**Online Supplementary Table. Predictors of Clinical Outcome from Sport-Related Concussion.**

From: Iverson, G.L., Gardner, A.J., Terry, D.P., Ponsford, J.L., Sills, A.K., Broshek, D.K., and Solomon, G.S. (2017). Predictors of Clinical Recovery from Concussion: A Systematic Review. *British Journal of Sports Medicine*.

| **First Author (Year)****PMID** | **Total N, # Concussed, % Female****Age (in years) (Mean, SD, Range)****Setting**  | **Study Design and Outcome** | **Predictors** | **Time****Period** | **Level of****Evidence** |
| --- | --- | --- | --- | --- | --- |
| Asken (2016)[27111584](https://www.ncbi.nlm.nih.gov/pubmed/27111584) | N=97, 97, 23%Age: M=20.4, SD=1.3, Range=NRSetting: University | Retrospective chart review, case-control studyOutcome: Days missed; normal vs. prolonged recovery (> 7 days) | Significant: Delayed removal from play; prior psychiatric conditionNot Significant: ADHD, learning disability, prior concussions | 7 days | 4 |
| Asplund (2004)[15523205](https://www.ncbi.nlm.nih.gov/pubmed/15523205) | N=101, 101, 10%Age: M=18.7, SD=NR, Range=14-23Setting: Primary care sports providers | Physician practice survey studyOutcome: Return to Play | Significant: LOC and retrograde amnesia, headache > 3 hours, difficulty with concentration > 3 hoursNot Significant: Age, sex, race, LD, PTA, difficulty with memory > 3 hours | 7 days | 4 |
| Baker (2015)26084537 | N=91, 91, 23%Age: M=15.1; 15.7, SD=1.4; 1.7, Range=13-19Setting: Clinic | Retrospective cohort studyOutcome: Problems on return to school | Significant: Concussion recovery time; number of symptomsNot Significant: Sex, age, prior concussions | 14.4 months, SD=9.6 months | 3 |
| Baker (2016)[26378093](https://www.ncbi.nlm.nih.gov/pubmed/26378093) | N=147, 147, 25%Age: M=15.4, SD=1.5, Range=13-19Setting: Concussion Clinic | Retrospective cohort studyOutcome: Clinical recovery (including exertional testing) | Significant: Sex (females greater first-visit symptoms and longer recovery time)Not Significant: None | 3 months following injury | 3 |
| Barlow (2011)[21904694](https://www.ncbi.nlm.nih.gov/pubmed/21904694) | N=106, 106, 35%Age: M=15.38, SD=1.7, Range=11-19Setting: Hospital Sports Medicine system | Retrospective chart review, case-control studyOutcome: Physician diagnosed post-concussion syndrome | Significant: Lower first visit symptom scores (not greater)Not Significant: Initial performance on balance or cognitive testing; Prior concussions | Approx. 3 months | 4 |
| Bauman (2016) Abstract | 207, 207, 56%Age: M-NR, SD=NR, Range=10-60Setting: clinic | Retrospective chart reviewOutcome: Recovery time (0-2 months; 3-5 months; >6 months) | Significant: Sex (female)Not significant: None explicitly reported | Several months | 4 |
| Benson (2011)21502355 | N=559, 559, 0%Age: M=27.0, SD=NR, Range=18-41Setting: Professional hockey | Prospective cohort studyOutcome: Return to play (> 10 days vs. ≤ 10 days) | Significant: Prior concussions, initial symptom severity, initial headache, LOC, initial fatigue, initial light sensitivityNot Significant: Amnesia, dizziness, nausea, neck pain, blurred vision, nervousness, irritability, vomiting, abnormal neurologic exam  | Median=6, IQR=2-13Range: 0-342 | 2 |
| Berz (2013)[23703518](https://www.ncbi.nlm.nih.gov/pubmed/23703518) | N=37, 37, NRAge: M=15, SD=1.9, Range=11-17Setting: Sports medicine clinic | Retrospective cohort studyOutcome: Total symptom score.  | Significant: sex (females reported more symptoms)Not Significant: Time between injury and presentation to clinic | 7 days | 4 |
| Black (2016)26862834 | N=759, 75\* (5 with multiple concussions), 42%Age: M=19.81; 19.34, SD=2.86; 1.81, Range=NRSetting: University | Retrospective cohort studyOutcome: Clinical recovery (symptoms and cognitive) | Significant: NoneNot Significant: Sex | Median=6 days (range 0-65) for symptom resolution; 11 days (range 0-135) for cognitive recovery | 3 |
| Bock (2015)[26243160](https://www.ncbi.nlm.nih.gov/pubmed/26243160) | N=361, 361, 34%Age: M=NR, SD=NR, Range=11-18Setting: Concussion clinic | Retrospective chart review cohort studyOutcome: Time to return to play | Significant: Female gender, referral for a concussion rehabilitation program, acute headache rescue medication, and chronic headache medication predicted longer RTP; Those who had a specialty evaluation within the first week of their concussion and those who had an acute headache had significantly shorter RTP than those who did notNot Significant: Academic performance, comorbid conditions, and on-fieldmarkers such as loss of consciousness, amnesia, and confusion | Several months | 3 |
| Broglio (2011)[21644811](https://www.ncbi.nlm.nih.gov/pubmed/21644811) | N=95, 19, 0%Age: M=16.7, SD=0.8, Range=15-19Setting: High school | Prospective cohort studyOutcome: Cognition and symptoms; days to recovery | Significant: NoneNot Significant: Biomechanics of the concussive injury and of pre-concussion hits (cumulative hits) | Cognition assessed within 12-18 hours. RTP < 14 days.  | 3 |
| Brown (2014)[24394679](https://www.ncbi.nlm.nih.gov/pubmed/24394679) | N=335, 335, 38%Age: M=15, SD=2.6, Range=8-23Setting: Clinic | Prospective cohort studyOutcome: Symptom duration | Significant: Total Symptom burden at initial visit; Cognitive Activity LevelNot Significant: Sport, Past Concussion History, LOC, Amnesia | Average=43 days; SD=53 | 3 |
| Bruce (2004)15505180 | 433, 57, 0%Age=NRSetting: Division I athletics | Prospective CohortOutcome: Symptom reporting at one week | Significant: Prior history of concussionNot Significant: NR | 1 week | 3 |
| Buckley (2016) Abstract | 41, 41, 51%Age: M=19.6, SD=1.2, Range=NRSetting: College | Prospective cohortOutcome: Days until symptom resolution; Days to RTP | Significant: NoneNot significant: Physical activity level, cognitive activity level, and hours of sleep (all in the first two days post-injury) | RTP M=13 days 95%CI=11.8-14.3 | 3 |
| Castile (2011)22144000 | N=2,417, 2,417, NRAge: NRSetting: High school online reporting | Inception cohort studyOutcome: Clinical recovery (symptoms), return to play | Significant: Prior concussion, Acute symptom burden Not Significant: None | 3 weeks; 1 month | 2 |
| Chermann (2014) 25741414 | N=35, 35, 14%Age: M=23.1, SD=5.5, Range=NRSetting: Hospital | Prospective cohortOutcome: Return to play >21 days | Significant: Age (younger), LOC, Cantu grade 3, PCS > 5 daysNot Significant: Sex | Mean=22, Range=7-45 | 3 |
| Chou (2016) Abstract | 31, 31, NRAge: NR (high school)Setting: University research lab | Prospective cohortOutcome: Symptom reporting, gait stability (medial-lateral motion of the center-of mass) | Significant: Previous concussions Not significant: None explicitly reported | 8 weeks | 3 |
| Chrisman (2013)[23252433](https://www.ncbi.nlm.nih.gov/pubmed/23252433) | N=1,412, 1,412, 23%Age: M=15.9, SD=1.2, Range=13-18Setting: Database, retrospective cohort | Retrospective cohort studyOutcome: Concussion Symptoms ≥ 1 week in football players and other athletes | Significant: ≥4 symptoms (for football players); weight >90th percentile of the sample; history of concussion; acute specific symptoms: drowsiness, nausea, concentration difficulties, confusion, sensitivity to light/noise, amnesia for males (not females)Not Significant: Age, Sex, LOC, Acute specific symptoms: headache, dizziness, tinnitus, irritability  | 1 week | 3 |
| Collie (2006)16421129 | 615, 61, 0%Age: Asymptomatic M=23.3 SD=3.9, Symptomatic M=22.3 SD=3.6, Range=NRSetting: Australian rules football league | Prospective cohortOutcome: Hours to symptom resolution and days to return to Sport | Significant: Being symptomatic (vs. asymptomatic) during the first clinical assessment was associated with greater acute symptoms, greater time to symptom resolution, greater number of days to return to sport, and objective cognitive deficits at time of first assessment.Not Significant: NR (in relation to recovery time) | < 11 days | 3 |
| Collins (2003)[12642248](https://www.ncbi.nlm.nih.gov/pubmed/12642248) | N=110, 110, 15%Age: M=15.8, SD=1.2, Range=NRSetting: High School | Prospective cohort studyOutcome: Headache status at 7 days following injury | Significant: Anterograde amnesia, 3-4 on-field clinical signs, > 5 minutes on-field signsNot Significant: LOC, retrograde amnesia, disorientation | 1 week | 3 |
| Colvin (2009)19460813 | N=234, 234, 60%Age: M=M 16.3; F 16.5, SD=M 2.4; F 2.45, Range=8-24Setting: Clinic | Prospective cohort studyOutcome: Cognition, symptom burden | Significant: ≥ 1 prior concussion, female genderNot Significant: BMI | M=12-13 days, SD=12 days | 3 |
| Corwin (2014)25262302 | N=247, 247, 42%Age: M=14, SD=NR, Range=5-18Setting: Tertiary specialty clinic (often sees slow to recover youth) | Retrospective Cohort Study (77% with sport-related concussions)Outcome: Return to school/ sports | Significant: Pre-existing depression, pre-existing anxiety, acute dizziness, increased symptoms from initial oculomotor exam, abnormal near point convergence, prior concussionsNot Significant: LOC, Age, Referral for cognitive rest | RTP Median=76 days (IQR=30-153) | 3 |
| Corwin (2015)[25748568](https://www.ncbi.nlm.nih.gov/pubmed/25748568) | N=247, 247, 42%Age: M=14, SD=NR, Range=5-18Setting: Clinic (often sees slow to recover youth) | Retrospective Cohort Study (77% with sport-related concussions)Outcome: Return to school and/or sports; Improved Cognition | Significant: Abnormal vestibular ocular reflex or tandem gait on initial medical evaluation in a specialty clinic (Median RTP 106 days vs. 29 days)Not Significant: None | RTP Med=29 days and 106 days | 3 |
| Covassin (2007)[17762747](https://www.ncbi.nlm.nih.gov/pubmed/17762747) | N=79, 79, 49%Age: NRSetting: University | Prospective cohort studyOutcome: Symptoms and cognition within 10 days of injury | Significant: Gender (Visual memory worse acutely for women; men reported more vomiting and sadness acutely)Not Significant: No sex differences in reaction time, verbal memory, processing speed, or total symptoms acutely or at 7 days following injury | 7-10 days | 3 |
| Covassin (2012)[22539534](https://www.ncbi.nlm.nih.gov/pubmed/22539534) | N=296, 296, 31%Age: M=male hs 15.6; fm hs 15.43;m college 19.52; fm college 18.94SD=1.19; 1.22; 1.08; 1.55Setting: High school and university | Inception cohort studyOutcome: Clinical recovery (symptoms, cognition, balance) | Significant: Age (high school worse than college); Sex (female); high school males worse at balance following concussion than college males; college females worse at balance following concussion compared to high school females (interaction between age & sex on postural stability)Not Significant: None | 14 days | 2 |
| Covassin (2013)[23959963](https://www.ncbi.nlm.nih.gov/pubmed/23959963) | N=598, 598, 30%Age: Mostly 14-21Setting: High school and University | Inception cohort studyOutcome: Clinical recovery (symptoms, cognition) | Significant: 3+ concussionsNot Significant: 0 concussions, 1 concussions(Results covaried for age but not gender) | 8 days | 2 |
| Covassin (2013)[24197616](https://www.ncbi.nlm.nih.gov/pubmed/24197616) | N=95, 95, 57%Age: M=male 17.69, fm 17.78, SD=2.10, 2.30, Range=NRSetting: University | Inception cohort study (controlled for BMI)Outcome: Cognition; symptom reporting | Significant: Sex (females)Not Significant: None | Average 8 days, Range 2-19 days | 2 |
| Covassin (2016)[26950073](https://www.ncbi.nlm.nih.gov/pubmed/26950073) | N=1,702, 1,702, 53%Age: NRSetting: Collegiate athletic association | Epidemiological studyOutcome: Return to play  | Significant: Sex (female) during soccer practice (but not games) and basketball games (but not practice)Not Significant: Sex (baseball/softball, ice hockey, lacrosse) | Approximately 8 days, SD=7 | 3 |
| Cross (2016) Abstract | 810, 80 (complete data), 0%Age: NRSetting: Professional Rugby Union | Prospective cohortOutcome: Days to RTP (Protracted recovery > 14 days) | Significant: Greater acute symptom burden and worse objective balance (on BESS)Not Significant: None explicated reported. | RTP>14 days (18% of players) |  |
| Custer (2016)[26885702](https://www.ncbi.nlm.nih.gov/pubmed/26885702) | N=670, 315 (analyzed), 30%Age: M=17.4, SD=2.3, Range=13-23Setting: High school and university | Cohort StudyOutcome: Acute clinical outcome (symptoms, cognition) | Significant: High baseline preseason symptoms (baseline PCSS>18 vs. PCSS=0) associated with worse acute post-injury cognitive functioning. Not Significant: None | 3 (SD=2) days following injury | 3 |
| Eisenberg (2013)23753087 | N=235, 235, 43%Age: M=14.3, SD=NR, Range= 11-22Setting: Emergency department | Prospective Cohort Study(64% with sport-related concussions)Outcome: Time to Symptom Resolution | Significant: Age >13 (older=worse outcome), initial RPSQ score >18, female gender, history of depression, absence of LOC, and abnormal neurologic examination on presentation, past concussion history (if < 1 year ago)Not Significant: Race, ethnicity, mechanism of injury, amnesia, migraine history, LD, ADHD, history of anxiety, family migraine history, taking an oral contraceptive, SSRI, stimulant, antihistamine, family concussion history, GCS < 15, hospital admission status, treatment prescription (e.g., whether rest was prescribed, whether physical activity was prescribed). | 90 days | **3** |
| Ellis (2015)[26359916](https://phstwlp2.partners.org:2052/pubmed/26359916) | N=174, 174, 38%Age: M=14.2, SD=2.34, Range= ≤ 19 yearsSetting: Pediatric concussion program | Retrospective Cohort StudyOutcome: Presence of psychiatric sequelae (i.e., worsening of symptoms of a pre-existing psychiatric disorder, new suicide ideation, or presence of a new psychiatric disorder) vs. no psychiatric disorder | Significant: Female, higher initial PCSS score, higher initial emotional PCSS sub-score, presence of a pre-injury psychiatric history, presence of a family history of psychiatric illness, sadness rating at initial consultation, anxiousness rating at initial consultationNot Significant: Prior concussion, migraine, LOC, amnesia, age, irritability at first visit | 1 month+ | 3 |
| Erlanger (2003)12650417 | N=47, 47, 43%Age: M=NR, SD=NR, Range=14-22Setting: Survey to high school, college, sports organizations | Cohort studyOutcome: Symptom duration | Significant: Acute dizziness, memory impairment at initial visitNot Significant: LOC, prior concussions | 16 days | 3 |
| Field (2003)[12756388](https://www.ncbi.nlm.nih.gov/pubmed/12756388) | N=92, 54, 4%Age: M=15.9; 19.9, SD=NR, Range=14-25Setting: High school and university | Prospective case control studyOutcome: Clinical recovery (cognition, symptoms) | Significant: Age (high school age had worse outcome than college age)Not Significant: Prior concussions | 1-7 days | 4 |
| Frommer (2011)[21214354](https://www.ncbi.nlm.nih.gov/pubmed/21214354) | N=812, 812, 25%Age: M=15.9; 15.9, SD=1.2; 1.7, Range=NRSetting: High school online reporting | Prospective epidemiology studyOutcome: Return to play, symptom resolution time | Significant: NoneNot Significant: Sex | Average RTP=7 days, Maximum=31 days | 4 |
| Gibson (2013)23758286 | N=184, 184, 27%Age: M=15, SD=3, Range=8-26Setting: Clinic | Retrospective case-control studyOutcome: Symptoms > 30 days | Significant: Symptom burden at time of first specialty clinic visit and recommendation for cognitive rest both associated with having persistent symptoms beyond one monthNot Significant: Age, sex, prior concussions, LOC, amnesia, recommendation for cognitive rest | 30 days or more | 4 |
| Greenhill (2016)27005467 | N=4,580, 4,580, 0%Age: M=15.6, SD=1.25, Range=13-19Setting: National High school database | Prospective cohort studyOutcome: Number of acute symptoms/acute symptom presentation (e.g., drowsiness, noise sensitivity, hyperexcitability); symptom duration; percentage with symptoms > 1 week | Significant: Number of acute symptoms (with longer symptom duration); Taller players (> 70 inches) had greater acute symptoms; poorly fitted helmets with symptoms > 1 week/worse acute symptom presentation; gel/foam helmet liner (with more LOC, more drowsiness, sensitivity to noise) Not Significant: Age/weight (with acute symptom burden) | 1 week | 3 |
| Guskiewicz (2000)11032218 | N=17,549, 888, 0%Age: M=NRSetting: High school and university surveys | Observational;Prospective epidemiology studyOutcome: Concussion frequency;PCS; time to return to play | Significant: Prior concussion influenced likelihood of future concussion and acute symptom reporting; Level (high school and div III collegiate had greater injury rates than Div I and II); head contact with artificial turf influenced likelihood of concussion; Grade of concussion influenced number of symptoms and recovery time (Grade II> Grade I)Not Significant: None | 8 days | 3 |
| Guskiewicz (2001)[12937495](https://www.ncbi.nlm.nih.gov/pubmed/12937495) | N=72, 36, 31%Age: M=19.5; 20, SD=1.34; 2.36, Range=NRSetting: University | Prospective case-control studyOutcome: Postural stability and cognition | Significant: NoneNot Significant: LOC and Amnesia | First 5 days following injury | 4 |
| Guskiewicz (2003)[14625331](https://www.ncbi.nlm.nih.gov/pubmed/14625331) | N=2,905, 184, 0%Age: NRSetting: University | Prospective inception cohort studyOutcome: Symptom recovery time | Significant: Prior concussions, LOC, and amnesiaNot Significant: None | Prolonged recovery defined as greater than 7 days | 2 |
| Hang (2015)26430968 | N=109, 109, 21%Age: M=NR, SD=NR, Range=11-18Setting: Emergency Department | Prospective cohort studyOutcome: Symptom recovery | Significant: Symptom severity in emergency department; vomiting, fatigue, and difficulty concentrating reported in the ED; prior concussionsNot Significant: Age, sex, ADHD, learning disability, prior treatment for headaches, or initial severity of cognitive impairment on ImPACT, neurologic disorders (e.g., brain surgery, meningitis, epilepsy) | First 2 weeks following injury | 3 |
| Henry (2016)[26445375](https://phstwlp2.partners.org:2052/pubmed/26445375) | N=66, 66, 36%Age: M=16.5, SD=1.9, Range=14-23Setting: NR | Prospective cohort studyOutcome: Cognitive functioning, symptoms, and vestibular-oculomotor symptoms | Significant: Female sex associated with slower recovery on symptomsNot Significant: None | First 4 weeks following injury | 3 |
| Heyer (2016)27056449 | N=1,953, 1,953, 37%Age: M=14.1, SD=2.1Setting: Children’s hospital  | Retrospective cohort studyOutcome: Return to play (days) | Significant: Female sex, premorbid headaches, LOC, anterograde amnesia, continuing to play following injury, day of injury emotional symptoms, symptom reporting at time of clinic visit, rate of cancelled/missing clinic appointments, symptom worsening between post-injury assessment and clinic visitNot Significant: Age, ethnicity, insurance plan, managing physician, prior concussions, mechanism of injury, retrograde amnesia | 1-353 days RTP; Median=18 days | 3 |
| Hinton-Bayre (2002)12370464 | N=175, 21, 0%Age: M=NR, SD=NR, Range=NRSetting: National rugby team clubs | Prospective observational studyOutcome: Cognitive outcome at 10 days | Significant: Severity of concussion (grade 1 worse than grade 2)Not Significant: LOC | 10 days following injury | 4 |
| Iverson (2006)[16537266](https://www.ncbi.nlm.nih.gov/pubmed/16537266) | N=30, 30, 7%Age: M=16.1, SD=2.1, Range=12-21Setting: Middle school, high school, university | Retrospective cohort, baseline with repeated measures studyOutcome: Return to baseline symptoms and ImPACT scores | Significant: NoneNot Significant: Trend toward pre-existing headaches, prior concussion history | Approx. 10 days | 3 |
| Iverson (2007)[17304003](https://www.ncbi.nlm.nih.gov/pubmed/17304003) | N=2,206, 114, 100%Age: M=simple 16.2; complex 16.1, SD=1.2; 1.1, Range=13-19Setting: High school | Case-control studyOutcome: Meeting clinical criteria for recovery (Complex concussion > 10 days out of sport) | Significant: 3 or more low (<10th %tile) ImPACT scores and high early symptom reporting within 72 hours post-injury were associated with prolonged recoveryNot Significant: Age, education, concussion history | Approx. 10 days | 4 |
| Kerr (2014)[26535354](https://www.ncbi.nlm.nih.gov/pubmed/26535354) | N=2,526, 2,526, NRAge: M=NR, SD=NR, Range=NRSetting: High school football online reporting | Retrospective epidemiological studyOutcome: Symptom resolution time and RTP | Significant: Prior concussion history Not Significant: Head impact location  | Approx. 3 weeks | 4 |
| Kerr (2016) Abstract | 1846, 1846, 26.3%Age: NR (high school)Setting: high school | Prospective Cohort using national database (NATION)Outcome: PCS (symptoms lasting > 4 weeks) vs. those with symptom resolution < 2 weeks | Significant: Disorientation, balance issues, visual impairments, noise sensitivity, retrograde amnesia, and difficulty concentratingNot Significant: Sex, sport contact level, and prior concussions | 4 weeks | 3 |
| Ketcham (2016) Abstract | 1,161, 89 (8 with ADHD), NRAge: NR (university students)Setting: University | Cross-sectional studyOutcome: Days to recover | Significant: Those with ADHD took longer to recover (M=13.3 days versus 7.3 days)Not Significant: None explicitly reported | NR | 3 |
| Kontos (2010)[20861034](https://www.ncbi.nlm.nih.gov/pubmed/20861034) | N=96, 96, 18%Age: M=19.33, SD=2.08, Range=14-23Setting: High school and university | Case-control studyOutcome: Cognition | Significant: Race (African American worse than White)Not Significant: None | 7 days | 4 |
| Kontos2012[22503738](https://www.ncbi.nlm.nih.gov/pubmed/22503738) | N=75, 75, 32%Age: M=hs 15.74; uni 19.68, SD=1.28; 1.33, Range=NRSetting: High school and university | Prospective, baseline with repeated measures post-injuryOutcome: Depression symptom score, cognition, symptom reporting  | Significant: Age (college students had > BDI-II vs. high school)Not Significant: Sex | Approx. 14 days | 4 |
| Kontos (2013)[24067122](https://www.ncbi.nlm.nih.gov/pubmed/24067122) | N=138, 138, 0%Age: M=15.96, SD=1.18, Range=13-19Setting: High school | Prospective study of high school football players; grouped into posttraumatic migraine, headache but no migraine, and no headache groupsOutcome: Cognition, symptom reporting | Significant: Presence of migraine in week 1 predicted: (1) higher overall sx factor scores, (2) worse neurocognitive test scores in the first 2 weeks post-injury, and (3) and protracted recovery (>21 days) vs. headache or no headache groupsNot Significant: Non-migraine headache | Approx. 21 days | 2 |
| Kostyun (2014)25520301 | N=545, 545, 45%Age: M=m 14.4; fm 14.6, SD=NR, Range=11-18Setting: Clinic | Retrospective cross-sectional cohort Outcome: Clinical recovery (cognition, symptom reporting) | Significant: > 9 hours of sleep (with cognition), < 7 hours of sleep (with symptom reporting); self-reported sleep difficulties (trouble falling asleep, sleeping less than normal, sleeping more than normal). Sleep symptoms and cognition assessed on same day. Not Significant: None | Within 90 days of injury (Mean=22, SD=18) | 3 |
| Kostyun (2015)[25553213](https://www.ncbi.nlm.nih.gov/pubmed/25553213) | N=266, 266, 36%Age: M=male 14.3; fm 14.9, SD=2.3; 3.4, Range=11-18Setting: Clinic | Retrospective epidemiological studyOutcome: Meeting clinical criteria for recovery (based on symptom reporting and full re-engagement in normative activities) | Significant: Sex (female=worse)Not Significant: NA | Several months | 4 |
| Kriz (2016)26781190 | N=145, 145, 30%Age: M=male 15.4; fm 15.2, SD=1.5; 1.4, Range=13-18Setting: Clinic, ice hockey players | Prospective case-control study Outcome: Duration of concussion symptoms (> 28 days) | Significant: Among males, less physically mature adolescents (measured by a Pubertal Developmental Scale) and lower weight were associated with prolonged sxs (>28 days to recovery). Among females, heavier weight was associated with prolonged sxs (>28 days to recovery), and wings/centers had > odds of prolonged sxs vs. goalies/defendersNot Significant: Age | Approx. 45 days(Range=4-324 days) | 4 |
| Lau (2009)[19423974](https://www.ncbi.nlm.nih.gov/pubmed/19423974) | N=108, 108, 0%Age: M=16.01, SD=1.2, Range=13-19Setting: High School | Case control studyOutcome: Meeting clinical criteria for recovery; Complex (> 10 days recovery) vs. Simple (< 10 days) | Significant: Acute (within 2 days) migraine, sleep, and cognitive symptom clusters, total PCSS score, worse Visual Memory and processing speed associated with slow recoveryNot Significant: Age, education, prior concussion history, Reaction Time, Verbal Memory | Several weeks | 4 |
| Lau (2011)21285444 | N=108, 108, 0%Age: M=16.12, 15.9, SD=1.2, 1.2, Range=NRSetting: High School | Inception cohort studyOutcome: Return to play; >14 days | Significant: Acute (~2 days) visual memory, processing speed, migraine cluster, cognitive cluster, sleep cluster; worse cognition and greater symptoms=protracted recoveryNot Significant: Age, education, history of prior concussions, headache history, and migraine history | 14 days (RTP very variable) | 2 |
| Lau (2011)21712482 | N=107, 107, 0%Age: M=16.02, SD=1.22, Range=13-19Setting: High school | Prospective cohort studyOutcome: Protracted recovery (≥ 21 days) vs. Short Recovery (≤ 7 days) | Significant: Acute dizzinessNot Significant: Headache history, migraine history, ADHD, LD, 1+ prior concussion, PTA, retrograde amnesia, acute balance problems | Until recovery (mean=13 days, SD=9 days) | 2 |
| Lau (2012)21841522 | N=108, 108, 0%Age: M=16.12; 15.9; 15.94, SD=1.2, Range=NRSetting: High School | Case-control studyOutcome: Cognition; short recovery (≤14 days) vs. protracted recovery (>14 days) | Significant: NoneNot Significant: Age, education, time between injury and evaluation, migraine history, headache history, ADHD, LD, at least 1 prior concussion. | 14 days cutoff  | 4 |
| Lax (2015)26362811 | N=211, 25, 29%Age: M=15; 19.1, SD=0.8; 1.1, Range=8-15Setting: Hockey association | Retrospective cohort studyOutcome: Cognition | Significant: None. Girls initially had greater acute cognitive effects but there was not a sex difference in clinical recovery.Not Significant: Sex (on clinical recovery) | Mean=20 days, SD=31 days | 3 |
| Lee (2013)24063601 | N=184, 184, 57%Age: M=15.0; 19.1, SD=0.8, 1.1, Range=13-22Setting: Middle school, high school, university | Retrospective cohort studyOutcome: Number of post-concussive symptoms, total symptom severity post-injury; % of sample whose symptoms resolved in 30 days | Significant: NoneNot Significant: Age (13-16 vs. 18-22) | 30 days | 3 |
| Lishchynsky (2016) Abstract | 30, 30, 17%Age: Med=14, Range=12-17Setting: Clinic | Cohort StudyOutcome: Days to RTP  | Significant: Those with high levels (>45 minutes) of moderate and vigorous physical activity (MVPA) in the first three days post-injury recovered slower compared to the low MVPA group (< 45 minutes). Median RTP 19 days vs. 15 days.Not Significant: None | RTP Median 15 and 19 days; range 10-55  | 3 |
| Lovell (2003)12593614 | N=88, 64, 14%Age: NRSetting: High school | Prospective Cohort studyOutcome: Memory dysfunction | Significant: > 5 mins on-field mental status change (e.g., retrograde amnesia, anterograde amnesia or confusion)Not Significant: None | Approx. 7 days | 3 |
| Luoto (2016) Abstract | 28, 28, 0%Age: 26.4, SD=4.3, Range=NRSetting: Professional ice hockey | Prospective cohortOutcome: Prolonged recovery (>10 days) | Significant: Acute symptom severity, dizzinessNot Significant: acute symptom score, all other individual symptoms | 10 days | 3 |
| Maerlender (2015)[26230745](https://phstwlp2.partners.org:2052/pubmed/26230745) | N=28, 28, 71%Age: NRSetting: University | Prospective Cohort studyOutcome: Symptom resolution | Significant: NoneNot Significant: Exercise during recovery | 2 weeks | 3 |
| Majerske (2008)18523563 | N=95, 95, 16%Age: M=15.88, SD=1.35, Range=13-18Setting: University medical center | Retrospective cohort studyOutcome: Cognition, symptom reporting | Significant: Activity level (high=worse; moderate=best), age (younger= worse), Sex (female), return to play timeNot Significant: Concussion grade, prior concussions, sport | Until recovered; 33 days maximum | 3 |
| Makdissi (2010)20194953 | N=1,015, 78, 0%Age: Median=22, SD=NR, IQR=19-24, Range=NRSetting: Elite and community-based | Prospective Cohort StudyOutcome: Return to Play | Significant: ≥ 4 acute symptoms, headache lasting ≥ 60 hours, self-reported “fatigue/fogginess”Not Significant: Acute confusion; acute memory disturbance; LOC, amnesia, sleep disturbance, nausea, visual disturbance, dizziness; cognitive deficit; self-reported concussive history; Level of play (elite senior, elite junior, community level); Headache: absent; present 24-60 hrs; 1-3 acute symptoms  | Mean RTP ~5 days (range not reported) | 3 |
| Master (2016)Abstract | 274, 274, NRAge: Median=14, Range=3-18Setting: Clinic | Cohort studyOutcome: Symptomatic vs. Asymptomatic at day 28 post-injury | Significant: Vestibular ocular testing, vision problems (assessed at clinic visit at median 14 days following injury)Not Significant: None explicitly reported | 28 days (4 weeks) | 3 |
| Mautner (2015)[25353721](https://www.ncbi.nlm.nih.gov/pubmed/25353721) | N=2,041, 70, 38%, Age: M=15.5; 15.7, SD=NR, Range=13-18Setting: High school | Retrospective case control studyOutcome: Clinical recovery (symptoms, cognition) | Significant: NoneNot Significant: ADHD, Prior concussions | Unclear, but average was 16.5 days | 4 |
| Mayers (2013)[23686028](https://phstwlp2.partners.org:2052/pubmed/23686028) | N=95, 95, 31%Age: M=19.8, SD=2.1, Range=18-30Setting: University | Observational cohort studyOutcome: Symptom duration and return to play | Significant: NoneNot Significant: Gender | Unclear for RTP | 3 |
| McCrea (2002)11950406 | N=3,581, 91, NR (but examined football)Age: M=Injured 17.52, SD= Injured 2.1, Range=NRSetting: High School and University | Prospective cohort studyOutcome: Cognitive outcome at 48 hours | Significant: None Not Significant: LOC and PTA | 2 days; 90 days | 3 |
| McCrea (2009)[19834399](https://www.ncbi.nlm.nih.gov/pubmed/19834399) | N=635, 635, 11.5%Age: M=17.49, SD=1.62, Range=NRSetting: High school and University | Inception cohort studyOutcome: Clinical outcomes (cognition, balance, SAC) | Significant: NoneNot Significant: Symptom free waiting period | 90 days | 2 |
| McCrea (2013)[23058235](https://www.ncbi.nlm.nih.gov/pubmed/23058235) | N=736, 570, 11.1%Age: M= typical recovery 17.5; prolonged 17.0; control 17.495% CI= 17.3-17.7 typical; 16.4-17.7 prolonged; 17.1-17.7 controlsSetting: High school and collegiate | Retrospective study with repeated measures assessments Outcome: Recovery < or > 7 days on BESS, GSC, SAC | Significant: LOC, retrograde amnesia, post-traumatic (anterograde) amnesia, initial symptom burden (immediate and at Day 1 post-injury), time withheld from play, time symptom free before return to sportsNot Significant: Age, gender, mechanism of injury, concussion history, level of competition, position on field, height, weight, SAC score, balance score (BESS) | 90 days | 4 |
| McDevitt (2011)[21902461](https://www.ncbi.nlm.nih.gov/pubmed/21902461) | N=96, 48 (history of concussion), NRAge: M=19.46; 19.44, SD=1.42; 1.34, Range=NRSetting: NCAA University data | Retrospective case control studyOutcome: Return to play (in days) | Significant: NoneNot Significant: Gene (NEFH polymorphism) | Mean=11 days, SD=15 | 4 |
| McDevitt (2015)[26502998](https://www.ncbi.nlm.nih.gov/pubmed/26502998) | N=87, 87, 26%Age: M=19.47, SD=6.02, Range=NRSetting: Hospital concussion program | Case series studyOutcome: Prolonged recovery (greater than 60 days) | Significant: Gene (GRIN2A long-long allele)Not Significant: Age, sex, race, prior concussions, and history of migraine; Initial symptoms = acute dizziness, acute balance issues, LOC | Many months | 4 |
| Meehan (2010)[20716683](https://www.ncbi.nlm.nih.gov/pubmed/20716683) | N=544, 544, NRAge: M=NR, SD=NR, Range=13-18Setting: High school  | Descriptive epidemiological (inception cohort) studyOutcome: Time to symptom resolution/recovery | Significant: Athletes who had post-injury neurocognitive testing were less likely to RTP within one week than those who had not been tested.Not Significant: Age | Greater than one month following injury | 2 |
| Meehan (2013)[23628374](https://phstwlp2.partners.org:2052/pubmed/23628374) | N=182, 182, 36%Age: M=15.2, SD=3.04, Range=7.6-26.7Setting: Clinic | Prospective cohort studyOutcome: Prolonged recovery (> 28 days vs. less than 28 days) | Significant: Early symptom burdenNot Significant: Age, amnesia, sex, LOC, concussion history, previous headache treatment, migraine history, family history of concussion | 28 days  | 3 |
| Meehan (2013)23727697 | N=486, 486, 37%Age: M=15.5, SD=3.5, Range=NRSetting: Clinic | Case-Control StudyOutcome: Symptom burden | Significant: Prior undiagnosed concussionNot Significant: None | Not mentioned | 4 |
| Meehan (2014)[25381296](https://phstwlp2.partners.org:2052/pubmed/25381296) | N=531, 531, 38%Age: M=14.6, SD=2.9, Range=7-26Setting: Clinic | Prospective cohortProlonged recovery (> 28 days vs. less than 28 days) | Significant: Early symptom burden, cognitive test scores at initial visit, amnesia, prior headache treatment, concussion history (binary), Not Significant: age, sex, LOC, history of migraines, family concussion history, number of concussions | 28 days | 3 |
| Merritt2015[25685959](https://phstwlp2.partners.org:2052/pubmed/25685959) | N=54, 54, 15%Age: M=19.89, SD=1.41, Range=NRSetting: University | Case-control studyOutcome: PCSS score (High >2; Low ≤2) | Significant: Early symptom burden, acute headachesNot Significant: LOC, PTA, retrograde amnesia, acute dizziness, acute fogginess, acute visual disturbance  | 1 week | 4 |
| Merritt (2016)[26483005](https://phstwlp2.partners.org:2052/pubmed/26483005) | N=42, 42, 17%Age: M=19.93; 20.00, SD=1.39; 1.59, Range=NRSetting: University | Case-control studyOutcome: Symptom reporting (total score) | Significant: Gene (APOE-E4)Not Significant: None | Average=10 days, range=0-72 | 4 |
| Mihalik (2005)15926709 | N=261, 261, 19%Age: M=16.36, SD=2.6, Range=NRSetting: High school and university | Prospective cohort studyOutcome: Cognition, Symptom reporting (total score) | Significant: Post-Traumatic Migraine (worse cognition, higher total symptom score). Headaches: (higher symptom total)Not Significant: None | Average=4 days, SD=6 days | 2 |
| Mihalik (2007)17227375 | N=180, 180, 31%Age: M=16.51, SD=3.02, Range=NRSetting: University | Cohort studyOutcome: Clinical recovery (cognition, symptoms) | Significant: NoneNot Significant: Mouthguards | 3 days, SD=6 | 3 |
| Mihalik (2013)23696213 | N=296, 296, 19%Age: M=16.7, SD=1.9, Range=NRSetting: SRC assessment program | Prospective cohort studyOutcome: Symptom reporting (total score); development of posttraumatic migraine; balance (BESS) | Significant: Acute migraine-like headaches associated with greater symptoms at 7 days following injury; females were more likely to have acute migraineNot Significant: Acute headache not associated with worse 7-day outcome | 7 and 90 days | 2 |
| Miller (2016)26684762 | N=294, 294, 23%Age: M=13.7; 12.6, SD=2.5; 2.5, Range=6-18; 4-18Setting: Clinic | Case-control study (2 subgroups analyzed separately)Outcome: Prolonged Recovery (>28 days) | Significant: Patients with SCAT 2: Sex (female), prior concussions, SCAT score <80, low SCAT score, nonhelmet sport, SCAT symptom severity, LOC. Patients without SCAT: Sex (female), ADHDNot Significant: Patients with SCAT2: Age, ADHD, preinjury history of migraines, loss of balance, age. Patients without SCAT2: age, history of migraines, prior concussion, LOC, loss of balance, nonhelmet sport | 28 days | 4 |
| Moor (2015)25883871 | N=56, 56, 46%Age: M=15.15, SD=1.73, Range=12-19, Setting: Clinic | Cohort studyOutcome: Return to play | Significant: NoneNot Significant: Adherence to specific rest-based treatment recommendations, Gender, Number of prior concussions, initial symptom burden, level of competition | RTP mean=47 days, range 9=212 days | 3 |
| Morgan (2015)25745949 | N=120, 40, 51%Age: M=PCS 14.9; control 14.8, SD=2.1; 2.0, Range=NRSetting: Database, high school | Retrospective case-control studyOutcome: Development of PCS | Significant: Prior concussions, prior mood disorder, prior psychiatric illness, family history of mood disorder, family history of psychiatric disorder, family migraine history, delayed symptom onset (asymptomatic >3 hrs), significant stressorsNot Significant: Age, race, sex, type of insurance, sport played, BMI, migraine history, ADHD, LD, acute symptoms, subacute symptoms, LOC, neck pain, amnesia, use of pain medication, initial consultation with healthcare provider, helmet | PCS diagnosis made at 3 months | 4 |
| Nelson (2016)[26974186](https://www.ncbi.nlm.nih.gov/pubmed/26974186) | N=771, 621, 10%% female is based off #s in table.Age: M=HSI 16.4; HSC 16.24; CI 19.72; CC19.27, SD=.99; .73; 1.47; 1.46, Range=NRSetting: High school and university | Prospective cohort studyOutcome: Clinical recovery (symptoms, cognition, and balance) | Significant: Number of prior concussions related to symptom reportingNot Significant: LOC, posttraumatic amnesia, Age (high school vs. college), gender, sport played, years of play  | Recovery=1 week. Study=90 days  | 3 |
| Nelson (2016)27164666 | N=2,055, 127, 20%Age: NRSetting: High school and university | Prospective Cohort StudyOutcome: Symptom recovery | Significant: Acute symptom severity, Pre-injury and acute Brief Symptom Inventory-18 somatization scoreNot Significant: Age, Gender, Level of Play (HS vs. college), Sport played, Years of play, Headache history, Migraine history, LD, ADHD, Household SES, Estimated IQ, preinjury symptom severity, preinjury /acute depression (BSI-18), preinjury /acute anxiety (BSI-18), preinjury /acute cognition ImPACT), preinjury /acute balance (BESS), LOC, PTA, Retrograde amnesia, satisfaction with life scale | Approximately 1 week for most patients; follow-up continued to 45 days  | 3 |
| Ono (2016)[26672026](https://phstwlp2.partners.org:2052/pubmed/26672026) | N=176, 176, 23%Age: M=NR, SD=NR, Range=NRSetting: Middle and high schools | Prospective Cohort StudyOutcome: Total symptom score | Significant: None. Not Significant: Females report more symptoms at all time points but the rate of recovery did not differ by sex. | Approx. 1 month | 3 |
| Pearce (2015)[26453625](https://phstwlp2.partners.org:2052/pubmed/26453625) | N=78, 78, 42%Age: M=14.31, SD=2.77, Range=9-24Setting: Clinic | Prospective, Cross-sectional StudyOutcome: Cognition and symptoms | Significant: Convergence Insufficiency (Near Point Convergence > 5cm)Not Significant: None | Mean=6 days, SD=6 days | 3 |
| Pellman (2004)[15509317](https://www.ncbi.nlm.nih.gov/pubmed/15509317)(Part 5) | N=68, 68, 0%Age: M=27.6, SD=3.6, Range=NRSetting: Professional | Prospective cohort studyOutcome: ≥ 7 days out of play (vs. < 7 days) | Significant: LOC ≥ 1 minute, quarterback, passing play, not oriented to time, LOC, retrograde amnesia, acute fatigue, acute personality change, acute fatigue, acute sleep disturbance, acute photophobia, acute immediate recall, acute memory, the total number of acute signs/symptoms, action taken (removal from play, hospitalized)Not Significant: Nausea, vomiting, neck pain, back pain, syncope, seizures, acute irritability, acute anxiety, acute depression, acute loss of libido, acute loss of appetite, dizziness, vertigo, tinnitus, nystagmus, hearing loss, diplopia, blurred vision, pupil response, pupil size | 7 days (though RTP was 0-98 days; only 8% were >7 days) | 3 |
| Pellman (2004)[15574211](https://www.ncbi.nlm.nih.gov/pubmed/15574211)(Part 6) | N=95, 95, 0%Age: M=NFL 25.4; collegiate 20.4, SD=NR, Range=NFL 20-44Setting: Professional | Prospective cohort studyOutcome: Cognition (at 1 day); Return to play (>7 days vs. < 7 days) | Significant: Those with on-field memory deficits had lower acute (1 day) neuropsychological test scores compared to those without on-field memory dysfunctionNot Significant: Prior concussions (3 or more vs. fewer than 3) was not associated with cognition at 1 day post injury; Return to play > 7 days was not associated with acute neuropsych (1 day post injury) when compared to players who returned in 7 days or less | Mean=1.3 days, Range= 1-9; 7 day cutoff for RTP | 3 |
| Pellman (2006)[16462480](https://www.ncbi.nlm.nih.gov/pubmed/16462480)(part 12) | N=193, 193, 0%Age: M=Pro 26.3; HS=15.8, SD=NR, Range= Pro 20-33; HS 13-18Setting: Professional and High School sports | Prospective Sample of convenience within a cohortOutcome: Cognition | Significant: Level of competition (High School athletes slower to recover to baseline neuropsychological performance level)Not Significant: Prior concussions | 7 days | 2 |
| Preiss-Farzenagan (2009)[19627902](https://phstwlp2.partners.org:2052/pubmed/19627902) | N=215, 215, 33%Ages: Adult sample and child/adolescent sample; Range=18-59; 18-56; 7-17; 4-17Setting: Emergency department | Prospective Nested cohort studyOutcome: Symptoms at 3 months following injury | Significant: Women more likely to have persistent symptoms than men. Adults more likely to have persistent symptoms than children. Not Significant: No sex differences in persistent symptoms in adolescents. | 3 months | 2 |
| Prichep (2013)[22588360](https://phstwlp2.partners.org:2052/pubmed/22588360) | N=65, 65, 0%Age: M=17.9, SD=NR, Range=15.1-23.2Setting: High school and university | Prospective cohort studyOutcome: Return to play; clinical recovery (cognition; balance; SAC, symptom reporting) | Significant: Moderate initial severity of concussion had worse acute symptoms, greater acute cognitive deficits, and longer RTP (compared to mild concussion)Not Significant: None | 45 days | 2 |
| Putukian (2016) Abstract | 208, 208, 19.7%Age: NRSetting: University | Prospective cohort studyOutcome: Days to symptom free and return to play | Significant: Acute symptom burden and slower measured reaction time and processing speed.Not Significant: Sex, prior concussions, LD, prior headaches/migraine, prior depression/anxiety, acute cognition (SAC), acute balance (M-BESS) | >3 weeks | 3 |
| Register-Mihalik (2007)17620782 | N=364, 247, NRAge: M=16.65, SD=1.87, Range=NRSetting: High school and university | Retrospective cohortOutcome: Symptom severity/ presence and cognition at 3 and 7 days post injury | Significant: Preseason baseline headache and acute post-injury headache were related to worse symptom outcome at 7 days (but not worse balance or cognition at 7 days) | 7 days  | 3 |
| Register-Mihalik (2009)18728571 | N=108, 108, 31%Age: M=18.8, SD=1.27, Range=NRSetting: University | Retrospective case-control studyOutcome: Balance in first few days following injury | Significant: Headache associated with worse balanceNot Significant: None | First few days following injury | 4 |
| Register-Mihalik (2016) Abstract | 179, 179, NRAge: Med=15, Range 8-18Setting: Family medicine clinics (3) | Prospective Cohort studyOutcome: Symptom presence at 1 month | Significant: Sex (female), initial visit symptom severity, worse verbal memory, processing speed, and reaction time at initial visitNot significant: None explicitly reported | 1 month | 3 |
| Resch (2015)[26565424](https://phstwlp2.partners.org:2052/pubmed/26565424) | N=76, 76, 33%Age: M=19.5, SD=1.65, Range=NRSetting: University | Cohort studyOutcome: Days of symptom reporting | Significant: Initial symptom burden, acute neck pain duration, acute drowsiness duration, acute nervousness duration, acute tingling durationNot Significant: 53 other predictors (not listed in paper) | Approximately 9 days (range: 2-31) | 3 |
| Slobounov (2007)17762746 | N=160, 38, 48%Age: M=m 20.95; fm21.42, SD=NR, Range=18-25Setting: University | Inception Cohort studyOutcome: Visual-kinetic integration | Significant: Prior concussion (1)Not Significant: None | 30 days | 3 |
| Sufrinko (2015)[25649087](https://phstwlp2.partners.org:2052/pubmed/25649087) | N=348, 348, 26%Age: M=17.43, SD=2.34, Range=14-23Setting: Middle school, high school, and University | Cohort studyOutcome: Clinical recovery (Cognition, symptom reporting) | Significant: Pre-injury sleep difficulties Not Significant: None | 14 days | 3 |
| Terwilliger (2016)[26421452](https://phstwlp2.partners.org:2052/pubmed/26421452) | N=42, 42, 48%Age: M=14.9, SD=.87, Range=13-16Setting: Clinic | Case-Control StudyOutcome: Symptom burden at 14 days; recovery time | Significant: Additional head impact within 24 hours of concussion; Age (younger=worse)Not Significant: Sex, LOC, Amnesia, Seizures, Prior concussion, headache history, depression/ anxiety/ ADHD history | 14 days | 4 |
| Vargas (2015)[25643158](https://phstwlp2.partners.org:2052/pubmed/25643158) | N=128, 84, 32%Age: M=18.4; 18.9, SD=.8; .9, Range=NRSetting: University | Case-control studyOutcome: Post-injury depression | Significant: Baseline depression, baseline symptoms, estimated IQ, age of sports enrollment (older=more depressed), games missed (less=worse depression) years in sports (fewer=more depressed), race (non-white=higher depression)Not Significant: Age, sex, alcohol use, marijuana use, prior concussions | Mean=7 days, SD=9 | 4 |
| Wasserman (2015)26546304 | N=1,670, 1,670, 32%Age: M=NR, SD=NR, Range=NRSetting: Epidemiological database | Descriptive epidemiological studyOutcome: Symptom reporting; long symptom resolution (>28 days); long return to play (>28 days)  | Significant: Those with prior concussions had longer symptom resolution times and RTP timesNot Significant: Sex was not clearly related to prolonged symptoms or prolonged RTP | >28 days | 3 |
| Yang (2015)[25649775](https://www.ncbi.nlm.nih.gov/pubmed/25649775) | N=71, 71, 25%Age: M=NR, SD=NR, Range=NRSetting: University | Prospective cohort studyOutcome: Depression and anxiety at one-week following injury | Significant: Football players, freshman, those with preseason depression symptoms, and those with post-injury anxiety had post-injury depression. Post-injury anxiety was predicted by preseason and post-injury depression symptoms.Not Significant: Sex, race | 1 week post injury | 3 |
| Zemek (2016) | N=2,584, 2,584, 39%Age: Median=12, IQR=9.2-14.6, Range=5-18Setting: Multiple pediatric emergency departments | Multicenter cohort studyOutcome: PCS at 1-month | Significant: Older age (13-18^ > 8-12^ > 5-7), Sex (female)^, prior concussions, prior concussion with great 1 week symptom duration^, migraine history^, LD, history of anxiety, history of depression, LOC, dazed/confused, answered questions slowly^, repeats questions, forgetful of recent information, parent reported increases in post-injury symptoms (headache^, noise sensitivity^, fatigue^), acute balance (BESS tandem stance ≥4 errors)^, neck tenderness, time between head injury and triage (> 16 hrs = worse outcome), prior treatment for headaches, previous sleep disorder, symptoms worsen with cognitive activity, SAC-C Orientation/Immediate Memory^These predictors were significant in the multivariable predictor model, too.Not Significant: Time since last concussion, ADHD, mechanism of injury, SCAT score, Glasgow Coma scale score, range of neck motion, less forceful blow than other concussions, family migraine history, other developmental disorder, “psychiatric disorder diagnosis,” LOC duration, post-injury seizure, symptoms worsen with physical activity, helmet use, mouth guard use, injury impact location, mandible impact, BESS double-leg stance errors, SAC-C Concentration, Digits backwards, delayed recall | 1 month | 2 |
| Zuckerman(2012)23030348 | N=80, 80, 50%Age: M=male 15.8; fm 15.9, SD=1.88; 1.75, Range=NRSetting: High school soccer database | Retrospective cohort studyOutcome: Cognition  | Significant: NoneNot Significant: Sex | 10 days | 3 |
| Zuckerman (2012)23227435 | N=200, 200, 47%Age: M=15.1; 19.1, SD=0.8; 1.2, Range=13-22Setting: High school and university | Prospective cohort studyOutcome: Cognitive and symptom return to baseline | Significant: Younger age had slower return to baseline (13-16yrs vs. 18-22yrs)Not Significant: None | About 7 days | 2 |
| Zuckerman (2014)24206343 | N=244, 244, 50%Age: M=male 16.2; fm 16.1, SD=2.1; 2.0, Range=NRSetting: Middle school, high school, university | Retrospective cohort studyOutcome: Symptom reporting (severity, total score, and return to baseline) | Significant: Sex (female) for total symptom score and return to baseline, but not symptom severityNot Significant: None | Until symptom resolution (females mean=9 days, SD=7) | 3 |
| Zuckerman(2015)25664998 | N=138, 138, 3%Age: Median=16; 16, 95% CI=15-16; 15-17Setting: Middle school, high school, and university | Prospective cohort studyOutcome: Cognition | Significant: NoneNot Significant: Helmet status | <10 days | 2 |
| Zuckerman (2016)27032916 | N=1,507, 1,507, 31.2%Age: M=NR, SD=NR, Range=NRSetting: University | Prospective cohort with case controlOutcome: PCS (symptoms persisting ≥ 4 weeks) compared to those with resolution of symptoms ≤ 2 weeks | Significant: Recurrent concussion, initial symptom burden, Specific symptoms; retrograde amnesia, difficulty concentrating, sensitivity to light, insomnia, PTA, excess irritability, nausea/vomiting, loss of balance, visual disturbance, sensitivity to noise, excess drowsiness, dizzinessNot Significant: Contact level, gender, LOC, helmet status, disorientation, headache, excessive excitability, tinnitus.  | 4 weeks | 3 |
| Zuckerman (2016) Abstract | 282 high school and collegiate athletesAge: Med=15.8 (range: 11.6-22.2)Setting Sport concussion center | Retrospective cohortOutcome: Symptom duration, days missed school, and days missed practice | Significant: Private insurance cases had fewer missed days of school.Not significant: Most socioeconomic status variables were not related to symptom duration or time loss. | NR | 3 |

Note: Each study labeled “Abstract” was presented at the Concussion in Sport Conference in Berlin in October of 2016. The abstracts will be published in the proceedings of the conference, in the British Journal of Sports Medicine. ADHD=Attention deficit hyperactivity disorder; BESS=Balance Error Scoring System; BDI-II=Beck Depression Inventory-2nd Edition; BMI=body mass index; BSI-18=Brief Symptom Inventory 18; CC=collegiate control; CI=collegiate injured; Div=division; ED=emergency department; fm=female; GCS=Glasgow Coma Scale; hs=high school; HSC=high school control; HIS=high school injured; ImPACT=Immediate Post-Concussion Assessment and Cognitive Test; IQ=intelligence quotient; IQR= Interquartile Range; LD=learning disorder; LOC=loss of consciousness; M=mean; m=male; Med=Median; M-BESS= Modified Balance Error Scoring System; NFL=National Football League; NR=not reported; PCS=Post-Concussion Syndrome/Post-Concussion Symptoms; PCSS=Post-Concussion Symptom Scale; Pro=Professional; PTA=post-traumatic amnesia; RPSQ=Rivermead Post-Concussion Symptom Questionnaire; RTP=return to play; SAC=Standardized Assessment of Concussion; SAC-C=Standardized Assessment of Concussion- Child version; SCAT=Sport Concussion Assessment Tool; SD=standard deviation; SSRI=Selective Serotonin Reuptake Inhibitor; Sx=Symptom; uni=university; yrs=years. The Iverson (2007) study and the four Lau studies appeared to use the same sample so their results for significant and nonsignificant predictors were presented only once in the text and tables in the present review.

**Search Strategy**: Eligible articles were retrieved via on-line database searching, hand-searching reference lists, and cited reference searches. The online databases of CINAHL, Cochrane Library, MEDLINE, MEDLINE in Process, EMBASE, PsycINFO, SPORTDiscus, Scopus, and Web of Science were searched. Keywords and combinations of these words were used to search the databases comprehensively.

sport

sports [MeSH])

athletic

athlete

player

AND

craniocerebral trauma

brain injuries

brain concussion

sports concussion

athletic injuries

mild traumatic brain injury

mTBI

traumatic brain injury

TBI

brain concussion

concussion

multiple concussions

repeated concussion

repetitive concussion

cumulative concussions

concussion history

brain damage

prognosis

outcome

recovery

risk factor

injury incidence

sex differences

gender

genetics

ApoE

BDNF

S100B

GFAP

severity

loss of consciousness

LOC

post-traumatic amnesia

PTA

amnesia

retrograde amnesia

seizure

seizures

learning disorder

ADHD

level of education

migraine

mental health

sleep disorders

medications

cervical injury

vestibular injury

psychological reactions

anxiety

depression

headaches

intractable headaches

magnetic resonance imaging

MRI

computer tomography

CT