2016

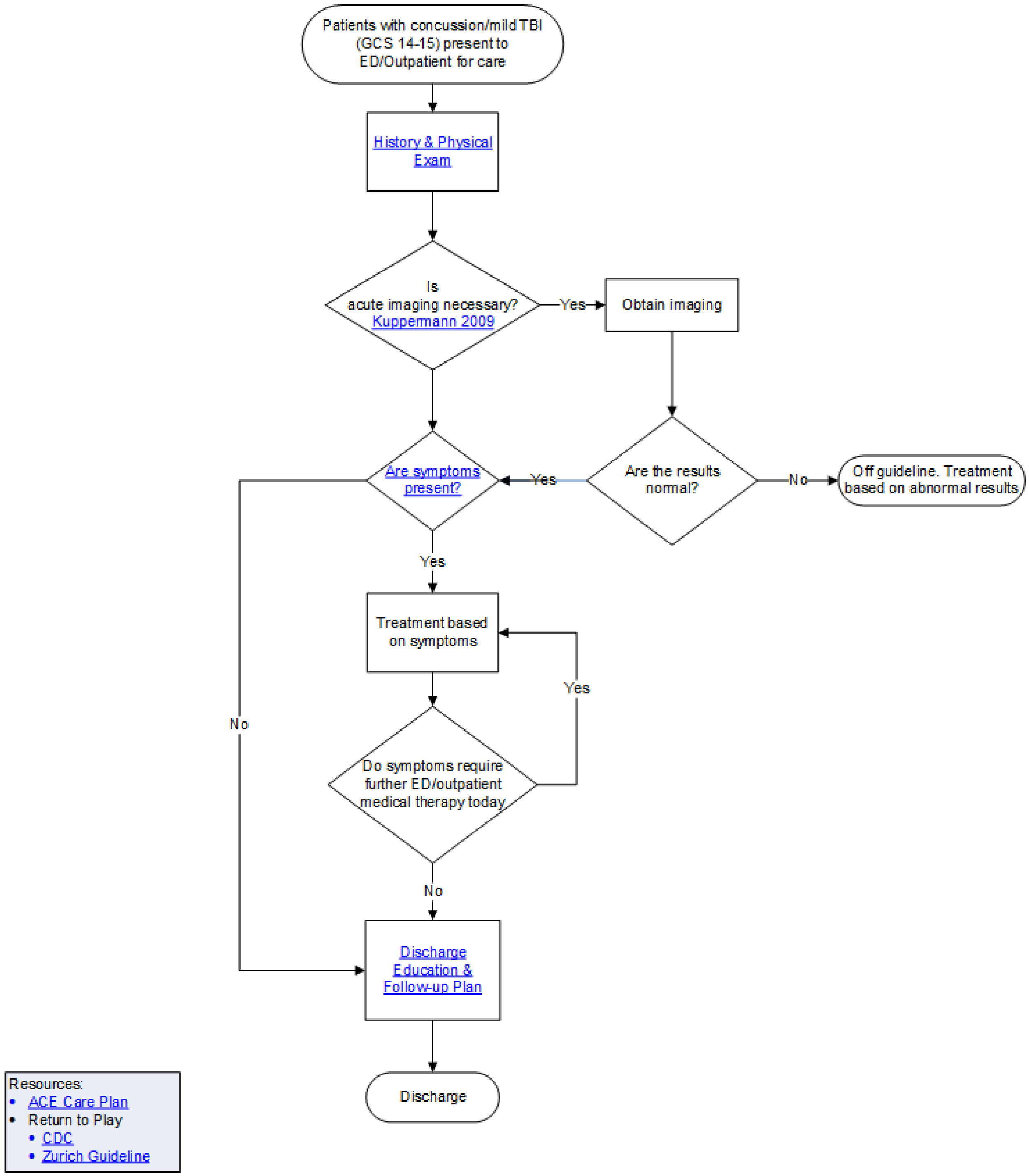
Concussion

Children's Mercy Kansas City

These guidelines do not establish a standard of care to be followed in every case. It is recognized that each case is different and those individuals involved in providing health care are expected to use their judgment in determining what is in the best interests of the patient based on the circumstances existing at the time. It is impossible to anticipate all possible situations that may exist and to prepare guidelines for each. Accordingly, these guidelines should guide care with the understanding that departures from them may be required at times.

Children's Mercy Hospitals and Clinics
Evidence Based Practice - Care Process Model

Management of Sports Related Concussion in the ED



Epidemiology:

Concussion is a brain injury, and is a subset of a mild traumatic brain injury (mTBI) (McCrory et al., 2013). Castile, Collins, McIlvain, & Comstock (2011) reported that 732,805 concussions were reported by 100 nationally representative high schools including nine sports between the years 2005-2011. New concussions occurred at a rate of 22.2 per 100,000 athletic exposures, and recurrent concussion occurred at a rate of 3.1 per 100,000 athletic exposures. However, the data are self-reported, and are subject to bias. Standard definitions for mTBI, along with methods to determine the incidence and prevalence of this type of injury were included in *The Children's Health Act of 2000* which was passed by Congress (L. & Binder, 2003). Giza et al. (2013) reported a range of concussion as 0.08-1.55 per 1000 games for male athletes (five sports) and as 0.04-0.97 per 1000 games (four sports) for female athletes.

Common features of a concussion include:
- A result from a direct blow to the head, or a result from a high velocity injury when force is transmitted to the head
- Symptoms appear early and usually resolve on their own, but symptoms can develop over time
- Although functional aberrations may be present, structural abnormalities are not seen reliably on neuroimaging studies.

Objective of Care Process Model (CPM): The objective of the CPM is to create a structure for the management of mild sports related concussion at Children's Mercy.

Target Users: Physicians, Advance Practice Nurses, Nurses in Emergency Departments, Urgent Care Centers, and Outpatient Clinics

Guideline Inclusion Criteria: Children >/= 8 years and < 18 years of age with sports related concussion

Guideline Exclusion Criteria: Concussion from other causes.

Clinical Questions Answered by Guideline:

a. Should neurocognitive assessment tools (SCAT3, ImPACT, or HEADMinder) vs. no neurocognitive assessment tools be used for children with sports related concussion?
b. Should diagnostic radiology tools (computed tomography or MRI) vs. no diagnostic radiology tools be used for children with sports related concussion?
c. Should medications vs. no medications be used for children presenting with sports related concussion?
    a. Should narcotics vs. no narcotics be used for children with headache associate with sports related concussion?
    b. Should anti-nausea medications vs. no anti-nausea medication be used for children with sports related concussion?
d. Should liberalized return to learn/play vs. conservative return to learn/play be used for children with sports related concussion?

Search Strategies:

Pub Med: Pharmacological Management: : (("Brain Concussion"[Mesh] OR "Post-Concussion Syndrome"[Mesh]) AND ("Drug therapy"[Mesh] OR "drug therapy"[Subheading] OR "Anti-Inflammatory Agents, Non-Steroidal"[Mesh] OR "Anti-Inflammatory Agents, Non-Steroidal"[Pharmacological Action] OR "Amantadine"[Mesh])) AND ("2007/10/20"[PDAT] : "2012/10/17"[PDAT] AND "humans"[MeSH Terms] AND English[lang]) 16 results Performed July 2014

Search repeated August 9, 2016. 2 results

PubMed: Complications: Search: (("Brain Concussion"[Mesh] OR "Post-Concussion Syndrome"[Mesh]) AND ("return to play"[All Fields] OR "complications"[Subheading] OR "Brain Injury, Chronic"[Mesh] OR "chronic brain injury"[All Fields] OR "chronic traumatic encephalopathy"[All Fields] OR "second impact syndrome"[All Fields] OR "second impact"[All Fields] OR "Recovery of Function"[Mesh] OR "Outcome Assessment (Health Care)"[Mesh] OR "Glasgow Outcome Scale"[Mesh] OR "Treatment Outcome"[Mesh] OR "Prognosis"[Mesh] OR "Morbidity"[Mesh] OR "Mortality"[Mesh] OR "Comorbidity"[Mesh] OR "Attention Deficit Disorder with Hyperactivity"[Mesh] OR "Age Factors"[Mesh] OR "Cognition Disorders"[Mesh] OR "Neuropsychological Tests"[Mesh] OR "Trauma Severity Indices"[Mesh] OR "Severity of Illness Index"[Mesh])) AND ("2007/10/20"[PDAT] : "2012/10/17"[PDAT] AND "humans"[MeSH Terms] NOT (Case Reports[ptyp] OR Comment[ptyp] OR Editorial[ptyp] OR Letter[ptyp] OR "Review"[Publication Type:noexp]) AND English[lang] AND ("child, preschool"[MeSH Terms] OR "child"[MeSH Terms] OR "adolescent"[MeSH Terms])) July 2014

PubMed: Imaging: Search: ("Brain Concussion"[Mesh] OR "Post-Concussion Syndrome"[Mesh]) AND ("Radiography"[Mesh] OR "radiography"[Subheading] OR "Ultrasonography"[Mesh] OR "Diagnostic Imaging"[Mesh] OR "ultrasonography"[Subheading] OR "imaging"[All Fields]) AND ("2007/10/20"[PDAT] : "2012/10/17"[PDAT] AND "humans"[MeSH Terms] NOT (Case Reports[ptyp] OR Comment[ptyp] OR Editorial[ptyp] OR Letter[ptyp]) AND English[lang]) AND "humans"[MeSH Terms] AND (Meta-Analysis[ptyp] OR systematic[sb] OR Practice Guideline[ptyp] OR Randomized Controlled Trial[ptyp]) July 2014

Practice Recommendations: are based on the child who is 8 years old or older who presents with a mild concussion that occurred while the child was engaged in a sport activity.

Diagnostic Evaluation: (McCrory et al., 2013)

1. Evaluation
    a. General medical history
    b. Mechanism of injury
    c. Physical Exam- detailed head and neck exam and detailed neurological exam, including balance
    d. Assessment Tools
2. Acute imaging- Use the (Kuppermann et al., 2009) algorithm to determine the need for imaging
3. Criteria for admission:
    a. Persistent vomiting
    b. Pain
    c. Unable to walk (i.e. get to the restroom)
4. Treatment
    a. Physical rest
    b. Cognitive rest
    c. Return to Play
    d. Return to Learn

    e. Medications
5. Complications
    a. Symptoms lasting > 10 days
        i. Headache
        ii. Feeling like "in a fog"
        iii. Sleep disturbance
        iv. Irritability
        v. Emotional
        vi. Dizziness
6. Discharge education
    a. Kids Health Discharge and After-care Instructions
        i. Caring for Your Child With a Concussion (English and Spanish)
            1. Concussion
            2. Concussion, Inpatient
            3. Concussion, ED
            4. Concussion, Specialty
        ii. Caring for Your Child with a Head Injury
            1. Head Injury, Age < 3 years
            2. Head Injury, Age > 3 years
            3. Head Injury, Age > 3 years, Inpatient

Principles of Clinical Management:

Assessment tools-

The most recent consensus statement on concussion in sport from the 4th International Conference on Concussion in Sport, held in Zurich, 2012 (McCrory et al., 2013) states using symptom scales, balance assessment and neurocognitive testing provide the best assessment of injury. Neurocognitive testing has not been validated in the ED.

From the included studies, neurocognitive assessment tools appear to have variations in scores based on factors other than the index injury. Upper class high school students and females had higher scores than freshman high school students and males (Covassin, 2012; McLeod, 2012). In a study by Baillargeon (2012), there were no differences between the group with concussion and the group without concussion for six neuropsychological tests. They reported differences in the BESS (balance assessment) test.

Diagnostic radiology-

The Concussion Care Process Model Team recommends following the Kuppermann (2009) clinical decision rule (CDR) when deciding to obtain a CT for a child with a sports related concussion. In general, children with a GCS = 15 who do not have evidence of a basilar skull fracture are not candidates for radiologic imaging. McCrory et al. (2013) state in the Zurich Consensus Statement that "acute clinical symptoms largely reflect a functional disturbance rather than a structural injury and as such, no abnormality is seen on standard structural neuroimaging studies." Meehan (2011) reiterates that the adverse effects of radiologic testing may be worse than the index injury.

Medications-

Both the Zurich Guidelines (Version 4) and Meehan,, Taylor, & Proctor, (2011) provide guidance for medications to use for concussion related symptoms that do not resolve within the typical time for symptom resolution. None of the publications speaks about medication use when the child/teen is seen in the ED after injury. Only the Zurich Guideline (McCrory et al., 2013) states that the use of medications to treat the unresolved concussion symptoms (headache insomnia, depression) should be a factor considered when making return to play decisions.

Return to play/school-

The included literature supports assessment of concussion prior to allowing the athlete to return to school or play. The included studies are cohort studies or consensus statements; therefore, the quality of the evidence is very low. However, based on clinical expertise we recommend, in concordance with the Zurich Guidelines (McCrory et al., 2013) that a player diagnosed with a concussion should not be allowed to return to play on the day of the injury. Further, a stepwise return to play/return to school plan, such as the ACE Care Plan (Gioia, Collins, & Isquith, 2008) should be used to determine an athlete's ability to return to school or play.

Measures:

For the ICD codes:

850.9 Concussion, Unspecified
850.0 Concussion with no loss of consciousness

Count of patients in the inclusive ICD9/ codes
Number of patients admitted
- CT scan
- Narcotics

Potential Cost Implications:

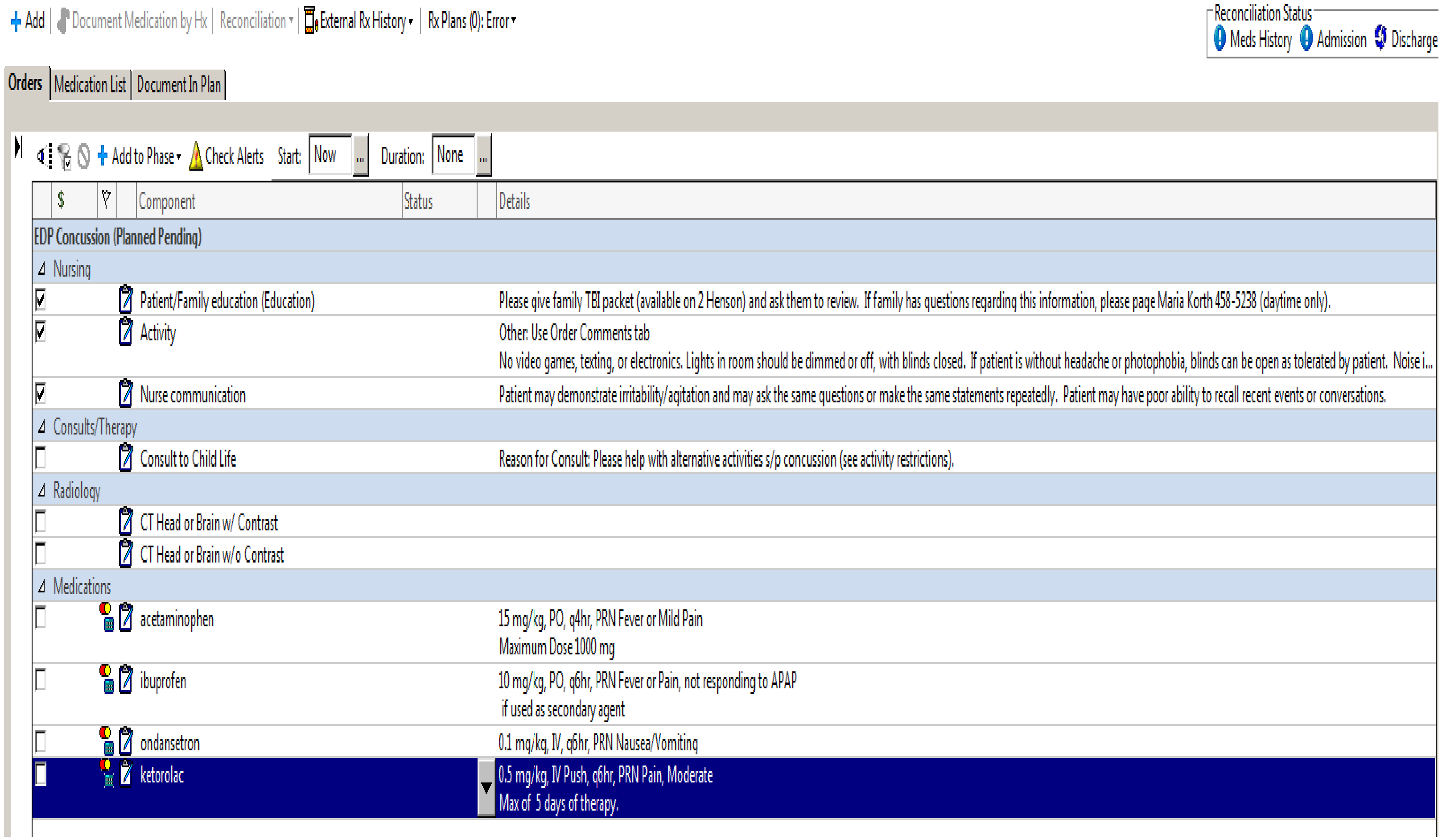
- Decreased use of medications
- Decreased utilization of laboratory tests
- Decreased utilization of radiological tests
- Decrease hospital admission
- Decrease in PICU admission
- Change in readmission
- Change in return to the ED
- Decrease in consults
- Decrease unnecessary interventions

Potential Organizational Barriers:

- Training of staff on new procedures, protocols, equipment
- Reluctance of providers to change practice
- Change in process
  - Providers
  - Nursing
  - Pharmacy
- Staff education
- Parental expectations

Children's Mercy

Supporting Documentation



Add | Document Medication by Hx | Reconciliation | External Rx History | Rx Plans (0): Error

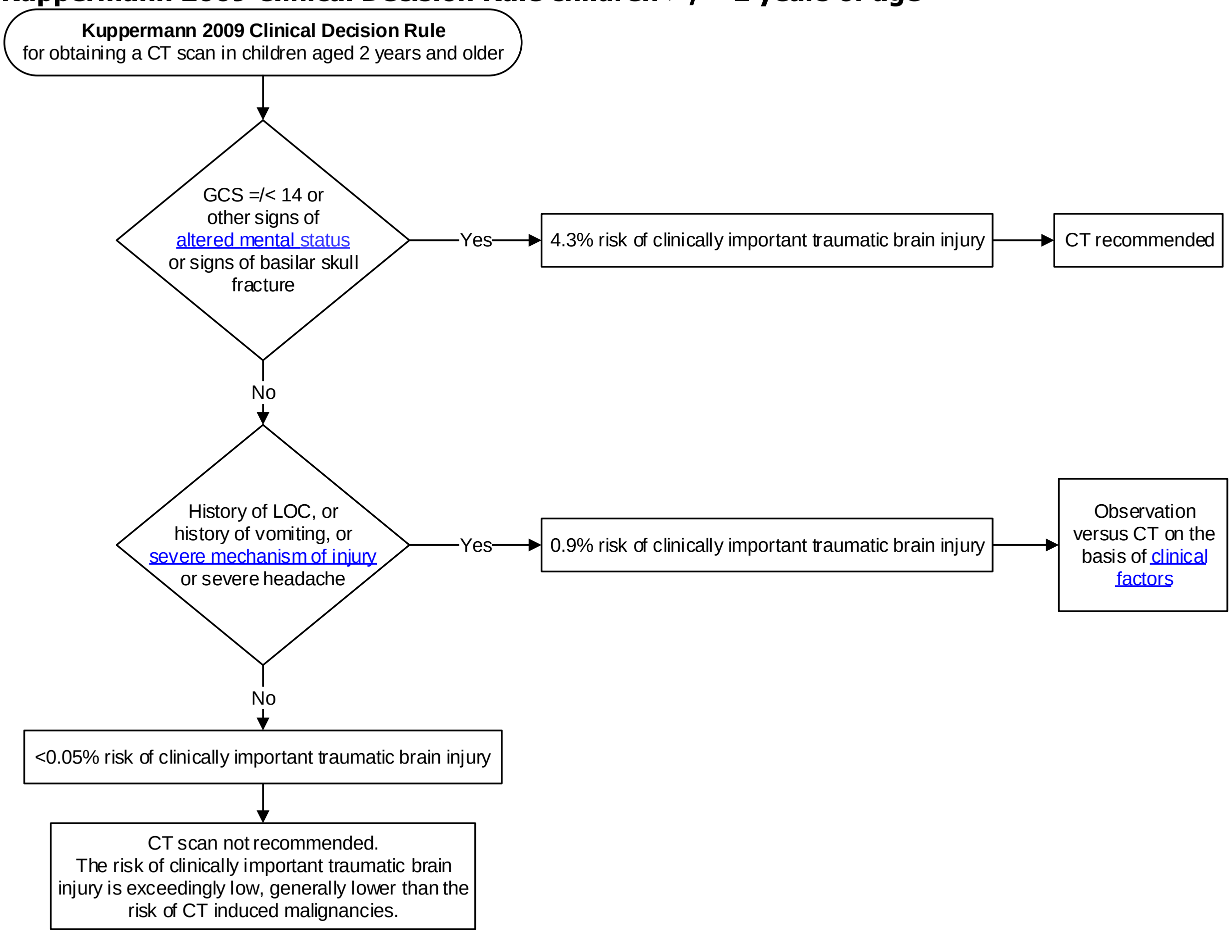
Reconciliation Status: Meds History, Admission, Discharge

Orders | Medication List | Document In Plan

Add to Phase | Check Alerts | Start: Now | Duration: None

Component	Status	Details
EDP Concussion (Planned Pending)		
Nursing		
Patient/Family education (Education)		Please give family TBI packet (available on 2 Henson) and ask them to review. If family has questions regarding this information, please page Maria Korth 458-5238 (daytime only).
Activity		Other: Use Order Comments tab No video games, texting, or electronics. Lights in room should be dimmed or off, with blinds closed. If patient is without headache or photophobia, blinds can be open as tolerated by patient. Noise i...
Nurse communication		Patient may demonstrate irritability/agitation and may ask the same questions or make the same statements repeatedly. Patient may have poor ability to recall recent events or conversations.
Consults/Therapy		
Consult to Child Life		Reason for Consult: Please help with alternative activities s/p concussion (see activity restrictions).
Radiology		
CT Head or Brain w/ Contrast		
CT Head or Brain w/o Contrast		
Medications		
acetaminophen		15 mg/kg, PO, q4hr, PRN Fever or Mild Pain Maximum Dose 1000 mg
ibuprofen		10 mg/kg, PO, q6hr, PRN Fever or Pain, not responding to APAP if used as secondary agent
ondansetron		0.1 mg/kg, IV, q6hr, PRN Nausea/Vomiting
ketorolac		0.5 mg/kg, IV Push, q6hr, PRN Pain, Moderate Max of 5 days of therapy.

Kuppermann 2009 Clinical Decision Rule children >/= 2 years of age



Kuppermann, N., Holmes, J. F., Dayan, P. S., Hoyle, J. D., Jr., Atabaki, S. M., Holubkov, R., . . . Wootton-Gorges, S. L. (2009). Identification of children at very low risk of clinically-important brain injuries after head trauma: a prospective cohort study. *Lancet, 374*(9696), 1160-1170. doi: 10.1016/S0140-6736(09)61558-0 S0140-6736(09)61558-0 [pii] Used with permission.

Guideline Preparation: This guideline was prepared by The Office of Evidence Based Practice (EBP) in collaboration with content experts at Children's Mercy Hospital Kansas City. Development of this guideline supports the Department of Clinical Effectiveness's initiative to promote care standardization that builds a culture of quality and safety that is evidenced by measured outcomes. If a conflict of interest is identified the conflict will be disclosed next to the team members name.

Children's Mercy

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Guideline development funded by: Funding was not obtained to create this guideline.

Development Process:

The Sports Concussion Care Process Model was developed using the following steps:

1. Review preparation
   a. PICOT questions established
   b. Team leaders confirmed search terms used
2. Databases searched
   a. AHRQ National Guideline Clearinghouse
   b. Medline
   c. Cochrane
   d. CINAHL
3. Critically analyze the evidence
   a. Guidelines
      i. AGREE criteria were used to analyze published clinical guidelines
   b. Literature
      i. CASP tools were used to analyze the literature (e.g. study limitations, consistency of results, directness of evidence, precision and reporting bias)
      ii. GRADE criteria evaluated the literature based on:
         1. The balance between desirable and undesirable effects
         2. Patient values and preferences
         3. Resource utilization

         The table below defines how the quality of the evidence is rated and how the recommendation is established based on the type of evidence:

Quality	Type of Evidence
High	Consistent evidence from well-performed RCTs or exceptionally strong evidence from unbiased observational studies.

Moderate	Evidence from RCTs with important limitations (inconsistent results, methodological flaws, indirect evidence, or imprecise results) or unusually strong evidence from unbiased observational studies.
Low	Evidence for at least 1 critical outcome from observational studies, from RCTs with serious flaws or indirect evidence.
Very Low	Evidence for at least 1 of the critical outcomes from unsystematic clinical observations or very indirect evidence.
Recommendation	Type of Evidence
Strong	Desirable effects clearly outweigh undesirable effects or vice versa
Weak	Desirable effects closely balanced with undesirable effects

4. Recommendations for the guideline were developed by a consensus process incorporating the three principles of EBP (current literature, content experts, and patient and family preference [when possible])

Approval Process: Guidelines are reviewed and approved by the Content Expert Team, the Office of EBP, and other appropriate hospital committees as deemed suitable for the guidelines intended use. Guidelines are reviewed and updated as necessary every 3 years within the Office of EBP at CMH&C. Content expert teams will be involved with every review and update.

Disclaimer:

The content experts and the Office of EBP are aware of the controversies surrounding Management of Sports Related Concussion CPG. When evidence is lacking or inconclusive, options in care are provided in the guideline and the power plans that accompany the guideline.

These guidelines do not establish a standard of care to be followed in every case. It is recognized that each case is different and those individuals involved in providing health care are expected to use their judgment in determining what is in the best interests of the patient based on the circumstances existing at the time.

It is impossible to anticipate all possible situations that may exist and to prepare guidelines for each. Accordingly, these guidelines should guide care with the understanding that departures from them may be required at times.

Evidence Profiles:

Assessment Tools

(Baillargeon, Lassonde, Leclerc, & Ellemberg, 2012)

Methods	Cross sectional cohort study.
Participants	**Setting:** referred to the study by coaches or medical personnel. The study occurred in a clinic **Number included:** 9-12 years N=32 (16 with concussion, 16 without) 13-16 years N= 34 (17 with concussion, 17 without) Adults N= 30 (15 with concussion, 15 without) **Inclusion criteria:** Athletes, soccer, hockey, rugby and football players who had a sport related concussion (50% of subjects), the other half never had a concussion. In the group with a concussion mean time since the last concussion (across age groups) was 6 months. 100 % male
Interventions	Concussion was diagnosed by specialized health professionals, using the Third International Conference on Concussion in Sport and the guidelines of the American Academy of Neurology. Symptom intensity was assessed with the Post-Concussion Symptoms Scale. Neuropsychological assessment included 1. Event-related potentials (ERPs) 2. Brown-Peterson test, a measure of traumatic brain injury 3. Symbol Digit Modalities Test (SDMT) 4. Hopkins Verbal Learning Test-Revised (HVLT-R) 5. Colour Trails 6. Pennsylvania State University Cancellation Task (PSU) 7. Brief Viso-spatial Memory Test-Revised (BVMT-R) 8. Controlled Oral Word Association Test (COWAT)

Outcomes	The concussion and control group were similar in regards of age, level of education and number of years practicing a sport. The concussion groups did not differ in time since last concussion, the number of concussions sustained and the number of concussion symptoms experienced.
	Neuropsychological symptoms-
	• Significant findings were found for adolescents in the concussion group recalled fewer items than adolescents in the control group on the Brown Peterson test. The Group X Age interaction was (f (1,90) = 4, 393 p< 0.05) See figure.
	• No significant differences were found between groups on the following neuropsychological tests: SDMT, BVMT-R, HVLT-R, Colour Trails, PSU, and the COWAT. (p> 0.05).
	• On the ERP task performance, there was no significant difference between the concussed and control group
	• EEG findings
	  ○ On the EEG there was not significant interaction for latency between the group with concussion and those without concussion
	  ○ On the EEG the amplitude of the P3b was significantly lower in all age groups compared to controls, while P3a was not different.
	  ○ Adolescents who had more symptoms at the time of injury had lower amplitude of P3b when tested

Notes All subjects who were in the concussion group were injured in the previous year, and time elapsed since last concussion averaged ~ 6 months for each age group.

(Covassin et al., 2012)

Methods Cohort study- prospective

Participants **Setting:** high school and college athletes from an ongoing sport concussion surveillance study in 4 States (CA, MI, LA & TN) in 2009-2001 academic years. About 2000 athletes were tested at baseline for concussion symptoms
Number included: 222 athletes remained after applying exclusion criteria of 296 athletes in the cohort who sustained a concussion
Number complete: N/A cohort study
Gender: 71 % male (157 male/ 65 female)
Inclusion criteria: 14-25 years of age. Concussion diagnosed by a sports medicine professional, using the Concussion in Sport Group guidelines McCrory
Exclusion criteria: History of treatment of substance abuse, psychiatric disorder, special education, years repeated in school and speech problems.
Power analysis: N/A cohort study

Interventions **Independent variables:** age (high school or college), sex, and time (baseline, 2 , 7 and 14 days post-concussion) for ImPACT and days 1, 2 and 3 post concussion for BESS)
Dependent variables: BESS (balance assessment) and neurocognitive test scores as measured by ImPACT neurocognitive tests including verbal and visual memory, processing speed, and reaction time

Outcomes BESS scores days 1, 2 and 3 days post concussion (lower is better)
ImPACT scores (verbal and visual processing, visual memory, processing speed & reaction time) baseline and days 2. 7, and 14 post concussion (higher is better)

Notes
- Females performed worse than male athletes on visual memory (mean 65.1% and 70.1%, respectively) (p=0.049)
- Females reported more symptoms than male athletes (mean 14.1 and 10.1, respectively) (p= 0.001)
- High school athletes performed worse than college athletes on the verbal section (mean 78.8% and 82.7%, respectively) (p= 0.001),
- High school athletes were scored worse on verbal memory on the 7th day post concussion compared with collegiate athletes ((p=0.001)
- High school male athletes scored worse in the BESS than college male athletes (mean, 18.8 and 13.0 respectively) (p= 0.001).
- College female athletes scored worse on the BESS than high school female athletes (mean, 21.2 and 16.9, respectively) (p=0.001)

Grubenhoff 2011

Methods Prospective case-control study

Participants children of 6-18 years old with head injury or a minor extremity injury
Three groups:
Head injury with Altered Mental Status (AMS) N=99
Head injury without AMS N= 66
Control group N=183
Inclusion criteria; children 6-18 years of age during the hours of 12pm and 10pm 6 days a week when research assistants were available that have suffered isolated blunt head trauma in the 24 hours preceding presentation.

	Exclusion; Subjects were excluded if they had received opioid pain medications prior to enrollment, had a history of intracranial surgery or neoplasm, developmental delay or autism, structural brain abnormality, inborn error of metabolism, had evidence of an open skull fracture or appeared to be intoxicated.
Interventions	This is not an intervention study. we are looking at the Standardized Assessment of Concussion tool
Outcomes	The Standardized Assessment of Concussion tool includes 15 symptoms associated with mild traumatic brain injury (mTBI) 1. Headache 2. Nausea 3. Vomiting 4. Dizziness 5. Poor balance 6. Blurred/double vision 7. Photophobia 8. Phonophobia 9. Tinnitus 10. Poor concentration 11. Memory problems 12. Not feeling 'sharp' 13. Fatigue/sluggish 14. Sadness 15. Irritability
Results	**Head injury without AMS vs. Control:** All subject with head injury without AMS had significantly higher scores on the inventory for 15 variables listed above than the control group. **Head injury with AMS vs. Control**: All subjects with altered mental status had significantly higher scores on the inventory for 14 variables listed above. than the control group **Head injury with AMS vs. Head injury without AMS**: Subjects with altered mental status had significantly higher scores on the inventory for 7/15 variables above. Those that are significantly different include: Dizziness, Photophobia, Nausea, Fatigue, Phonophobia, Vision, and Headache

(McLeod 2012)

Methods	Descriptive epidemiology study of the SCAT2
Participants	**Setting:** Interscholastic athletes were evaluated with the SCAT2 at pre season session. (possible scores 0-100; higher is better) USA **Number included:** Total N=1134 baseline **Number completed**- NA **% Male** subjects 872/1134 (77%) were male athletes **Inclusion criteria:** adolescents 9-12 grades **Exclusion criteria-** none **Power analysis:** not done, it is a cohort study **Intervention:** The SCAT 2 is an inventory that assesses concussion related signs and symptoms: cognition, balance, coordination. The hypothesis was the SCAT 2 scores will differ by gender, grade in school and self reported concussion history
Interventions	They did not do pre-post concussion reporting, they reported on differences between male/female, grade in school and self reported concussion history

Outcomes Male athletes scored significantly lower on the SCAT2 than did female athletes (P = .03; 87.7 6 6.8 vs. 88.7 6 6.8)
There appears to be an increasing SCAT2 score as grade level increased, Significance was found between 11th graders' scores being significantly higher than 9th graders' scores
(F = 5.22; P = .001)
Athletes with at least one self reported concussion scored significantly lower on the SCAT2 than did those without a concussion history. (P<.001; 87.0 6 6.8 vs. 88.7 6 6.5)
9th graders scored significantly lower on the SAC (Standardized Assessment of Concussion) (F = 9.27; P <.001) and the BESS test (F = 50.5; P = .002),
Other scores were not significantly different.

Notes The goal of this study was to show the variation in scores across gender, age and concussion history. Baseline scores are important because of the found variation

(Meehan, d'Hemecourt, Collins, Taylor, & Comstock 2012)

Methods Cohort

Participants Setting: High schools that employed at least one athletic trainer (AT) who is affiliated with the National Athletic Trainers Association. 192 schools reported data. Not all schools reported data for all 20 sports. Data comes from an online surveillance system called High School Reporting Information Online (HS ROI) during the 2009-2010 academic year. Also, 183 ATs were sent a survey at the start of the academic year on the use of computerized testing at their schools.
Number included 1056 concussions and 183 surveys
Number completed: all concussions 178/183 surveys (97%)
% Male subjects; Not reported
Inclusion criteria: High school athletes
Exclusion criteria: No concussion
Power analysis: Not performed cohort study

Interventions No intervention

Outcomes Survey: of the 178 schools that completed the survey,
40% used computerized neurocognitive testing. (93% ImPACT; 2.8% Cogsport; 1.4% HeadMinder & 2.8% unspecified
Of schools that used neurocognitive testing:

- 86% did both pre and post injury tests
- 12.7% of schools only did post injury testing
- All other schools that used neurocognitive testing, used it to make return to play decisions
- 79% were interpreted by an AT
- 79% were interpreted by an AT and/or a physician

Computerized neurocognitive testing of 1056 concussions
99% of concussions had neurocognitive testing performed (in the 2008-2009 academic year 26% of concussions reported to the HS ROI were managed with computerized neurocognitive testing)

- Athletes with symptoms lasting longer than 7 days were more likely to undergo computerized neurocognitive testing (57% vs. 36%; P < .001)
- Athletes who had computerized neurocognitive testing were less likely to return to play within 10 days of injury (38.5% vs. 55.7%; P < .001)
- Athletes who had computerized neurocognitive testing were more likely to have a physician (as opposed to an AT) decide when they should return-to-play

(60.9% vs. 45.6%;
P < .001)

- Athletes that attended schools with neurocognitive testing were more likely to have symptoms for > 7 days than those that did not (27.6% vs. 16.7%; P,.001)
- Schools that used computerized cognitive testing were less likely to return athletes to play within 10 days than schools that did not offer computerized testing (41.7% vs. 53.0%; P = .002)
- Some schools that used computerized cognitive testing, did not use it for all concussions, so for those concussions managed without computerized testing, there was no difference between those managed with computerized neurocognitive testing and return to play in schools that did not offer it.
- Schools that used computerized neurocognitive testing were more likely to have a physician (as opposed to an AT or other medical professional - RN, NP, PA or neuropsychologist) make the decision when to return to play (63.1% vs. 46.1%; P < .001)

Adjusted Odds Ratios (95% CI) for the use of neurocognitive testing, adjusted for duration of symptoms (> 7 days)

- Return to play within 10 days- 0.725 (0.538–0.976)
- AT (as opposed to a physician) returned the athlete to play- 0.600 (0.457–0.788)

Neuroimaging

(McCrory et al., 2013)

Methods Consensus statement the 3rd International Conference on Concussion in Sport held in Zurich, November 2008.

Outcomes

1) "Concussion may result in neuropathological changes, but the acute clinical symptoms largely reflect a functional disturbance rather than a structural injury and as such, no abnormality is seen on standard structural neuroimaging studies." If a more severe brain injury is suspected, emergent diagnostic imaging may be indicated, and the child/teen should be treated appropriately.
   a) Suspect an intracerebral or structural lesion, prolonged disturbance of the conscious state, focal neurological deficit or worsening of symptoms- Brain CT or MR brain scan are recommended
   b) Do not obtain positron emission tomography, diffusion tensor imaging, magnetic resonance spectroscopy, functional connectivity. Research has not been done to assess the usefulness of these diagnostic tools.

Notes

(Meehan, 3rd et al., 2011)

Methods Descriptive epidemiology study

Participants All concussions recorded by the High School Reporting Information Online (HS RIO) during the 2009-2010 school year.
N= 1056 sport-related concussion

Outcomes

1. Computerized neuro-physiological testing 41.2% (n=435)
2. Physician made the return to play decision 50.1% (n=529)
3. Assessed by CT scan 21.2% (n=224)
   1. Of those who had a CT scan, 75% were assessed in the ED
   2. Of those who had a CT scan 20% were assessed by a neurologist
4. Assessed by MRI 3% (n=32)

1. No difference in rates based on the physician specialty who did the assessment

Notes 1. data are of low quality, there are no large, double blind, randomized controlled trials
2. of the studies that exist, many include head injuries that are more severe than those seen in sports
3. All diagnostic testing has adverse effects that may be worse than the symptoms.
4. DD

(Schrader et al., 2009)

Methods Non randomized cohort study

Participants Adults 18-40 years
Number in the intervention group- 20 who presented with history and symptoms of a concussion. Number in the control group- 20 who presented with minor orthopedic injury
Inclusion- Subjects had no other injuries than concussion, except for small skin lesions. Their neurological exam was normal, except amnesia, slight & transitory confusion. Loss of consciousness did not exceed 5 minutes. Subjects had to have a reliable witness to the injury.
Exclusion- diabetes, hypertension, affective disorders, prior history o f alcohol or drug abuse, prior history of psychiatric or neurological disorder, prior history of epilepsy or seizure associated with the concussion, earlier concussion and concussion due to an assault.
Control group: age matched, same exclusion criteria, Subjects incurred minor to moderate non-head injuries who were assessed in the ED within 2 weeks of the matched subject with a head injury.
Gender – Study group: 50% male Control group: 50% male

Interventions Subjects in each group underwent a MRI within 24 hours and again at 3 months post injury. The two neuro-radiologists who read the MRI were blinded to the subject's injury.

Outcomes There was complete inter-rater agreement between the neuro-radiologists

	Normal MRI	Alteration on MRI
Concussed group within 24 hours	15	5 – 2 were incidental findings
Control group within 24 hours	18	2 – 1 was an incidental finding
Concussed group at three months (2 lost to follow-up)	13	Unchanged
Control group at three months	18	Unchanged
The prevalence of cases with hyper-intensive focus/foci of the group with concussion (3) was not different from that found in the control group (1) (p=0.60; two sided Fisher's exact test)		

Notes The authors conclude that diffuse axonal injury is not reliably seen on MRI (field strength up to 1.5 T) in patients who present with an ordinary concussion with short lasting loss of consciousness.

(Kuppermann et al., 2009)

Methods Prospective cohort study

Participants
Children presenting within 24 hours of head trauma N= 44904 enrolled, 42412 were analyzed of which 7% were sport related (n= 2934)
25 emergency rooms across the USA
Two populations
- The derivation population (June 2004-March 2006)
- The validation population (March- Sept 2006)

Gender
Age- mean age was 7.1 years 10718 (25%) were younger than 2 years of age
Inclusion: children who presented within 24 hours of head trauma. Children with head trauma who met criteria, but not enrolled were evaluated to assess for selection bias. GCS less than 14 (3%) were included, but not included in the main analysis
Exclusion: trivial injury, penetrating trauma, known brain tumors, preexisting neurological disorders, any neuroimaging at an outside hospital before presenting at a participating hospital, patients with ventricular shunts, bleeding disorders,

Interventions
A standard History and Physical was taken before knowing the results of imaging (if imaging was obtained). For 4% of the subjects, a second assessment was done by a second ED physician within 60 minutes of the first assessment-- at each site

Outcomes
Clinically important brain injury (ciTBI)
Death
Neurosurgery
Intubation > 24 hours
Hospitalization >/= 2 nights with associated changes on ct findings
Traumatic brain injury

Notes
CT scans were obtained in 14969 (35.3%) of the subjects
A clinical decision rule was formulated:
In children < 2 years old with a GCS of > 13
- Get a CT scan when
  - Other signs of altered mental status
  - Palpable skull fracture
- Consider observation vs. a CT scan on the basis of
  - Occipital, parietal, or temporal scalp hematoma or history of loss of consciousness or severe mechanism of injury-
  - Provider experience
  - Multiple isolated findings such as vomiting, headache, certain scalp hematomas in children > 3 months of age
  - Worsening signs and symptoms after Emergency Dept observation
  - Age < 3 months
  - Parental preference

In children > 2 years of age with a GCS of > 13
Get a CT scan when
Signs of altered mental stats
Signs of a basilar skull fracture
Consider observation vs. a ct scan on the basis of
Provider experience
Multiple isolated findings such as vomiting, headache certain scalp hematomas
- Worsening signs and symptoms after emergency dept observation
- Parental preference

Medications

(McCrory et al., 2013)

Methods Consensus statement the 3rd International Conference on Concussion in Sport held in Zurich, November 2012

Outcomes Describes two distinct situations where medications may be applied

1. for the management of specific prolonged symptoms such as sleep disturbance, anxiety,
2. to modify the underlying pathophysiology of the condition with the aim of shortening the duration of concussion symptoms

(Meehan III, 2011)

Methods Medical therapies for concussion 2011 Narrative review

Participants Athletes should be treated only if the symptoms exceed the typical time to symptom resolution for a sport related concussion the symptoms are severe enough that the risk of the benefits outweigh the adverse effects
the provider has knowledge and experience in managing sport related concussion or concussion in general

Outcomes **Sleep disturbance**-

1. Consider melatonin, trazodone. Consider zolpidem, tricyclic antidepressants, psychotherapy, phototherapy and chronotherapy

Somatic- (mostly headache)- analgesics, such as ibuprofen. Discern between tension type headache and migraine.

1. Post traumatic headaches- antidepressants specifically amitripyline
2. Other therapies- B-blockers, calcium channel blockers, valproic acid, topiramate, triptans, dihydroergotamine and gabapentin
3. Non-pharmacologic- biofeedback, physical therapy, and psychotherapy

Emotional-

1. consider tricyclic antidepressants and serotonin reuptake inhibitors for injury related depression
2. Sertraline for depression and improvement in psychomotor speed, memory and general cognitive efficiency

Cognitive-

1. Cognitive rehabilitation - due to the short existence of symptoms, may not be useful, but for symptoms that persist there may be a role
2. In the athlete with quantifiable cognitive deficits, a trial of medications may be considered
    1. Best studied:
        1. methylphenidate
        2. amantadine
    2. Less research
        1. doenpezil
        2. rivastigmine
        3. cytidine diphosphoryl choline
        4. fluoxetine
        5. sertraline
        6. pramiracetam
        7. bromocriptine
        8. amomoxetine

Notes Confounders
1. Data are of low quality, there are no large, double blind, randomized controlled trials
2. Of the studies that exist, many include head injuries that are more severe than those seen in sports
3. All therapies have adverse effects than may be worse than the symptom

Return to Play

(Brown et al., 2014)

Methods Prospective cohort study

Participants Children who presented to a Sports Concussion Clinic within 3 weeks of injury N= 335
Setting: USA
N= 335
Gender 62% male
Age 15 years (range 8-23 years)
Inclusion: sports related concussion or concussion from a similar injury, such as a playground fall. Diagnosis of concussion: Athletes who experienced a traumatic acceleration of the brain followed by the onset of symptoms of concussion, signs of concussion, or changes in neurocognitive function.
Exclusion: incomplete medical records, alternate diagnosis being considered, severe mechanism of injury,

Interventions Standard intake and follow up forms, the Post-Concussion Symptoms Scale (PCSS), cognitive activity scale.
When baseline values were unavailable, neuropsychologists made estimates of pre-injury function by history of previous testing, including neuropsychological, academic, patient and parent reports

Outcomes Primary outcome: duration of post concussive symptoms.
Recovery of concussion: (a) symptom free at rest, (b) symptom free with exertion and after discontinu9ing medications prescribed for post concussion symptoms (c) their balance error symptom scores were back to baseline, when available, and (d) their computerized neurocognitive test scores were at or above baseline values, when available.

Notes Results: N=335 subjects, Only the total score on the PCSS at the initial visit, and cognitive activity-days were independently associated with the duration of symptoms. Gender, age, loss of consciousness, amnesia, and number of previous concussions were not independently associates with time to symptom resolution.

(Echlin et al., 2010)

Methods Prospective cohort study to measure the duration of medical restriction from play (return to play period) after each physician observed and diagnosed concussion or recurrent concussion by direct clinical evaluation augmented with the SCAT2 and ImPACT neuropsychological tools.

Participants Male ice hockey players during a regular season
Setting: USA
N= 17 subjects
Gender= 100% male
Age:16-21 year old

Inclusion: complete a baseline SCAT2 and ImPACT. if the baseline was not completed by a subject, post concussion information was compared to sex matched normative levels.
Exclusion:

Interventions After diagnosis of concussion at the sports event, the subject was evaluated at the physician's office, The return to play decision was based on the Zurich return to play protocol and additional the SCAT2 and ImPACT tools were used.

Outcomes Days until return to play-
Mean number of physician office visits

Notes 15 subjects who sustained a concussion:

- Days until return to play- 12.8 days +/- 7.02 days (median 10 days, range 7-29 days)
- Mean number of physician office visits- 2.1 +/- 1.29 (median 1.5 visits)

5/15 subjects who suffered a previous concussion

- Days until return to play- 78.6 days +/- 39.8 days (median 82 days)

The conclusion is that the increase in the time to return to play for first and secondary concussion in this study than in previously published studies on sport concussion may be the result of the methods in this study, including (a) direct independent physician observation, (b) diagnosis, and (c) adherence to the Zurich return to play protocol Limitation included poor compliance to the baseline testing.

(Eisenberg, Andrea, Meehan, & Mannix, 2013)

Methods Prospective cohort study

Participants acute concussion
Setting ED in a metropolitan US hospital
Number = 280
Gender= 57%
Exclusion: extremity fracture, developmental or cognitive delay, victim of assault, GCS < 13,

Interventions Rivermead Post Concussion Symptoms Questionnaire (RPSQ)- Symptom free was declared when all inventories of the test were scored 0- or symptom not present.

Outcomes Time to resolution of symptoms assessed by the Rivermead Post Concussion Symptoms Questionnaire (RPSQ) administered in serial fashion for 3 months post concussion. The RPSQ has high degree of inter-rater and test-retest reliability; It has been shown to be valid in young children.

Notes See above for table with results.

Lau 2011

Methods Prospective Cohort

Participants High school male football athletes US
N= 108
Age
Protracted recovery > 14 days N= 50
Short recovery < or = 14 days N=58

Interventions Completed a computer based neurocognitive test within 2.23 days of injury and were followed until returned to play by international criteria (not identified)
Tests used ImPACT, Post-Concussion Symptom Scale (PCSS), and four symptom clusters derived from the PCSS Migraine (a) Migraine, (b) Neuropsychiatric, (c) Cognitive, and (d) Sleep.

(McCrory et al., 2013)

Findings Return to play :

Day of injury- When a player shows ANY features of a concussion

1. The player should be evaluated by a physician or other licensed healthcare provider onsite using standard emergency management principles and particular attention should be given to excluding a cervical spine injury.
2. The appropriate disposition of the player must be determined by the treating healthcare provider in a timely manner. If no healthcare provider is available, the player should be safely removed from practice or play and urgent referral to a physician arranged.
3. Once the first aid issues are addressed, an assessment of the concussive injury should be made using the SCAT3 or other sideline assessment tools.
4. The player should not be left alone following the injury and serial monitoring fro deterioration is essential over the initial few hours following injury
5. A player with diagnosed concussion should not allowed to return to play (RTP) on the day of injury.

Graduated RTP

A step in the plan is expected to take 24 hours. If any post-concussive symptoms occur during the progression, the player should drop back to the previous asymptomatic level and progress after 24 hours at that level. An athlete should not return to play if post-concussion symptoms are present or if they are taking any medication that may mask or modify the symptoms of a concussion.

Persistent symptoms- are defined as symptoms that are still present greater than 10 days post index injury. It can be seen in 10-15% of reported concussions. If persistent symptoms are present, other causes for the symptoms should be considered.

(Yard & Comstock, 2009)

Methods Prospective cohort study

Participants Concussed high school athletes. USA Data was collected for the 2005 through 2008 school years

Certified athletic trainers reported injury reports to the High School RIO™ (Reporting Information Online).

Boy's sports- football, soccer, basketball, wrestling, baseball

Girls sports- soccer, basketball, volleyball, softball

Concussions were graded retrospectively.

Interventions

Outcomes Did athletes follow the American Academy of Neurology (AAN) Return to Play guidelines or the Prague Return to Play guidelines?

Notes There were 1308 concussions reported (23.2 concussions per 100,000 athlete-exposures.

At least 40.5% and 15% of the athletes returned to play prematurely under the AAN and Prague guidelines respectively

Males (12.6%) were more likely than females to return to play (5.9%) within 1-2 days after sustaining an initial grade II concussion.

(Zuckerman 2012)

Methods Prospective cohort study

Participants High school and college athletes with sport related concussion. USA

N=200 (N= 100 in the 13-16 year age group and N= 100 in the 18-22 year age group)

	Concussion diagnosed as on-field presentation and at least one of the following symptoms: self-reported post concussive symptoms, such as lethargy, fogginess, headache, etc., alteration in mental status; loss of consciousness; or amnesia. Inclusion criteria- with the age ranges, participating in high school or college athletics, valid pre participation ImPACT test results, valid completion of 2 post injury ImPACT test battery within 30 days of the index injury Exclusion criteria, outside of age range; invalid ImPACT testing; self-report of special education, speech therapy, repeated school year(s), learning disability, ADHS, dyslexia, or autism; self reported history of brain surgery or seizure disorder; self reported history of treatment for drug/alcohol abuse or psychiatric illness. 17 year olds were excluded on purpose to have a clear line between the age groups.
Interventions	Each subject completed the baseline and post concussion neurocognitive testing using the ImPACT test battery. Definition of return to baseline- post concussion neurocognitive and symptom scores being equivalent to baseline using reliable change index (RCI) criteria.
Outcomes	Number of days to return to cognitive and symptom baseline were calculated. Specifically the return to the participant's own baseline. The RCI was set at the 80% confidence interval and any score within 80%-100 of baseline was considered return o baseline.
Notes	Findings 740 potential athletes were identified. 200 subjects remained after inclusion and exclusion criteria were applied. Younger athletes averaged a significantly higher number of days to return to baseline of all indices except Process Speed than did athletes in the older group.

Study or Subgroup	Younger Mean	Younger SD	Younger Total	Older Mean	Older SD	Older Total	Weight	Mean Difference IV, Fixed, 95% CI
1.1.1 Verbal memory								
Zuckerman 2012	7.2	5.6	100	4.7	4.6	100	23.0%	2.50 [1.08, 3.92]
Subtotal (95% CI)			**100**			**100**	**23.0%**	**2.50 [1.08, 3.92]**
Heterogeneity: Not applicable								
Test for overall effect: Z = 3.45 (P = 0.0006)								
1.1.2 Visual memory								
Zuckerman 2012	7.1	5.6	100	4.7	4.9	100	21.8%	2.40 [0.94, 3.86]
Subtotal (95% CI)			**100**			**100**	**21.8%**	**2.40 [0.94, 3.86]**
Heterogeneity: Not applicable								
Test for overall effect: Z = 3.23 (P = 0.001)								
1.1.3 Reaction time								
Zuckerman 2012	7.2	5.8	100	4.1	5.2	100	19.9%	3.10 [1.57, 4.63]
Subtotal (95% CI)			**100**			**100**	**19.9%**	**3.10 [1.57, 4.63]**
Heterogeneity: Not applicable								
Test for overall effect: Z = 3.98 (P < 0.0001)								
1.1.4 Processing speed								
Zuckerman 2012	6.8	5.8	100	5.3	5.4	100	19.2%	1.50 [-0.05, 3.05]
Subtotal (95% CI)			**100**			**100**	**19.2%**	**1.50 [-0.05, 3.05]**
Heterogeneity: Not applicable								
Test for overall effect: Z = 1.89 (P = 0.06)								
1.1.5 Post concussion scale								
Zuckerman 2012	8.1	6.8	100	6.1	5.4	100	16.0%	2.00 [0.30, 3.70]
Subtotal (95% CI)			**100**			**100**	**16.0%**	**2.00 [0.30, 3.70]**
Heterogeneity: Not applicable								
Test for overall effect: Z = 2.30 (P = 0.02)								

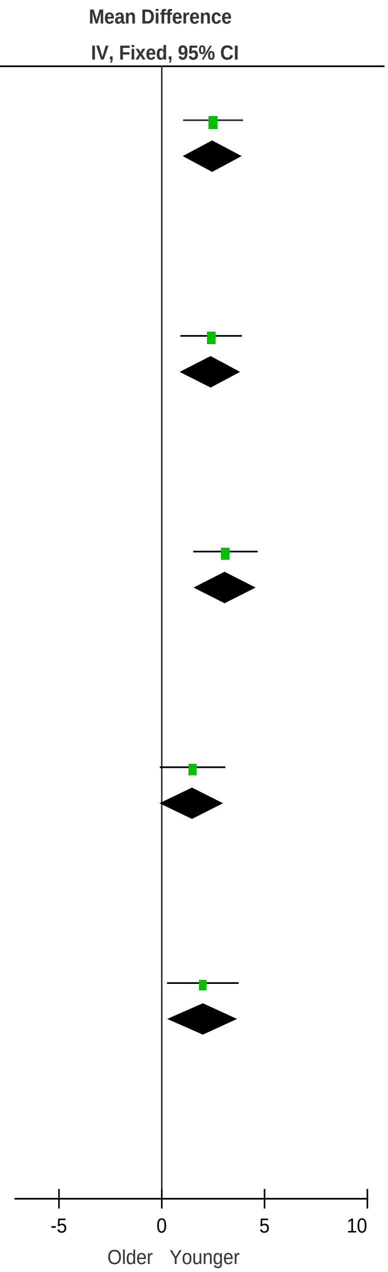

Figure XX. Younger athletes (13-16 years) vs. older athletes (18-22 years), Outcome: Days to return to baseline. It can be seen that the older athletes had significantly fewer days to return to baseline than the younger athletes for all but the processing speed test. For that test, the older athletes trended to have fewer days to recovery, but the difference was not significant.

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