

TABLE 1 Summary of concussion treatment guidelines and recommendations^a

Problem	Assessment	Treatment	Specialists with training in assessment and/or treatment
Overall recovery, return to sports/school/work	Standardized symptom checklist	Sleep hygiene, physical rest, cognitive rest	Sports medicine, physiatry
Headache	Determine headache type using IHS or ICHD II criteria	Headache persisting more than 3-4 d may require treatment tailored to phenotype (ie, migraine, tension-type, occipital neuralgia, etc)	Neurology
Cognitive function	Symptoms, cognitive testing, neuropsychologist evaluation	Sleep hygiene, cognitive rehabilitation	Neuropsychology, neurology, occupational therapy, speech therapy
Vestibular function/postural stability and gait	Dix-Hallpike test, Romberg test, dynamic standing, tandem gait	If Dix-Hallpike is normal, or if the Epley maneuver does not relieve symptoms, consider vestibular rehabilitation	Neurology, otolaryngology, physiatry, physiotherapy
Vestibular function/eye movements	Examine CN 3, 4, and 6 for tracking, saccades, diplopia, nystagmus	Vestibular rehabilitation	Neurology, otolaryngology, physiatry, physiotherapy
Near-vision function	Near-point accommodation and binocular convergence	Vision therapy	Ophthalmology, optometry

Abbreviations: CN, cranial nerve; ICHD II, International Classification of Headache Disorders II; IHS, International Headache Society.

^aGuidelines summarized include 5th International Conference on Concussion in Sports,⁷ Veterans Administration/Department of Defense,⁸ American Medical Society for Sports Medicine,⁹ Canadian Guidelines,¹⁰ Ontario Neurotrauma Foundation,¹² and American Academy of Neurology Guidelines.¹¹

with broad training could screen each patient for the common concussion problems and then refer “off-site” to the appropriate specialist team member for a detected problem. This model is efficient and practical for the initial concussion specialist but not for the patient, who may be required to travel to multiple locations for follow-up appointments with various specialists on the team. Several authors have described multidisciplinary clinics using this model.^{19,24,25} Yet, a third option is to have select specialists “embedded” in the clinic who can be called on to evaluate a patient when a problem is detected. This option is attractive but requires knowledge of the key specialists that are most likely to be needed for the particular patient population of the clinic. This option may also be difficult to operationalize, as embedded providers may not always be required for each patient and have no way to generate income if they are not seeing patients.

Research investigating the effectiveness of multidisciplinary clinics on concussion outcomes is in its infancy. Janak et al²⁶ reported a reduction in postconcussive symptoms among 257 active duty military service members with concussion undergoing multidisciplinary treatment; however, there was no comparison to a control group. Vikane et al²⁷ studied 151 concussed adults with symptoms greater than 2 months and found those randomized to multidisciplinary concussion care had fewer postconcussive symptoms 12 months after injury but a similar number of days to return-to-work as those treated by a general practitioner. Interesting as these studies are, they leave many questions unanswered. What is the best structure for a multidisciplinary clinic? Do nonathlete patients require a different clinic structure than athletes? Are patient outcome affected by provider type, such as physician versus nonphysician, or neurologist versus sports medicine? Are there certain team members that should be embedded on-site and others who are more appropriately accessed off-site? Should all team members agree on collecting a standard set of history and physical examination elements? If so, what should these elements be?

This topical issue on multidisciplinary concussion care features studies focused on the use of specialist teams to provide outpatient treatment for this injury. The first series of articles highlights the provision of concussion care from the perspective of the specialist team. Bailey and colleagues²⁸ report the added value of sub symptom threshold exercise therapy on overall recovery to multidisciplinary care provided by sports medicine and primary care concussion specialists. This study also describes the important role of the neuropsychologist in the multidisciplinary care team. Scratch and colleagues²⁹ describe their experience with an interdisciplinary concussion clinic model. Interdisciplinary care is often considered a variation of multidisciplinary care in which

team members collaborate to work directly with the patient, their caregivers, and family members to assess their needs and develop a treatment plan.³⁰ In this study, interdisciplinary team members included physicians (neurologist and developmental pediatricians), nurse, occupational therapist, physiotherapist, social worker, neuropsychologists, and a team intake coordinator. In a multidisciplinary sports concussion clinic, Kontos and colleagues³¹ identified 5 pre- and postinjury factors associated with more prolonged recovery among concussed athletes: younger than 18 years, female sex, history of migraine, posttraumatic migraine symptoms, and high postconcussive symptom burden. Interestingly, the authors detected a significant relationship between the number of factors and the delay in recovery. Finally, Lee and colleagues³² describe the unique features of multidisciplinary concussion care provided to military service members by the Department of Defense and Veterans Administration. These include a residential treatment program (University Model), a 5-week outpatient treatment program (Return to Forces initiative), and a 3- to 12-week inpatient treatment program (Post Deployment Rehabilitation and Evaluation Program). These

programs are highly interdisciplinary and treat patients in groups, rather than individually, to leverage the group dynamic of support and encouragement fostered by military training.

The final 3 articles in the issue are from the perspective of a single discipline—physician, neuropsychologist, and occupational therapist. Haider and colleagues present their approach to the physical exam of the concussed patient, including the use of sub threshold exercise testing.³³ The studies by Baker and Harris highlight the positive impact of the neuropsychologist and occupational therapist, respectively, on multidisciplinary concussion care.^{34,35} In sum, this topical issue brings to light the different ways in which medical teams can coordinate and organize to provide care for an injury that is increasingly understood as complex and multifaceted. Recognizing that access to resources such as university-based specialists varies widely across the United States, these articles provide practical options for tailoring a multidisciplinary concussion clinic based on local resources. Finally, these studies provide a solid foundation on which future research into the effectiveness of multidisciplinary concussion care can be based.

REFERENCES

- Langlois JA, Rutland-Brown W, Wald MM. The epidemiology and impact of traumatic brain injury: a brief overview. *J Head Trauma Rehabil.* 2006;21:375–378.
- Centers for Disease Control and Prevention. *Report to Congress. Traumatic Brain Injury in the United States: Epidemiology and Rehabilitation.* Atlanta, GA: National Center for Injury Prevention and Control; 2015.
- Barlow KM. Postconcussion syndrome: a review. *J Child Neurol.* 2016;31:57–67.
- Zemek R, Barrowman N, Freedman SB, et al. Clinical risk score for persistent postconcussion symptoms among children with acute concussion in the ED. *JAMA.* 2016;315(10):1014–1025.
- Babcock L, Byczkowski T, Wade SL, Ho M, Mookerjee S, Bazarian JJ. Predicting postconcussion syndrome after mild traumatic brain injury in children and adolescents who present to the emergency department. *JAMA Pediatr.* 2013;167(2):156–161.
- Association of Blue Cross & Blue Shield. The steep rise in concussion diagnoses in the U.S. <https://www.bcbs.com/about-us/capabilities-initiatives/health-america/health-of-america-report/steep-rise-concussion>. Published September 27, 2016.
- McCroly P, Meeuwisse W, Dvorak J, et al. Consensus statement on concussion in sport—the 5th International Conference on Concussion in Sport held in Berlin, October 2016. *Br J Sports Med.* 2017;51(11):838–847.
- Management of Concussion/mTBI Working Group. VA/DoD clinical practice guideline for management of concussion/mild traumatic brain injury. *J Rehabil Res Dev.* 2009;46(6):CP1–CP68.
- Harmon KG, Drezner JA, Gammons M, et al. American Medical Society for Sports Medicine position statement: concussion in sport. *Br J Sports Med.* 2013;47:15–26.
- Marshall S, Bayley M, McCullagh S, et al. Updated clinical practice guidelines for concussion/mild traumatic brain injury and persistent symptoms. *Brain Inj.* 2015;29(6):688–700.
- Giza CC, Kutcher JS, Ashwal S, et al. Summary of evidence-based guideline update: evaluation and management of concussion in sports: report of the Guideline Development Subcommittee of the American Academy of Neurology. *Neurology.* 2013;80(24):2250–2257.
- Ontario Neurotrauma Foundation. Guidelines for Mild Traumatic Brain Injury and Persistent Symptoms. http://onforg/system/attachments/60/original/Guidelines_for_Mild_Traumatic_Brain_Injury_and_Persistent_Symptoms.pdf. Published 2012.
- Collins MW, Kontos AP, Reynolds E, Murawski CD, Fu FH. A comprehensive, targeted approach to the clinical care of athletes following sport-related concussion. *Knee Surg Sports Traumatol Arthrosc.* 2014;22(2):235–246.
- McCarthy M, O'Hara R. How physicians are managing concussions in Connecticut. *Conn Med.* 2010;74(8):485–487.
- Carl RL, Kinsella SB. Pediatricians' knowledge of current sports concussion legislation and guidelines and comfort with sports concussion management: a cross-sectional study. *Clin Pediatr (Phila).* 2014;53(7):689–697.
- Bazarian JJ, Veenema T, Brayer AF, Lee E. Knowledge of concussion guidelines among practitioners caring for children. *Clin Pediatr (Phila).* 2001;40(4):207–212.
- Taylor AM, Nigrovic LE, Saillant ML, et al. Trends in ambulatory care for children with concussion and minor head injury from Eastern Massachusetts between 2007 and 2013. *J Pediatr.* 2015;167(3):738–744.
- Bock S, Grim R, Barron TF, et al. Factors associated with delayed recovery in athletes with concussion treated at a pediatric neurology concussion clinic. *Childs Nerv Syst.* 2015;31(11):2111–2116.
- Wilkins SA, Shannon CN, Brown ST, et al. Establishment of a multidisciplinary concussion program: impact of standardization on patient care and resource utilization. *J Neurosurg Pediatr.* 2014;13(1):82–89.

20. Polinder S, Cnossen MC, Real RG, et al. A multidimensional approach to postconcussion symptoms in mild traumatic brain injury: a focused review. *Front Neurol.* 2018;9:1113.
21. Reed N, Murphy J, Dick T, et al. A multi-modal approach to assessing recovery in youth athletes following concussion. *J Vis Exp.* 2014;91:51892.
22. Ellis MJ, Ritchie L, Selci E, et al. Googling concussion care in the USA: a critical appraisal of online concussion healthcare providers. *Concussion.* 2017;2(2):CNC33.
23. Chamberlain-Salaun J, Mills J, Usher K. Terminology used to describe health care teams: an integrative review of the literature. *J Multidiscip Healthc.* 2013;6:65–74.
24. Reynolds E, Collins MW, Mucha A, Troutman-Ensecki C. Establishing a clinical service for the management of sports-related concussions. *Neurosurgery.* 2014;75(suppl 4):S71–S81.
25. Ellis MJ, Ritchie LJ, McDonald PJ, et al. Multidisciplinary management of pediatric sports-related concussion. *Can J Neurol Sci.* 2017;44(1):24–34.
26. Janak JC, Cooper DB, Bowles AO, et al. Completion of multidisciplinary treatment for persistent postconcussive symptoms is associated with reduced symptom burden. *J Head Trauma Rehabil.* 2017;32(1):1–15.
27. Vikane E, Hellström T, Røe C, Bautz-Holter E, Aßmus J, Skouen JS. Multidisciplinary outpatient treatment in patients with mild traumatic brain injury: a randomised controlled intervention study. *Brain Inj.* 2017;31(4):475–484.
28. Bailey C, Meyer J, Briskin S, et al. Multidisciplinary concussion management: a model for outpatient concussion management in the acute and post-acute settings. *J Head Trauma Rehabil.* 2019;34(6):375–384.
29. Scratch SE, Rummey P, Agnihotri S, Reed N. Pediatric concussion: managing persistent symptoms with an interdisciplinary approach. *J Head Trauma Rehabil.* 2019;34(6):385–393.
30. Jessup RL. Interdisciplinary versus multidisciplinary care teams: do we understand the difference? *Aust Health Rev.* 2007;31(3):330–331.
31. Kontos AP, Elbin RJ, Sufrinko A, Marchetti G, Holland CL, Collins MW. Recovery following sport-related concussion: integrating pre- and postinjury factors into multidisciplinary care. *J Head Trauma Rehabil.* 2019;34(6):394–401.
32. Lee KM, Greenhalgh WM, Sargent P. Unique features of the US Department of Defense multidisciplinary concussion clinics. *J Head Trauma Rehabil.* 2019;34(6):402–408.
33. Zasler N, Haider MN, Grzibowski NR, Jeddy JJ. Physician medical assessment in a multidisciplinary concussion clinic. *J Head Trauma Rehabil.* 2019;34(6):409–418.
34. Baker JG, Willer BS, Leddy JJ. Integrating neuropsychology services in a multidisciplinary concussion clinic. *J Head Trauma Rehabil.* 2019;34(6):419–424.
35. Harris MB, Rafeedie S, McArthur D, et al. Addition of Occupational Therapy to an Interdisciplinary Concussion Clinic Improves Identification. *J Head Trauma Rehabil.* 2019;34(6):425–432.