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Characteristics of Concussion in Elementary School-Aged Children: Implications for Clinical Management

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Objective To comprehensively characterize the clinical presentation and course of care for concussion among 5- to 11-year-old children, identifying preinjury and injury factors potentially influencing clinical outcomes.

Study design A single-institution retrospective cohort study using electronic health record data from children ages 5- to 11 years with a concussion from July 1, 2014, through June 30, 2015. Electronic health record data were abstracted for a 20% random sample of 292 patients.

Results Three-fourths of patients (74.3%) presenting for concussion care had a standardized visiovestibular assessment performed. Almost all of those who eventually sought specialty care (92.9%) also had such an assessment, and only 42.9% patients initially seen in the emergency department or urgent care were examined in this manner. Of those assessed, 62.7% (n = 136) demonstrated deficits, with children ages 9-11 years more frequently exhibiting deficits than their younger counterparts (67.9% vs 53.2%; $P = .03$). Almost all patients (95.9%) reported at least 1 somatic symptom (eg, headache, dizziness), and one-half to two-thirds reported problems with sleep (54.1%) and visiovestibular symptoms (66.1%). Only 11.6% of children were referred for rehabilitation therapies and less than one-half of concussed patients (43.8%) were provided with a letter recommending school accommodations.

Conclusions Somatic symptoms, sleep problems, and visiovestibular deficits are common in elementary school-aged children with concussion, but specific visiovestibular clinical assessments are often not performed, particularly in the emergency department setting. Recommendations for school accommodations are often not provided at the time of concussion diagnosis. Incorporating a standardized visiovestibular assessment into practice could facilitate early targeted school accommodations and thereby improve return to learning for elementary school-aged children with concussion. *(J Pediatr 2020;223:128-35)*.

Much of the literature on pediatric concussion has focused on characterizing concussions among adolescent athletes (ie, 12- to 19-year-olds in middle and high school).[1] However, in our previous study of concussions presenting to a large pediatric healthcare network, almost one-third of 0- to 18-year-old children who sustained a concussion were in elementary school, ages 5-11 years, about whom much less is known.[2] Previous research among concussed adolescents has identified differences in vestibular, balance, and visual deficits based on point of care (eg, presenting to the emergency department [ED] or specialty care practice), highlighting the importance of studying pediatric concussion across clinical settings to characterize fully the injury profile.[3] In addition, deficits of the visio-vestibular system can affect reading and note-taking[4] and predict longer recovery in adolescents.[5-7] These deficits likely affect learning for elementary school-aged children as well, but are not well-characterized. An improved understanding of the characteristics of concussion sustained in elementary school-aged children could influence the clinical management of concussions.

The objective of this study was to comprehensively characterize the clinical presentation and course of care among 5- to 11-year-old children diagnosed with a concussion within the Children's Hospital of Philadelphia's (CHOP) pediatric health care network. Specifically, we aimed to describe preinjury and injury characteristics that might influence outcomes, including a comparison of older and younger elementary school-aged children within middle childhood to identify any differences that might be related to development.[8]

CHOP	Children's Hospital of Philadelphia
ED	Emergency department
EHR	Electronic health record
ICD-9-CM	*International Classification of Diseases, Ninth Revision*

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Methods

The CHOP network consists of more than 50 locations throughout southeastern Pennsylvania and southern New Jersey, with 31 pediatric and adolescent primary care centers, 14 specialty care centers, a 535-bed inpatient hospital, 2 EDs, and 2 urgent care centers with more than 1 million visits per year. CHOP serves a racially and socioeconomically diverse population, and participates in most insurance plans, including Medicaid. A network-wide, unified electronic health record (EHR) system (EpicCare, Epic Systems, Inc., Madison, Wisconsin) is used across the network for all clinical care.

Two aspects of concussion care in the CHOP network deserve mention. First, CHOP introduced an EHR clinical decision support tool in July 2012, which standardized the documentation of concussion-specific assessments, including the visio-vestibular examination, as well as diagnosis and management. Second, all providers have been trained to perform a visio-vestibular assessment during their clinical examination for concussion.[5,9] Briefly, the visio-vestibular examination consists of an assessment of smooth pursuits, horizontal and vertical saccades, vestibulo-ocular reflex, and complex tandem gait, as well as an estimate of the near point of convergence. The current visio-vestibular examination (Table I) is similar to the vestibular/oculomotor screen, but includes an additional measure of tandem gait.[10]

Patient Identification

We queried the CHOP EHR to identify all 5- to 11-year-olds with a concussion visit from July 1, 2014, through June 30, 2015 (n = 1626 patients), defined as a visit with an *International Classification of Diseases*, *Ninth Revision* (ICD-9-CM) diagnosis code for concussion.[11] Patients with a concussion sustained before the beginning of the study, defined as those with a concussion-related CHOP visit within 6 months of their earliest visit in the study period (n = 95), were excluded. To minimize misclassification, we excluded patients who were also assigned an ICD-9-CM code for a more severe traumatic brain injury, as previously published (n = 4).[12] Abstraction was performed on a simple random sample of 20% of patients (n = 306). Distributions of race/ethnicity, sex, age, insurance payor (private, Medicare/self-pay), location of first visit (primary care, outpatient, or ED/urgent care) were similar between the randomly selected sample and the underlying cohort. We also compared younger (age 5-8) with older (age 9-11) children in this cohort, corresponding with the Centers for Disease Control and Prevention's subdivision of middle childhood.[8]

EHR Abstraction

Manualized EHR abstraction was performed by 2 abstractors trained by a study author. Seven cases were abstracted in training; all differences were resolved until complete agreement was reached. Clinical data (variables described elsewhere in this article) were abstracted from the EHR and reviewed by 1 study author, resolving discrepancies with the team's clinical expert. Based on abstraction, an additional 14 patients were excluded because there was no concussion (ie, erroneous ICD-9-CM coding; n = 6) or the first concussion visit during the study period was a follow-up visit for a previous concussion (n = 8). Of the 13 patients with more than 1 concussion during the study period, only the first concussion was included. The final sample included 292 patients aged 5- to 11-years-old with an initial visit for concussion within the CHOP network during the 1-year study period.

Abstracted Variables

The mechanism of injury was categorized in a standardized fashion, where external causes of injury codes (ie, fall, struck by object, struck by person) were assigned to each case and were subsequently characterized as sports or recreation related or not.[13] Additionally abstracted were the self-reported number of previous concussions and pre-existing

Table I. Visiovestibular assessment for concussion

Assessments	Procedures	Abnormal findings in concussion
Smooth pursuit	At a distance of 1 foot from patient, examiner moves visual target horizontally for 5 repetitions	Unable to follow visual target, headache or dizziness, eye pain, eyes watering, or eye redness provoked by pursuit
Saccades	Visual target held 2 feet apart, patient moves eyes horizontally then vertically between targets while holding head still up to 30 repetitions	Unable to visually jump back and forth between visual targets, headache or dizziness, eye pain, eyes watering, or eye redness provoked by saccades
Vestibulo-ocular reflex	Patient focuses on visual target at 1 foot from patient and shakes (horizontal) or nods head (vertical) while maintaining visual focus up to 30 repetitions	Unable to tolerate head movement with visual fixation, headache or dizziness, eye pain, eyes watering, or eye redness provoked by head movement
Near point of convergence	Use 20/30 visual target and bring towards nose; the near point of convergence is the distance from the forehead when the visual target becomes double	Visual target becomes double >6 cm from forehead*
Complex tandem gait	Tandem gait heel-toe forward and backward with eyes open and closed	Unable to maintain tandem gait or lifts arms up to maintain balance or demonstrates truncal sway off the midline while performing task

*Scheiman M, Convergence Insufficiency Treatment Trial Investigator Group. The Convergence Insufficiency Treatment Trial: design, methods, and baseline data. Ophthalmic Epidemiol 2008; 15:24-36.

co-occurring conditions that might influence recovery from concussion. Co-occurring conditions (with corresponding ICD-9-CM codes) included learning/developmental problems (learning and developmental disabilities: 315.x; autism spectrum disorder: 299.x; and intellectual disability: 317.x, 318.x, 319.x), vision problems (strabismus: 378.x; amblyopia: 368.0x; hypermetropia: 367.0; and myopia: 367.1), attention deficit hyperactivity disorder (314.x), migraine/headache (346.x), anxiety (300.x), hearing problems (ear disorders: 388.x and hearing loss: 389.x), mental/behavioral problems (mood disorders: 296.x, depression: 311.x, and oppositional defiant disorder: 313.81), motion sickness (994.6), and epilepsy (345.x).[14,15]

The patient's point of entry into the healthcare system (at CHOP or elsewhere) was abstracted (ED/urgent care, primary care, specialty care [ie, sports medicine, trauma surgery, neurology]).[12] Because not all children were seen for a formal clearance visit for return to organized sports, we defined the clinical course of care for the concussion—a proxy for time to recovery—as the number of days between the injury and the last CHOP visit for concussion, with abstraction of data from July 1, 2014, through January 29, 2018, to encompass all follow-up visits for the index concussion. Twenty-eight days was used as a clinically meaningful cutoff for comparisons regarding clinical course of care,[16] because most pediatric concussions spontaneously recover within that timeframe.[17] All provider types seen during the clinical course of care were noted; in addition, parent- or patient-reported visits to the school nurse or athletic trainer were noted. Documented referrals to therapy services (vision, vestibular, physical, speech, occupational, neuropsychology, and counseling) were recorded.

We also abstracted all patient or parent-reported concussion-related symptoms documented at any point during the clinical course of care. Symptoms from the Post-Concussion Symptom Scale were grouped into 5 categories, including a specific visiovestibular subcategory to compare with the widespread use of a visiovestibular assessment across the CHOP Network: (1) somatic symptoms (headache, nausea, vomiting, sensitivity to light, sensitivity to noise, numbness or tingling), (2) visio-vestibular symptoms (balance deficits, dizziness, or visual problems), (3) sleep symptoms (fatigue, trouble falling asleep, sleeping more than usual, sleeping less than usual, or drowsiness), (4) emotional symptoms (irritability, sadness, nervousness, or feeling more emotional), and (5) cognitive symptoms (feeling slowed down, feeling mentally foggy, difficulty concentrating, or difficulty remembering).[18] Whether a visio-vestibular examination was performed at each visit was recorded.[18-20] Finally, any recommendations for school accommodations and return to physical activity were abstracted.

Statistical Analyses

We described the distribution of relevant demographic and clinical characteristics among patients with a concussion using frequencies and proportions for categorical variables, and median and IQR for continuous variables. We compared the distribution of these variables by age group and, for select variables (eg, visiovestibular assessment), by point of care using χ^2 (for categorical variables) and Wilcoxon rank-sum tests (for continuous variables). All analyses were conducted using SAS software, Version 9.4 (SAS Institute Inc, Cary, North Carolina). This study was reviewed and approved by the CHOP Institutional Review Board.

Results

Patient and Injury Characteristics

The demographic characteristics of this cohort are fully described in Table II. We found no statistically significant differences in patient demographic characteristics between the 20% simple random sample and the overall cohort. In addition, no statistically significant differences in demographics were observed among younger (age 5-8 years) and older (age 9-11 years) elementary school-aged children. Younger children were more likely to have sustained their injury during a non-sports- and recreation-related activity than older children (41.9% and 32.6%, respectively; $P = .05$). Overall, 1 in 8 patients (13%) had a history of a prior concussion, and co-occurring medical diagnoses were identified in almost one-half of patients (44.9%), with no difference between the age subgroups. Specific co-occurring conditions identified in more than 5 patients per age group are presented in Table II, including learning/developmental problems, vision problems, and attention deficit hyperactivity disorder.

Clinical Course of Care

When considering the entire cohort, equal proportions of patients with a concussion reported initially presenting to primary care (49.0%) or the ED or urgent care setting (49.0%). The proportion that presented first to primary care was higher for those children who call the CHOP network their medical home (208/292 [61.1%]). The median clinical course of care was 2 visits (IQR, 2-3) within the CHOP network and there was no difference in clinical course of care based on point of entry into the health care system. Although patients rarely presented initially to specialty care (2.1%), almost one-fourth of patients (24.7%) were seen by a specialty care provider at some point during their course of care. One in 5 patients (21.9%) were documented as seeing a school nurse at some point during their clinical course of care. Overall, 39.4% of patients (n = 177) completed their clinical course within 1 week of injury (median, 10 days; IQR, 3-24 days), whereas 36.0% and 22.3% of patients had a clinical course of 8-28 days and ≥29 days, respectively. Overall, 11.6% were referred for various rehabilitative services, with vestibular therapy and vision therapy being the most common (n = 29 [9.9%] and n = 10 [3.4%], respectively).

Symptom Profile

Patients with a concussion reported a median of 4 distinct Post-Concussion Symptom Scale symptoms (IQR, 2-7) at any point during their course of care. Almost all patients

Table II. Characteristics of patients aged 5-11 years presenting with a concussion, July 1, 2014 through June 30, 2015 (n = 292)

	All ages (n = 292)		5-8 years (n = 105)		9-11 years (n = 187)		
Characteristics	**No.**	**%**	**No.**	**%**	**No.**	**%**	***P* value**
Demographic							
Sex							
Female	117	40.1	38	36.2	79	42.2	.31
Male	175	59.9	67	63.8	108	57.8	
Race/ethnicity							
Non-Hispanic white	203	69.5	66	62.9	137	73.3	.16
Non-Hispanic black	55	18.8	23	21.9	32	17.1	
Hispanic	11	3.8	3	2.9	8	4.3	
Non-Hispanic other	6	2.1	3	2.9	3	1.6	
Unknown	17	5.8	10	9.5	7	3.7	
Payor							
Private	229	78.4	79	75.2	150	80.2	.32
Medicaid/self-pay	63	21.6	26	24.8	37	19.8	
Patient							
Prior history of concussion	38	13.0	11	10.5	27	14.4	.33
Any co-occurring condition*	131	44.9	42	40.0	89	47.6	.21
Most common co-occurring conditions†	101	34.6	32	30.5	69	36.9	.27
Learning/developmental problems	47	16.1	23	21.9	24	12.8	.04
Vision problems	42	14.4	9	8.6	33	17.6	.03
Attention deficit hyperactivity disorder	34	11.6	9	8.6	25	13.4	.22
Concussion							
Sports- or recreation-related	187	64.0	61	58.1	126	67.4	.05
Mechanism of injury							
Fall	138	47.3	57	54.3	81	43.3	.21
Struck by object	91	31.2	27	25.7	64	34.2	
Struck by person	47	16.1	14	13.3	33	17.6	
Other/unknown	16	5.5	7	6.8	9	4.8	

*Co-occurring conditions include learning/developmental problems (learning and developmental disabilities: 315.x [ICD-9-CM code]; autism spectrum disorder: 299.x; and intellectual disability: 317.x, 318.x, 319.x), vision problems (strabismus: 378.x; amblyopia: 368.0x; hypermetropia: 367.0; and myopia: 367.1), attention deficit hyperactivity disorder (314.x), migraine/headache (346.x), anxiety (300.x), hearing problems (ear disorders: 388.x and hearing loss: 389.x), mental/behavioral problems (mood disorders: 296.x, depression: 311.x, and oppositional defiant disorder: 313.81), motion sickness (994.6), and epilepsy (345.x).
†Specific co-occurring conditions identified in ≤5 patients per age group are not presented.

(95.9%) reported at least 1 somatic symptom (**Table III**), and one-half to two-thirds reported problems with sleep (54.1%) and visiovestibular symptoms (66.1%). We did not observe age-related differences in the proportion of patients reporting somatic, sleep, emotional, or cognitive symptoms. However, 9- to 11-year-old patients were more likely to report visiovestibular symptoms than 5- to 8-year-olds (72.2% and 55.2%, respectively; $P = .003$).

Visio-vestibular Assessment

Overall, three-fourths of patients (74.3%) had a visio-vestibular assessment at some point during their clinical course of care in the CHOP Network. Among those whose initial point of care was at CHOP, 83.8% of patients received a targeted visio-vestibular assessment documented on the same day as their initial visit. This proportion varied by point of care; only 6 of 14 patients (42.9%) seen at CHOP ED/urgent care received an initial assessment compared with 101 of 112 patients (90.2%) initially seen at CHOP primary care (**Table IV**). Patients who were ever seen by specialty care at CHOP were more likely to have such an assessment compared with those who were never seen by specialty care (65/70 specialty patients [92.9%] vs 152/222 patients never seen by specialty care [68.5%]; $P < .001$). Of the 74% with a documented visio-vestibular assessment, 62.7% (n = 136) had identifiable deficits. A greater proportion of concussed patients ages 9-11 years had abnormal findings upon visio-vestibular assessment compared with those ages 5-8 years (95/140 patients [67.9%] and 41/77 patients [53.2%], respectively; $P = .03$). Those who reported visio-vestibular symptoms were more likely to have visio-vestibular deficits upon examination (107/156 patients with symptoms [68.7%]) compared with those who did not report visio-vestibular symptoms (29/61 patients without symptoms [47.5%]; $P = .004$). The most commonly noted deficits were in gaze stability (41.7%), tandem gait (40.0%), and saccades (38.8%), with deficits in convergence (18.4%) and smooth pursuits (16.8%) occurring at lower proportions.

Table III. Concussion symptoms reported over the clinical course of care, by age group (n = 292)

	All ages (n = 292)		5-8 years (n = 105)		9-11 years (n = 187)		
Symptoms	**No.**	**%**	**No.**	**%**	**No.**	**%**	***P* value**
Somatic	280	95.9	100	95.2	180	96.3	.67
Visiovestibular	193	66.1	58	55.2	135	72.2	.003
Sleep	158	54.1	58	55.2	100	53.5	.77
Emotional	67	22.9	22	21.0	45	24.1	.54
Cognitive	112	38.4	36	34.3	76	40.6	.28

Table IV. Proportion of patients by initial point of care within the CHOP Care Network with and without documented visio-vestibular assessment (n = 292)

	CHOP provider									
	Total (n = 292)		Primary care (n = 127)		ED/urgent care (n = 58)		Specialty outpatient (n = 5)		Non-CHOP provider (n = 102)	
Visio-vestibular assessment	No.	%	No.	%	No.	%	No.	%	No.	%
Documented	109	83.8	101	90.2	6	42.9	2	50	n/a	n/a
Not documented	75	25.7	15	11.8	44	75.9	1	20	15	14.7

n/a, not applicable.

Return to Learn and Return to Play

Fewer than one-half of all of the concussed patients (43.8%) were provided with a letter recommending standardized school accommodations, such as taking pacing breaks for symptoms, extra time for assignments, or larger printed font or use of audiobooks.[21] Slightly more than one-half (56.2%) had documentation of clearance for return to play/activities at the end of their clinical course; there were no differences in this aspect between the age subgroups. The vast majority of patients seen only in the ED (38/40 [95.0%]) were not provided with a letter for school accommodations.

Discussion

Even though almost one-third of pediatric concussions presenting for medical care occur in children less than 12 years of age, little is known about concussions presenting across a broad sample of healthcare settings in this age group.[11] Findings from this comprehensive description of ambulatory elementary school-aged concussions, including those presenting to a primary care setting, have important implications for the management of concussion in this age range.

With one-half of 5- to 8-year-olds and three-fourths of 9- to 11-year-olds reporting visio-vestibular symptoms, this high prevalence was similar to rates observed in adolescents, among whom these symptoms and the associated physical findings also predict prolonged recovery.[9,19] Although visio-vestibular deficits can affect school function, affecting both reading as well as note taking, one-fourth of patients with a concussion in this study were not assessed for these deficits.[15] Differences were found in clinical practice by the point of care, with most children seen in primary care (90.2%), and virtually all children eventually seen in specialty care (92.9%), being assessed with a visio-vestibular examination, whereas those evaluated only in the ED were much less likely to have this assessment (42.9%). Because this assessment captures neurophysiologic function beyond self-reported symptoms, it may add clinical value, particularly in younger children, who may be less able to describe adequately all their symptoms. Of note, all these rates are likely higher within the CHOP network compared with other healthcare settings due to concerted, system-wide training and implementation of an EHR-based clinical decision support tool that resulted in the increased use of this assessment from 1.8% to 71.0%.[22] In addition, in our cohort, there was a substantial group of children with deficits or symptom provocation upon assessment who did not self-report visio-vestibular symptoms, with a smaller proportion of younger children (ages 5-8 years) reporting these symptoms than older children (ages 9-11 years). This finding may be related to the developmental immaturity of younger children failing to recognize and report visio-vestibular symptoms, making a clinical assessment of this system even more important in the diagnosis and management of concussion in this age range. Because these visio-vestibular deficits are also associated with persistent symptomatology and poorer outcomes, identifying children with these deficits could be important in crafting relevant school-based accommodations for recovery from acute concussion.[9,21,23] Finally, although there is increasing evidence that vestibular oculomotor therapy is effective in reducing concussion symptoms among some patients with persistent visio-vestibular deficits, only 11.6% of our cohort were referred for vestibular or visual therapy, suggesting that rehabilitation for these deficits may be underutilized.[24-26]

Although the observed concussion symptom profile likely substantially affects a young child's ability to return to learning and playing, fewer than one-half of the children in our study, and very few seen only in the ED, received guidance for school accommodations after injury, as recommended by the American Academy of Pediatrics.[27] One prior study found that children received significantly more academic accommodations after a concussion diagnosis in the ED when they were provided with school-focused discharge instructions and a return to learn letter that specifically listed recommended accommodations.[28] Another study of children ages 8-18 years found that a little more than one-half (51.3%) received academic accommodations after the diagnosis of concussion in the ED, with accommodations being more likely if they had a co-occurring history of migraines or learning disability, a sport-related concussion, commercial insurance, or their parents' primary language was English.[29] In our study, close to 50% of our cohort of elementary school-aged children had co-occurring conditions that likely interact with concussion (eg, 16.1% with diagnosed learning disabilities, 14.4% with vision disorders, and 11.6% with attention deficit hyperactivity disorder). These conditions may be exacerbated in the classroom after injury and would likely benefit from academic accommodations following injury.[14,15,30] Our results suggest that younger children, in particular, are not being provided with recommendations for school accommodations as frequently as their middle-school and high-school counterparts, further highlighting gaps in clinical care.

Slightly more than one-half of the patients had formal documentation of clearance to return to play in sports, which is lower than the reported rate in CHOP adolescent patients with a concussion. This finding likely aligns with lower rates of organized sports participation in this age range, as well as less frequent sport- and recreation-related mechanisms of injury.[31,32] However, most, if not all, of these younger children are returning to physical education, recreational activities, or free play, where instructions for safe, gradual return to activity after a concussion would still be relevant. This gap represents an area that could be further addressed with additional interventions to optimize outcomes.

There are limited previous data characterizing the course of care for younger preadolescent children with a concussion. In this study, the median clinical course was 10 days, indicating that many young children likely have a self-limited course of spontaneous recovery after concussion, similar to their older adolescent counterparts.[33-36] However, close to one-quarter had a clinical course longer than 28 days, a proportion that mirrors reported rates of prolonged symptomatology for older children.[30,37] These data indicate that persistent symptoms from concussion are also a concern in this younger population, with implications for function in life and in school. Recent pediatric traumatic brain injury guidelines have urged assessment of factors that predict longer recovery in children after a concussion; these factors may vary by pediatric age range.[38]

Our study also revealed that, for some, the concussion burden at this age is already notable; 1 in 8 children had a prior history of concussion. A history of multiple concussions may be an important consideration when contemplating risk-bearing activities, such as contact sports.[16,39-45] Our previous work quantified that, for those children sustaining at least 2 concussions by age 15, one-quarter will experience at least a third injury within the next 2 years, suggesting that, for some of these elementary school-aged children, there is a strong likelihood of having a third or fourth concussion before they leave high school.[46] In addition, our previous work has also indicated that those with a history of concussion were more likely to demonstrate visio-vestibular disorders in a dose-response fashion correlating with persisting symptoms.[9,47] These observations are important clinical considerations in the ongoing management of children with concussion at this age, especially those ages 9-11 years, who present with more visiovestibular deficits than their younger counterparts.

Our study had several limitations. As a retrospective cohort study, data were not collected as systematically as they might have been if collected prospectively. However, an EHR clinical decision support tool with standardized documentation of concussion-specific assessments for diagnosis and management, including the use of a visio-vestibular examination, somewhat mitigates this issue. The reliability of the visio-vestibular examination remains an area for future study. Since its introduction in 2012, the vast majority of concussion visits within the CHOP network use this tool.[21] Second, although return to play in organized sports is a commonly used outcome in youth concussion studies, its role in determining "time to recovery" in elementary school-aged children was less useful due to lower rates of participation in organized sports where they might be less likely to return to a provider to receive formal medical clearance. Instead, we used length of time seen in outpatient clinics as a proxy for time to recovery because actual recovery could not be determined in this retrospective cohort. Because children seeking ongoing care for concussion at CHOP would likely have documentation, the clinical course of care was the most practical and meaningful outcome for elementary school-aged children. CHOP providers may also be unique in that a concerted effort has been undertaken in the form of extensive training and clinical decision support across the network to facilitate concussion diagnosis and management, including training in the use of the visio-vestibular examination in concussion.[22] Finally, the CHOP population of patients may not be completely representative of the overall population because the majority were non-Hispanic white and had private insurance. Private insurance and the perception of insurance adequacy can influence decisions to seek care at the time of the injury.[48] Further study of larger, nationally representative samples comparing across ethnicities and insurance types is needed to allow more specific exploration of these demographic factors.

Overall, although symptoms and clinical course observed in our study were similar to those observed in adolescents, we demonstrated a clinical practice gap in identifying common visio-vestibular deficits after a concussion in all care settings, but particularly in the ED, potentially influencing subsequent management. Children ages 9-11 years in this cohort had a higher rate of visio-vestibular deficits than their younger counterparts, highlighting the importance of a visio-vestibular assessment in the clinical diagnosis of concussion, with substantial management implications for school-based accommodations for return to learn during recovery. Further development of clinical decision support tools may aid clinicians in closing this gap and improving concussion care for children in this age group. ■

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Data Statement

Data sharing statement available at www.jpeds.com.

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50 Years Ago in *The Journal of Pediatrics*

Pancreatic Function in Malnutrition: How Far Have We Come?

Danus VO, Urbina AM, Valenzuela I, Solimano G. The effect of refeeding on pancreatic exocrine function in marasmic infants. J Pediatr 1970;77:334-7.

In 1970, Danus et al demonstrated that compared with normal infants, the amylase and lipase activities of children who were marasmic were markedly reduced. There was suboptimal response to pancreozymin stimulation, and the recovery was partial even after 30 days of intensive therapy. In marasmus, the acinar function was affected more than the duct.

What has changed in 50 years? El-Hodhod et al[1] showed that the pancreatic head also was significantly smaller in protein energy malnutrition (PEM), which normalized with therapy. Duration of nutritional rehabilitation, patient age, weight, and serum albumin were the most important determinants of recovery. Danus' cumbersome "Dreiling tube test" has now been replaced by an effective endoscopic pancreatic function test, with stimulation by cholecystokinin, secretin, or both. Endoscopic ultrasonography allows close visualization of the pancreas structure. Endoscopic retrograde pancreatography allows cannulation of pancreatic duct for intraductal stimulation test. However, European and North American Societies for Pediatric Gastroenterology, Hepatology and Nutrition (ESPGHAN and NASPGHAN) reserve the need for pancreatic function testing only in cases with steatorrhea, cystic fibrosis, and chronic pancreatitis.[2] Routine assessment of pancreatic exocrine function in PEM is thus not recommended. Malabsorption theories have seen a paradigm shift. Tropical enteropathy, bacterial overgrowth, and diet-microbial crosstalk are the newer missing pieces in the PEM jigsaw.[3] Over the years, the luminal disharmony has overpowered pancreatic malfunction.

Danus also commented that the type of diet used in rehabilitation needed serious thought. Rightly, the World Health Organization has approved polymeric formulas such as F-75, F-100, and various region-specific cereal-based diets in treatment of severe acute malnutrition. Five decades of wisdom has changed our research priorities in PEM malabsorption. What happens 50 years from now? Artificial intelligence may turn the table around. Will Danus' hypothesis experience a metempsychosis, the "Rise of the Phoenix"?

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