

Optometric Management of Concussion in Canadian Private Practice

Anne Marie Yeboah, MSc,
Kristine Dalton, OD, MSc, PhD,
MCOptom, FAAO, FBCLA,
Elizabeth Irving, OD, PhD

University of Waterloo,
Waterloo, Ontario, Canada

Abstract

PURPOSE

The purpose of this study was to determine the current prescribing and assessment practices of optometrists in Canada seeing patients with persistent concussion-associated vision deficits.

METHODS

A 6-question electronic survey was distributed to provincial and national boards of optometry in Canada. Questions pertaining to vision assessment, prescribing habits, daily living advice, appointment duration and follow-up appointment(s) were included. Practicing optometrists in Canada who have or have not managed concussion patients were eligible to complete the survey. Analysis consisted of categorizing and analyzing the frequency of the responses.

RESULTS

A total of 199 responses were received, of which 142 were complete (including 1 blank response). Of these, 13 optometrists indicated that they did not manage concussion.

Of the 128 optometrists who indicated that they had managed concussion, 98% performed a full eye exam. Visual acuity was assessed 96% of the time. Other frequent assessments were dry refraction 91%, pupil dilation 80%, and full binocular vision 78%.

Most respondents (n=116) indicated that they provided advice on daily living activity, and the most frequent advice was to limit activity (74/116, 64%).

One hundred twenty one optometrists gave a response regarding appointment duration. Most frequently, optometrists stated that concussion appointments lasted 30-60 minutes (69/121). One hundred nineteen optometrists gave a response regarding follow-up, which was most frequently 1-2 months (27/119).

CONCLUSION

These results provide insight into how optometrists in private practice manage vision deficits following concussion. Further research on the effectiveness of treatment will be required to develop an optometric protocol for the management of vision in patients with persistent concussion symptoms.

KEY WORDS:

Concussion, visual deficits, management, optometry, private practice

INTRODUCTION

Concussions are a significant public health concern. Each year an estimated 42 million individuals experience mild Traumatic Brain Injury (mTBI) worldwide.¹ Many individuals with concussion develop visual symptoms.² Optometrists play a prominent role in the management of patients with concussion-associated vision deficits and persistent concussion symptoms. At present, there is no consistent standard of care for individuals with these types of injuries.

Concussion is a type of mTBI that arises from acute impact to the brain.³ Acute impacts to the brain can occur when the brain is jarred against the skull, resulting in an adverse change in the brain's chemical status.⁴ The most common causes of mTBI are falls and motor vehicle accidents.⁵ Other causes include sports-related accidents or strikes by/against an object.⁶ While concussions typically resolve within four weeks in children and 10-14 days in adults, concussion symptoms can persist in up to 30% of individuals, resulting in prolonged concussion recovery, also known as persistent concussion symptoms.⁷

Concussions cannot be detected with conventional clinical neuroimaging techniques and are thought to be caused by metabolic disturbances in the brain.⁸ Consequently, the diagnosis and management of concussions is still based on patient symptoms. Concussion symptoms typically fall under four main categories: cognitive, emotional, sleep, and physical.^{3,7,9} Visual deficits are considered physical symptoms. It has been reported that up to 90% of individuals with TBI (including concussion) suffer from visual deficits.¹⁰ In 2007, Ciuffreda et al.¹¹ found that up to 90% of individuals with traumatic brain injury suffer from oculomotor dysfunction, and in 2018, 88% of children with concussion were found to have vision or vestibular deficits.¹² Common concussion-associated vision deficits include, but are not limited to light sensitivity, visual discomfort, convergence insufficiency, ocular motility issues and decreased visual acuity.^{13,14}

Visual deficits also appear to be predictive of prolonged concussion recovery or persistent concussion symptoms. A retrospective study by Master et al.¹² in 2018 examined a cohort of pediatric patients experiencing concussion. Time to clinical recovery was the main outcome measure and issues with balance, smooth pursuits, vestibulo-ocular reflex (VOR), and accommodative amplitude were found to be predictors of a prolonged recovery time.

Optometrists can play an essential role in the management and recovery of visual deficits following concussion, but there are still challenges in the optometric management of concussion. Clinicians have reported pseudomyopia following traumatic brain injury and have documented a dilemma in deciding whether to re-establish baseline refractive error or prescribe lenses.¹⁴ A pilot investigation found that spectacle correction focusing on improving near tasks in concussed patients reduced symptoms in 50% of patients.¹⁵ It is also possible that undiagnosed conditions, such as uncorrected astigmatism or latent hyperopia, that are asymptomatic prior to injury, may impair a patient's ability to cope following injury. While correcting refractive error in post-concussion patients may be an effective treatment for concussion-associated vision deficits, it is unknown how refractive error corrections are used in the management of post-concussion patients.

Currently, there is no recognized consistent optometric standard of care for individuals with these types of injuries. In 2016, Ciuffreda et al.¹³ found that eye care practitioners selected "relatively low-yield" visual assessments (i.e., visual acuity and refractive correction at distance) resulting in the concealment of visual deficits following traumatic brain injury. The purpose of this study was to determine the current assessment and prescribing practices of optometrists who manage post-concussion patients. The results of this study may provide important insight into how Canadian optometrists in private practice are managing concussion.

METHODS

Study design

A 6-question online survey investigating the assessment and prescribing practices of optometrists seeing individuals with concussion symptoms was built and managed on REDCap, an electronic data capture tool, hosted at the University of Waterloo.¹⁶ Questions pertaining to vision assessment, prescribing habits, daily living advice, appointment duration and scheduling of follow-up appointment(s) were included, and participation took approximately 5-10 minutes. The study received ethics clearance from the University of Waterloo's Research Ethics Office.

Upon opening the survey, participants were taken to an information link followed by consent to participation and a request for use of anonymous quotations. If respondents consented to participation, the survey instrument appeared and, after completion, an appreciation note was presented. If consent was not provided, an appreciation note appeared and the survey would come to an end. In the case that respondents no longer wanted to participate in the study, they could exit the web browser. The survey was administered anonymously, participants were not asked for any identifying information, and IP addresses were not stored.

Subjects and recruitment

Practicing optometrists in Canada who had or had not managed patients with visual deficits following concussions were eligible to complete the survey. An email was sent to the provincial and national boards and colleges of optometry in Canada asking them to distribute the survey to their members on behalf of the researchers. Attached was a

recruitment letter with a link to either an English or French version of the survey. The purpose of this study was to understand the current concussion practice patterns of optometrists, and therefore other eye-care practitioners, such as ophthalmologists and opticians, were excluded from participation in this study.

Analysis

Data were compiled in REDCap and analyzed. This consisted of categorizing verbal responses and analyzing the frequency of responses provided.

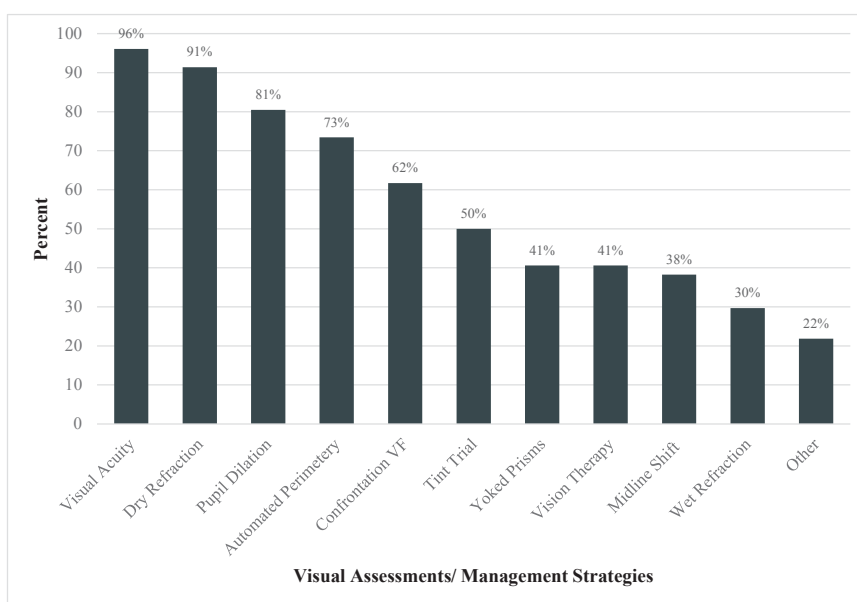
Results

A total of 199 surveys were started, and 142 of these were submitted. Although REDCap received responses that were not submitted, only those that were submitted were included in the data analysis. These were considered to be complete responses. Of the 142 submitted responses, 128 optometrists had managed concussion, 13 had not, and 1 response was blank.

Thirteen optometrists (10% of respondents) indicated that they did not manage concussion. The top reason provided for this was referral (31%), followed by lack of training (23.08%), “limited practice” (23.08%), no reason provided (15.38%), and watchful waiting (7.69%). “Limited practice” refers to optometry clinics that do not offer all services, including concussion management. Some responses included in this category were optometry clinics that did not specialize in concussion management or that did not have an interest in concussion management.

The frequencies of various visual assessments conducted by optometrists who manage concussion are shown in Figure 1. Of the 128 optometrists who indicated that they managed concussion, 98% reported performing a full eye examination and 78% reported conducting a full binocular vision assessment. The three tests most frequently performed were visual acuity (96%), dry refraction (91%), and pupil dilation (80%). Only 30% of optometrists reported performing a cycloplegic refraction.

Figure 1: Frequency of various types of visual assessments and management strategies reported by 128 optometrists. Confrontation VF, Confrontation Visual Field. ‘Other’ tests included syntonics, imaging (i.e., Optical coherence tomography and Optomap), dry eye assessment, VOR (vestibulo-ocular reflex) testing and non-optometric recommendations (i.e., diet change, postural change and counselling).



A minority of the respondents (n=26) recommended supplements, and the most commonly recommended supplement was Omega 3 (14/26). This was followed by other oral supplements (vitamins, minerals and herbal teas, 10/26), lubricating drops (6/26), pain medication (3/26) and topical steroids (loteprednol, 1/26). Water and ‘other’ (Tecamex) were suggested by 4% of optometrists who recommended supplements. The results regarding the optometrists’ recommendations on the management of activities of daily living are shown in Table 1. Most respondents

(n=116) indicated that they provided advice on activities of daily living and the most frequently given advice was to limit cognitive and physical exertion (74/116, 64%).

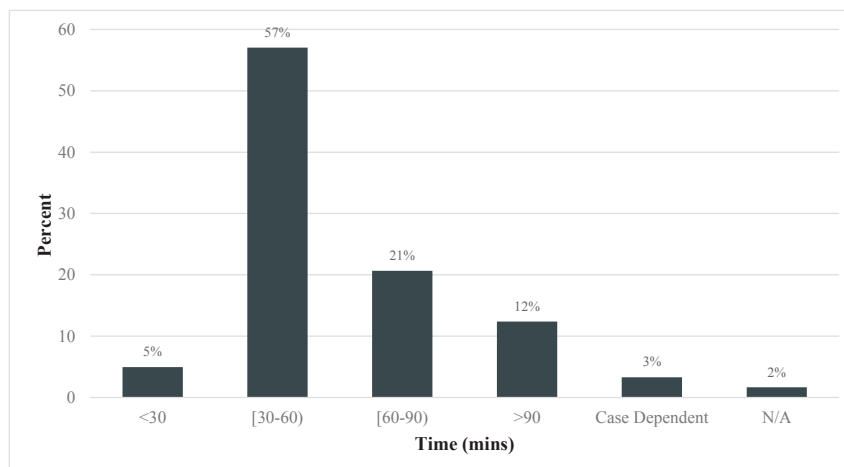
Table 1: Advice on activities of daily living. Responses from 116 optometrists.

Advice on Activities of Daily Living	N (%)
Limit	74 (64%)
Rest	14 (12%)
Case dependent	12 (10%)
Referred	9 (8%)
Watch/Be aware	7 (6%)
Follow specialist advice	7 (6%)
Tinted lenses	7 (6%)
Emotional support	5 (4%)
Educate/explain	3 (3%)
Positive health behavior	2 (2%)
Document symptoms	1 (1%)
Increase anti-inflammatory intake	1 (1%)
No advice	1 (1%)

Limiting exertion included responses such as to limit or moderate activity, increase gradually, do not overstimulate, reduce screen time, pacing and planning, minimize near work, minimize cognitive tasks and take breaks. Rest (12%) and ‘case dependent’ (10%) were the next most frequently reported pieces of advice on activities of daily living from optometrists.

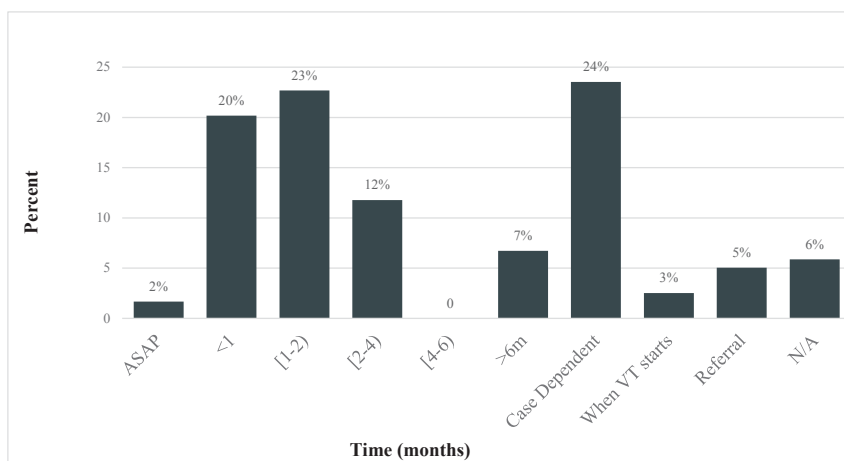
The responses offered by 121 optometrists on appointment duration are shown in Figure 2. Most frequently, optometrists stated that concussion appointments lasted 30-60 minutes (69/121). Less commonly (5%), optometrists indicated that appointments were less than 30 minutes (Figure 2).

Figure 2: Frequency of various appointment durations reported by 121 optometrists.



One hundred nineteen optometrists gave their responses regarding the scheduling of follow-up appointments (Figure 3). The most frequent response was 1-2 months (27/119). A long duration until follow-up appointments (up to 6 months after the initial appointment) was reported less often. Twenty-four percent of optometrists said that the timing of follow-up was case-dependent (Figure 3).

Figure 3: Frequency of scheduling follow-up appointments reported by 119 optometrists.



DISCUSSION

Clinical practice protocols are important in delivering quality health care because they facilitate effective diagnosis and management. Currently there are no standardized guidelines for the optometric management of concussion. This study compiles current concussion management practices by Canadian optometrists.

In this study, a proportion (9%) of optometrists did not manage concussion. The reasons given, including a lack of training (23%) and “watchful waiting” (8%), emphasize the need for protocols and training to provide optometrists with the guidance required for the optometric management of concussion.

Ciuffreda et al. proposed a 4-tiered conceptual pyramid of vision care for concussion. This model emphasizes the importance of comprehensively conducting assessments on each tier before proceeding to the next to avoid subsequent tests being “held in possible question and with uncertainty”.¹³ At the base of the pyramid, a basic vision examination encompasses refractive (including dry and/or cycloplegic refraction), binocular, and ocular health status. In agreement, a study by Master et al. emphasized the importance of conducting a comprehensive multidomain assessment for concussion sufferers.¹² It appears from our data that optometrists managing concussion are consistently completing the base level assessment, perhaps with the exception of cycloplegic refractions.

In the higher levels of the post-concussion vision care pyramid, Ciuffreda et al.¹³ recommend assessing oculomotor-based vision problems including those involving version, vergence, and accommodation. Their study found that prolonged concussion recovery in children can be predicted by vision and vestibular system dysfunction. Master et al.¹² also suggested that saccades, smooth pursuits, accommodative amplitude, and near point convergence be included in concussion assessments. Our study found that 98% and 78% of optometrists conduct a full eye exam and binocular vision exam, respectively. Both full eye exams and binocular vision exams incorporate oculomotor-based assessments. According to the Canadian Association of Optometrists, a full eye exam includes a case history, analysis of the patient’s visual needs, a visual acuity test, and assessments of refractive status, binocular vision, and ocular health.¹⁷ Common binocular vision assessments include tests of accommodation, vergence, ocular motility, and tracking. Binocular vision deficits identified with these assessments can often be managed through vision therapy.¹⁸ A study by Gallaway et al. found that 82% of concussion sufferers had oculomotor problems, most frequently accommodative issues, binocular problems, and deficits in eye movements.¹⁹ Vision therapy was suggested for the majority of patients (80%) and among the 54% who completed vision therapy, significant statistical and clinical changes were seen in positive fusional vergence, near point convergence, and accommodative amplitude. However, their study was limited by the absence of a control group.¹⁹ In our study, most optometrists conducted full eye exams

and binocular vision assessments, while only 41% used vision therapy, which may be the result of limited evidence on the efficacy of this treatment intervention. While different research groups have supported the efficacy of vision training in treating ocular motor deficits, more research on this management strategy is required.²⁰⁻²⁸ When applicable, vision therapy may be considered by optometrists as a management option for visual deficiencies.

The third level of the pyramid recommends examining “non-oculomotor” problems which includes assessments related to visual field processing, motion sensitivity, photosensitivity, visual field defects, and vestibular dysfunctions, which can manifest as visual symptoms like blur due to the close correlation between the vestibular and oculomotor systems, as observed in the vestibular-ocular reflex.²⁹ Our study showed that 73% of optometrists performed automated perimetry and 62% tested a confrontation visual field. However, other “non-oculomotor” assessments such as tint trials, yoked prisms, and visual midline shift assessments were conducted less commonly.

At the top of the pyramid, non-vision-based problems should be considered. These include assessments of cognitive impairment, behavioural issues, postural problems, neurological problems, attentional problems, fatigue, and depression.¹³

Our study revealed that the appointment duration for most optometrists (57%) is between 30 and 60 minutes, and for 5% the appointment lasts less than 30 minutes. Appointment duration largely depends on symptom severity and patient tolerance, as well as the number of tests conducted. A longer appointment may be required for highly symptomatic patients and /or to complete all of the recommended assessments.

Visual interventions suggested by Ciuffreda et al. include prisms, occluders, tints, near lenses, and vision therapy.^{13,30} In their review, Barton et al. expressed concerns regarding the use of occlusion, filters, prisms, and vestibular therapy due to limited evidence of their effectiveness in the literature.³¹ In contrast, a 2018 scoping review on vision rehabilitation treatment after concussion concluded that prisms, glasses, and vision and oculomotor therapy were promising interventions based on results from peer-reviewed literature generated from four electronic databases.³² Due to the limited available evidence on these interventions, additional research is required to determine their efficacy before guidelines for their use can be adopted.

The management of concussion concentrates largely on reducing symptoms to re-establish baseline function.³³ However, clinicians who only manage apparent symptoms may overlook assessments that reveal additional deficits (for example, by focusing on binocular vision problems and overlooking refraction or vice versa). It has been reported that some eye care practitioners select assessments that rarely lead to a definitive finding, like visual acuity, and miss some concussion-related deficits.¹³ In this study, most of the Canadian optometrists (78%) reported that they performed a full binocular vision assessment and some used a tint trial (50%), yoked prisms (41%), and vision therapy (41%) as management strategies.

Pharmacologic treatments can be administered for the management of specific symptoms and/or to alter the primary pathophysiology of an ailment. Currently, there are no specific pharmacotherapies for treatment in concussion and there is insufficient evidence on the effect of medical therapies for concussion to provide strong clinical recommendations for their use.^{7,34} In the present study, Omega-3 was the most recommended supplement by optometrists (14/26). While there are limited human studies proving the efficiency and efficacy of Omega-3 in concussion patients, DHA (docosahexaenoic acid), a type of Omega-3 fatty acid, has been reported to have the potential to improve cognition in concussed individuals.^{35,36} Animal-based research using rodents has found that Omega-3 protects against decreased plasticity, offers resistance to oxidative stress from concussion, and decreases the effect concussion has on the brain.³⁷⁻³⁹ Many of the optometrists in our study who prescribed supplements (38% of the 26) also suggested oral supplements such as vitamins, minerals, and herbal teas. While animal-based research on vitamins C, D, and E has suggested that they may have potential benefits for concussed individuals, there have been no human studies. A decrease in neurological deficits resulting from vitamin E intake was reported in concussed rats⁴⁰ and a study using rodents showed that vitamin D combined with progesterone reduced neuronal loss post-concussion.⁴¹ Randomized clinical trials are clearly needed to determine the efficacy of these potential treatments in humans who have suffered a concussion before guidelines recommending for or against their use can be implemented.

Pain medication was suggested by 12% of optometrists in our study and the effectiveness of pain medication in concussion management is supported by studies in the literature. While there may be some disagreement or controversy regarding a direct role of optometrists in pain management, one would expect them to ensure the patient was

seeing a physician to manage their pain through recommendation or referral, particularly if over-the-counter pain medications were insufficient. In concussion, prescription medications are mainly administered in cases where specific criteria are reached and when symptoms persist beyond the effectiveness of standard care.⁴² Headache is a common symptom post-concussion, and it is recommended to treat it according to type and characteristics.⁴³⁻⁴⁵ Acetaminophen and NSAIDs (nonsteroidal anti-inflammatory drugs) can be used primarily to minimize existing disruptive symptoms.⁴⁶ Antiepileptics and tricyclic antidepressants can be used as a preventative treatment plan for individuals with consistent daily headaches.^{42,47-49}

Most optometrists in this study advised patients to limit activity (64%) and to rest (12%). This is supported by suggestions from the 2016 International Consensus Conference on Concussion in Sports in Berlin. Initial rest during the acute phase, 24-48 hours after injury, followed by a gradual increase in activity while not surpassing the threshold of symptom worsening was recommended.⁷ Hon et al. warned that prolonged rest could potentially worsen concussion outcomes.⁵⁰ In this study, the fact that most of the optometrists advised habits regarding the activities of daily living was consistent with the previously mentioned guidelines.

Only 2% of optometrists in this study advised positive health behaviour. A 2021 study emphasized the importance of sleep hygiene in concussed individuals.⁴² Sleep hygiene entails reducing screen time, sleeping in a cool and dark room, exercising, avoiding alcohol and caffeine intake, reducing daytime napping and limiting noise.^{42,51} The initial medical help received by concussion sufferers is likely not from an optometrist. However, referral to an eye care provider can be pivotal for positive patient outcomes. Likewise, referrals from an optometrist to other specialists can be critical for improving patient outcomes. A large part of the optometrist's role is to recognize, refer, and provide information consistent with that given by other health practitioners. In the clinic, educating within their area of expertise, showing concern for the patient's overall wellbeing, and validating the patient's emotional concerns are necessary and play an important role in management. Evidence suggests that concussed individuals are highly receptive to patient-centered interactions, reassurance, and education.^{34,49,52} Because the scope of optometric management is largely confined to vision-based problems, it is recommended that non-vision-based issues be referred to a specialist after the concussion appointment.¹³

LIMITATIONS

Only 9% (13/142) of optometrists in this study did not manage concussion. It is possible that this survey disproportionately attracted optometrists who manage concussion compared to those who do not. The survey title, 'Optometric Management of Visual Deficits Following Concussion' could have deterred optometrists who do not manage concussion from participating. Additionally, because the survey was public and anonymous, no personal identifying information was collected, and IP addresses were not stored, it is possible that participants could have submitted multiple surveys. However, there is no reason to believe that anyone would want to, or go to, such lengths to deliberately skew the results.

CONCLUSION

At this time, there is no set standard of care for the optometric management of visual deficits following concussion. However, it seems that Canadian optometrists typically complete a full eye exam and a binocular vision assessment that includes a visual midline shift assessment. It seems logical that the standard of care for optometric management should build on the strengths of what is currently being done. In this study, the management of visual deficits included but was not limited to tint trial and vision therapy; these interventions should be considered in the management on visual deficits after concussion. Recommendations regarding activities of daily living should largely be to limit activity. The appointment duration should be around 30 to 60 minutes and follow-up appointments should be scheduled to occur at 1 to 2 months. Further studies on treatment efficiency are required. Until evidence-based standards can be determined, this study will inform optometrists, and other eye care providers, on how their colleagues are currently managing concussion.

ACKNOWLEDGEMENTS

We would like to thank Chris Mathers for the technical support provided with REDCap and Dr. Marlee Spafford and Dr. Lisa Christian for their intellectual contributions in the development of this manuscript. This study was supported by a School of Optometry and Vision Science (University of Waterloo) Seed Funding Grant. ●

CORRESPONDING AUTHOR:

Anne Marie Yeboah – am2yeboah@uwaterloo.ca

REFERENCES

1. Gardner RC, Yaffe K. Epidemiology of mild traumatic brain injury and neurodegenerative disease. *Mol Cell Neurosci.* 2015;66:75-80. doi.org/10.1016/j.mcn.2015.03.001
2. Master CL, Scheiman M, Gallaway M, Goodman A, Robinson RL, Master SR, Grady MF. Vision diagnoses are common after concussion in adolescents. *Clin Pediatr (Phila).* 2016 Mar;55(3):260-7. doi.org/10.1177/0009922815594367
3. McCulloch KL, Osborne MBA, Ramsey CR. Geriatric Mild Traumatic Brain Injury (mTBI). *Curr Geriatrics Rep* 2020;9:142-53. doi.org/10.1007/s13670-020-00329-3
4. Centres for Disease Control and Prevention. What is a concussion? Published 2017. Accessed August 2, 2022. www.cdc.gov/headsup/basics/concussion_what.html
5. 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:CPI-68.
6. Kushner D. Mild Traumatic Brain Injury. *Arch Intern Med* 1998;158:1617-24. doi.org/10.1001/archinte.158.15.1617
7. McCrory 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;51:838-847. doi.org/10.1136/bjsports-2017-097699
8. Howell DR, Southard J. The molecular pathophysiology of concussion. *Clin Sports Med.* 2021;40:39-51. doi.org/10.1016/j.csm.2020.08.001
9. Mayo Clinic. Concussion. Published 2020. Accessed August 3, 2022.
10. AOA. Concussion. Accessed August 3, 2022. www.aoa.org/healthyeyes/eye-and-vision-conditions/concussions?sso=y
11. Ciuffreda KJ, Kapoor N, Rutner S, Suchoff IB, Han ME, Craig S. Occurrence of oculomotor dysfunctions in acquired brain injury: A retrospective analysis. *Optometry.* 2007;78:155-61. doi.org/10.1016/j.optm.2006.11.011
12. Master CL, Master SR, Wiebe DJ, et al. Vision and vestibular system dysfunction predicts prolonged concussion recovery in children. *Clin J Sport Med.* 2018;28:139-45. doi.org/10.1097/JSM.0000000000000507
13. Ciuffreda KJ, Ludlam DP, Yadav NK, Thiagarajan P. Traumatic Brain Injury: Visual Consequences, Diagnosis, and Treatment. *Adv Ophthalmol Optom.* 2016;1:307-33. doi.org/10.1016/j.yaoo.2016.03.013
14. London R, Wick B, Kirschen D. Post-traumatic pseudomyopia. *Optometry* 2003;74:111-20.
15. Johansson J, Nygren de boussard C, Öqvist Seimyr G, Pansell T. The effect of spectacle treatment in patients with mild traumatic brain injury: a pilot study. *Clin Exp Optom.* 2017;100:234-42. doi.org/10.1111/cxo.12458
16. Harris PA, Taylor R, Thielke R, Payne J, Gonzalez N, Conde JG. Research electronic data capture (REDCap)—a metadata-driven methodology and workflow process for providing translational research informatics support. *J Biomed Inform.* 2009 Apr;42(2):377-81. doi.org/10.1016/j.jbi.2008.08.010
17. CAO. Eye Exam vs Sight Test. Accessed August 3, 2022. www.opto.ca/health-library/eye-exam-vs-sight-test
18. Advanced Vision Therapy Center. Binocular Vision Assessment. Published 2021. Accessed August 3, 2022. www.advancedvisiontherapycenter.com/assessments/binocular_vision/
19. Gallaway M, Scheiman M, Mitchell GL. Vision Therapy for Post-Concussion Vision Disorders. *Optom Vis Sci.* 2017;94:68-73. doi.org/10.1097/OPX.0000000000000935
20. Cornsweet TN, Crane HD. Training the visual accommodation system. *Vis Res.* 1973;13:713-5. doi.org/10.1016/0042-6989(73)90034-5
21. Cooper J, Duckman R. Convergence insufficiency: incidence, diagnosis, and treatment. *J Am Optom Assoc.* 1978;49:673-80.
22. Wold RM, Pierce JR, Keddington J. Effectiveness of optometric vision therapy. *J Am Optom Assoc.* 1978;49:1047-54.
23. Haynes H, McWilliams L. Effects of training on near-far response time as measured by the distance rock test. *J Am Optom Assoc.* 1979;50:715-8.
24. Grisham JD. The Dynamics of Fusional Vergence Eye Movements in Binocular Dysfunction. *Optom Vis Sci.* 1980;57:645-55. doi.org/10.1097/00006324-198009000-00016
25. Daum KM. The course and effect of visual training on the vergence system. *Am J Optom Physiol Opt.* 1982 Mar;59(3):223-7. doi:10.1097/00006324-198203000-00004.
26. Daum KM. Convergence Insufficiency. *Am J Optom Physiol Opt.* 1984;61:16-22. doi.org/10.1097/00006324-198401000-00003
27. Hung GK, Ciuffreda KJ, Semmlow JL. Static vergence and accommodation: population norms and orthoptics effects. *Doc Ophthalmol.* 1986 Feb 28;62(2):165-79. doi:10.1007/BF00229128. PMID: 3956367.
28. The efficacy of optometric vision therapy. The 1986/87 Future of Visual Development/Performance Task Force. *J Am Optom Assoc.* 1988 Feb;59(2):95-105.
29. Crampton A, Teel E, Cheignard M, Gagnon I. Vestibular-ocular reflex dysfunction following mild traumatic brain injury: A narrative review. *Neurochirurgie.* 2021;67:231-237. doi.org/10.1016/j.neuchi.2021.01.002
30. Ciuffreda KJ, Ludlam D. Conceptual model of optometric vision care in mild traumatic brain injury. *J Behav Optom.* 2011;22:10-2.
31. Barton JJS, Ranalli PJ. Vision Therapy: Ocular Motor Training in Mild Traumatic Brain Injury. *Ann Neurol* 2020;88:453-61. doi.org/10.1002/ana.25820
32. Simpson-Jones ME, Hunt AW. Vision rehabilitation interventions following mild traumatic brain injury: a scoping review. *Disabil Rehabil.* 2019 Sep;41(18):2206-2222. doi:10.1080/09638288.2018.1460407. Epub 2018 Apr 10.
33. Heimmler L, Gunton KB. A review of the current practice in diagnosis and management of visual complaints associated with concussion and postconcussion syndrome. *Curr Opin Ophthalmol.* 2016;27:407-412. doi.org/10.1097/ICU.0000000000000296
34. Hunt T, Asplund C. Concussion Assessment and Management. *Clin Sports Med.* 2010;29:5-17. doi.org/10.1016/j.csm.2009.09.002
35. Barrett EC, McBurney MI, Ciappio ED. ω-3 fatty acid supplementation as a potential therapeutic aid for the recovery from mild traumatic brain injury/concussion. *Adv Nutr.* 2014 May 14;5(3):268-77. doi:10.3945/an.113.005280.
36. Lewis M, Ghassemi P, Hibbeln J. Therapeutic use of omega-3 fatty acids in severe head trauma. *Am J Emerg Med.* 2013 Jan;31(1):273.e5-8. doi:10.1016/j.ajem.2012.05.014. Epub 2012 Aug 3.
37. Wu A, Ying Z, Gomez-Pinilla F. Dietary Omega-3 Fatty Acids Normalize BDNF Levels, Reduce Oxidative Damage, and Counteract Learning Disability after Traumatic Brain Injury in Rats. *J Neurotrauma.* 2004;21:1457-67. doi.org/10.1089/neu.2004.21.1457
38. Wu A, Ying Z, Gomez-Pinilla F. The Salutary Effects of DHA Dietary Supplementation on Cognition, Neuroplasticity, and Membrane Homeostasis after Brain Trauma. *J Neurotrauma.* 2011;28:2113-2122. doi.org/10.1089/neu.2011.1872
39. Bailes JE, Mills JD. Docosahexaenoic Acid Reduces Traumatic Axonal Injury in a Rodent Head Injury Model. *J Neurotrauma.* 2010;27:1617-24. doi.org/10.1089/neu.2009.1239
40. Yang J, Han Y, Ye W, Liu F, Zhuang K, Wu G. Alpha tocopherol treatment reduces the expression of Nogo-A and NgR in rat brain after traumatic brain injury. *J Surg Res.* 2013 Jun 15;182(2):e69-77. doi:10.1016/j.jss.2012.11.010. Epub 2012 Nov 26.
41. Trojian TH, Wang DH, Leddy JJ. Nutritional Supplements for the Treatment and Prevention of Sports-Related Concussion—Evidence Still Lacking. *Curr Sports Med Rep.* 2017;16:247-255. doi.org/10.1249/JSR.0000000000000387
42. Jones JC, O'Brien MJ. Medical Therapies for Concussion. *Clin Sports Med.* 2021;40:123-31. doi.org/10.1016/j.csm.2020.08.005
43. McConnell B, Duffield T, Hall T, et al. Post-traumatic Headache After Pediatric Traumatic Brain Injury: Prevalence, Risk Factors, and Association With Neurocognitive Outcomes. *J Child Neurol.* 2020;35:63-70. doi.org/10.1177/0883073819876473
44. Harmon KG, Drezner J, Gammons M, et al. American Medical Society for Sports Medicine Position Statement. *Clin J Sport Med.* 2013;23:1-18. doi.org/10.1097/JSM.0b013e31827f5f93
45. Lucas S. Characterization and Management of Headache after Mild Traumatic Brain Injury. In: Kobeissy FH, editor. *Brain Neurotrauma: Molecular, Neuropsychological, and Rehabilitation Aspects.* Boca Raton (FL): CRC Press/Taylor & Francis; 2015.
46. DiTommaso C, Hoffman JM, Lucas S, Dikmen S, Temkin N, Bell KR. Medication usage patterns for headache treatment after mild traumatic brain injury. *Headache.* 2014 Mar;54(3):511-9. doi:10.1111/head.12254.
47. Meehan WP. Medical Therapies for Concussion. *Clin Sports Med.* 2011;30:115-24. doi.org/10.1016/j.csm.2010.08.003
48. Langdon R, Taraman S. Posttraumatic Headache. *Pediatr Ann.* 2018 Feb 1;47(2):e61-e68. doi:10.3928/19382359-20180131-01.
49. Mittenberg W, Canyock EM, Condit D, Patton C. Treatment of post-concussion syndrome following mild head injury. *J Clin Exp Neuropsychol.* 2001 Dec;23(6):829-36. doi:10.1076/jcen.23.6.829.1022.
50. Hon KL, Leung AKC, Torres AR. Concussion: A Global Perspective. *Semin Pediatr Neurol.* 2019;30:117-127. doi.org/10.1016/j.spen.2019.03.017
51. Irish LA, Kline CE, Gunn HE, Buysse DJ, Hall MH. The role of sleep hygiene in promoting public health: A review of empirical evidence. *Sleep Med Rev.* 2015;22:23-36. doi.org/10.1016/j.smrv.2014.10.001
52. King N, Crawford S, Wenden F, Moss N, Wade D. Interventions and service need following mild and moderate head injury: the Oxford Head Injury Service. *Clin Rehabil.* 1997;11:13-27. doi.org/10.1177/026921559701100104