injuries. Many clinical factors, including a patient's need for surgical intervention, the sport's level of risk, whether the patient desired to return to competitive versus leisure sport, and whether a patient fully clinically recovered from the TBI were consistently identified as key contributors to decision making. The description of these RTP trends, in combination with the variability seen in both severity determination and recovery quantification, highlight the importance of further formalization of care for this patient population. The authors recommend future research in this area include a multispecialty Delphi consensus process to address areas of uncertainty and determine best practices in determining RTP decisions in complex cases of pediatric TBI.

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DISCLOSURE

The authors report no conflicts of interest to disclose.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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