RULE 17, EXHIBIT 2A

Mild Traumatic Brain Injury

Medical Treatment Guideline

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DIVISION OF WORKERS' COMPENSATION

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DEPARTMENT OF LABOR AND EMPLOYMENT

Division of Workers' Compensation

CCR 1101-3

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A. Guideline introduction

This document has been prepared by the Colorado Department of Labor and Employment, Division of Workers' Compensation (Division) and should be interpreted within the context of guidelines for physicians/providers treating individuals who qualify as injured workers with traumatic brain injury (TBI) under the Colorado Workers' Compensation Act.

Although the primary purposes of this document for practitioners are advisory and educational, this guideline is enforceable under the Workers' Compensation Rules of Procedure, 7 CCR 1101-3. The Division recognizes that acceptable medical practice may include deviations from this guideline, as individual cases dictate. Therefore, this guideline is not relevant as evidence of a provider's legal standard of professional care.

To properly utilize this document, the reader should not skip or overlook any sections.

B. General guideline principles

The principles summarized in this section are key to the intended implementation of all Division of Workers' Compensation medical treatment guidelines and critical to the reader's application of the guidelines in this document.

B.1 Application of the guidelines

The Division provides procedures to implement medical treatment guidelines and to foster communication to resolve disputes among the provider, payer, and patient through the Workers' Compensation Rules of Procedure. In lieu of more costly litigation, parties may wish to seek administrative dispute resolution services through the Division or the office of administrative courts.

B.2 Education

Education of the individual and family and/or support system, as well as the employer, insurer, policy makers, and the community, should be the primary emphasis in the treatment of TBI. Currently, practitioners often think of education last, after medications, manual therapy, and surgery. Practitioners must implement strategies to educate individuals with TBI, employers, insurance systems, policy makers, and the community as a whole. An education-based paradigm should always start with inexpensive communication that provides recovery, function-focused, patient-centered, and evidence-based information to the individual with TBI. More in-depth education is currently a component of treatment regimens that employ functional, restorative, preventive, and rehabilitative programs. No treatment plan is complete without addressing issues of individual and/or group patient education as a means of facilitating self-management of symptoms and prevention. Facilitation through language interpretation, when necessary, is a priority and part of the medical care treatment protocol.

B.3 Informed decision making

Providers should implement informed decision making as a crucial element of a successful treatment plan. Patients, with the assistance of their health care practitioner and support system, should identify their personal and professional functional goals of treatment at the first visit. Progress towards the individual's identified functional goals should be addressed by all members of the health care team at subsequent visits and throughout the established treatment plan. Nurse case managers, psychologists, physical therapists, and other members of the health care team play an integral role in informed decision making and achievement of functional goals. Patient education and informed decision making should facilitate self-management of symptoms and prevention of further injury.

B.4 Treatment parameter duration

Time frames for specific interventions commence once treatments have been initiated, not on the date of injury. Obviously, duration will be impacted by the individual's adherence, as well as availability of services. Clinical judgment may substantiate the need to accelerate or decelerate the time frames discussed in this document.

B.5 Active interventions

Active interventions emphasizing patient responsibility, such as therapeutic exercise and/or functional treatment, are generally utilized over passive modalities, especially as treatment progresses. Generally, passive interventions are viewed as a means to facilitate progress in an active rehabilitation program with concomitant attainment of objective functional gains.

B.6 Active therapeutic exercise program

Exercise program goals should incorporate patient strength, endurance, flexibility, coordination, and education. This includes functional application in vocational or community settings.

B.7 Positive patient response

Positive results are defined primarily as functional gains that can be objectively measured. Objective functional gains include, but are not limited to: positional tolerances, range of motion (ROM), strength, endurance, activities of daily living, ability to function at work, cognition and communication, psychological behavior, and efficiency/velocity measures that can be quantified. Subjective reports of pain and function should be considered and given relative weight when the pain has anatomic and physiologic correlation. Anatomic correlation must be based on objective findings. Patient completed functional questionnaires such as those recommended by the Division as part of Quality Performance and Outcomes Payments (QPOP, see Rule 18-8), the Patient Specific Functional Scale, or other validated function scales can provide useful additional confirmation.

B.8 Re-evaluation of treatment no less than every 3 to 4 weeks

If a given treatment or modality is not producing positive results within 3 to 4 weeks or within the time to produce effect in the guidelines, the treatment should be either modified or discontinued. Before discontinuing the treatment, the provider should have a detailed discussion with the patient to determine the reason for failure to produce positive results. Reconsideration of diagnosis should also occur in the event of a poor response to a seemingly rational intervention.

B.9 Surgical interventions

Surgery should be contemplated within the context of expected functional outcome and not purely for the purpose of pain relief. The concept of "cure" with respect to surgical treatment by itself is generally a misnomer. All operative interventions must be based upon positive correlation of clinical findings, clinical course, and diagnostic tests. A comprehensive assimilation of these factors must lead to a specific diagnosis with positive identification of pathologic conditions.

B.10 Six-month time frame

The prognosis drops precipitously for returning an injured worker to work once he/she has been temporarily totally disabled for more than six months. The emphasis within these guidelines is to move patients along a continuum of care and return to work within a six-month time frame, whenever possible. It is important to note that time frames may be less pertinent for injuries that do not involve work-time loss or are not occupationally related.

B.11 Return to work

When considering return-to-work options following TBI, the practitioner must skillfully match the individual's abilities (physical, cognitive, communicative, psychological, and behavioral) and the work requirements.

The practitioner must write detailed restrictions when returning an individual with TBI to limited duty. An individual with TBI should never be released to "sedentary or light duty" without specific physical, psychological, and cognitive limitations. The practitioner must understand essential job functions and job requirements/duties, as well as all of the physical, visual, cognitive, psychological, and behavioral demands of the individual's job position before returning him/her to full duty. Job duty clarification should be obtained from the employer or others if necessary, including but not limited to: employer supervisor or co-worker, an occupational health nurse, occupational therapist, physical therapist, speech-language pathologist, vocational rehabilitation specialist, case manager, industrial hygienist, or other appropriately trained professional.

B.12 Delayed recovery

For individuals with mild TBI (mTBI), strongly consider requesting a neuropsychological evaluation, if not previously provided. Interdisciplinary rehabilitation treatment and vocational goal setting may need to be initiated for those who are failing to make expected progress 6 to 12 weeks after an injury. In individuals with mTBI, neurological recovery is generally achieved within a range of weeks/months up to one year post-injury (McCrea et al., 2009), but functional improvements may be made beyond one year. The Division recognizes that 3–10% of all industrially injured individuals will not recover within the timelines outlined in this document despite optimal care. Such individuals should have completed a full neuropsychological evaluation. These individuals may require treatment beyond the limits discussed within this document, but such treatment will require clear documentation by the authorized treating provider focusing on objective functional gains afforded by further treatment.

B.13 Guideline recommendations and inclusion of medical evidence

All recommendations are based on available evidence and/or consensus judgment. A Division staff methodologist (MD, MSPH) researched and adopted literature critique criteria. Literature critiques were performed in a manner congruent with national standards and were completed independent of the multidisciplinary task force group which drafted initial recommendations. The methodology is described in detail on the Division’s website. Please also refer to the Division’s website for evidence tables and study critiques which provide details on the studies used to develop the evidence statements.

When possible, guideline recommendations note the level of evidence supporting the treatment recommendation. It is generally recognized that early reports of a positive treatment effect are frequently weakened or overturned by subsequent research. When interpreting medical evidence statements in the guideline, the following apply:

- Consensus means the judgment of experienced professionals based on general medical principles. Consensus recommendations are designated in the guidelines as “generally well-accepted,” “generally accepted,” “acceptable/accepted,” or “well-established.”
- “Some evidence” means the recommendation considered at least one adequate scientific study, which reported that a treatment was effective. The Division recognizes that further research is likely to have an impact on the intervention’s effect.
- “Good evidence” means the recommendation considered the availability of multiple adequate scientific studies or at least one relevant high-quality scientific study, which reported that a treatment was effective. The Division recognizes that further research may have an impact on the intervention’s effect.
- “Strong evidence” means the recommendation considered the availability of multiple relevant and high-quality scientific studies, which arrived at similar conclusions about the effectiveness of a treatment. The Division recognizes that further research is unlikely to have an important impact on the intervention’s effect.

There is limited and varied literature on TBI. Therefore, many of the studies cited focus on athletes, military personnel, or stroke survivors.

All recommendations in the guideline are considered to represent reasonable care in appropriately selected cases, irrespective of the level of evidence or consensus statement attached to them. Those procedures considered inappropriate, unreasonable, or unnecessary are designated in the guideline as “not recommended.”

B.14 Treatment of pre-existing conditions

The conditions that preexisted the work injury/disease will need to be managed under two circumstances: (a) A pre-existing condition exacerbated by a work injury/disease should be treated until the patient has returned to their objectively verified prior level of functioning or Maximum Medical Improvement (MMI); and (b) A pre-existing condition not directly caused by a work injury/disease but which may prevent recovery from that injury should be treated until its objectively verified negative impact has been controlled. The focus of treatment should remain on the work injury/disease.

The remainder of this document should be interpreted within the parameters of these guideline principles that may lead to more optimal medical and functional outcomes for injured workers.

B.15 Post maximum medical improvement (MMI) care

This document includes recommendations for post-MMI care in appropriate cases. (Refer to Section H, Maintenance management.)

C. Introduction to traumatic brain injury (TBI)

C.1 Definitions of TBI

Before a diagnosis of TBI is made, the physician should assess the level of trauma exposure to the individual using available objective evidence. According to the Institute of Medicine of the National Academies, TBI is an injury to the head or brain caused by externally inflicted trauma (Institute of Medicine, 2006). The Department of Defense defines TBI as a "traumatically induced structural injury and/or physiological disruption of brain functions as a result of an external force" (Management of Concussion-Mild Traumatic Brain Injury Working Group, 2016, p. 6). TBI may be caused by a blow to the head from an object or by striking an object, by acceleration or deceleration forces without impact, or by blast injury or penetration to the head that disrupts the normal function of the brain (Management of Concussion-Mild Traumatic Brain Injury Working Group, 2016).

A diagnosis of TBI is based on acute injury parameters and should be determined by the criteria listed below. Severity of initial impairment following TBI is subdivided into two major categories, mild TBI (mTBI) and moderate/severe TBI (M/S TBI). These definitions apply to the initial severity of impairment and do not necessarily define or describe the degree of subsequent impairment or disability.

After sustaining a TBI, whether initially diagnosed as mTBI (including complicated mTBI) or M/S TBI, assessment, evaluation, and testing under the Division's Moderate/Severe TBI Medical Treatment Guideline is appropriate when there are complex questions related to differential diagnosis (brain injury versus other diagnosis) or when the patient is not progressing in cognitive function and/or activities of daily living (ADLs). There should be a clear rationale for undertaking testing and/or treatment under the M/S TBI Guideline.

C.1.a Mild TBI (mTBI)

mTBI is a traumatically induced physiological disruption of brain function, as manifested by at least one of the following, documented within 24 to 72 hours of an injury (American Congress of Rehabilitation Medicine Head Injury Interdisciplinary Special Interest Group, 1993):

- any loss of consciousness
- any loss of memory for events immediately before or after the injury
- any alteration of mental status at the time of the injury (e.g., feeling dazed, disoriented, or confused) (Management of Concussion-Mild Traumatic Brain Injury Working Group, 2016)
- focal neurological deficit(s) that may or may not be transient but where the severity of the injury does not exceed the following:
  - loss of consciousness for approximately 30 minutes or less,
  - at 30 minutes, a Glasgow Coma Scale (GCS) of 13–15, and
  - post-traumatic amnesia (PTA) not greater than 24 hours.

If the GCS is not available, the closest approximation to the patient's state at 30 minutes post-injury should be used.

If the patient presents with any of the above after 72 hours, the clinician will need to use available information to construct a diagnosis.

C.1.b Complicated mTBI

Complicated mTBI is an mTBI accompanied by structural brain damage visualized on initial structural neuroimaging. More patients in this group have slow or incomplete recovery as compared to patients without this finding. However, the imaging finding alone may not fully predict the clinical course of an individual with mTBI (Grant L. Iverson, 2009). Based on a reanalysis of data from the Dikmen study, there is some evidence that mTBI and complicated mTBI – whether the GCS is 15 or 13-14 – are similar with respect to the frequency of persistent concussion symptoms at one month and one year (Dikmen, Machamer, & Temkin, 2017). The term is not separately addressed in this guideline to determine care, but it should be understood that **complicated mTBI cases will frequently require more extensive treatment than that described under mTBI and may be given access to care listed under M/S TBI as appropriate for the individual.** For those cases, refer to the Division's Moderate/Severe TBI Medical Treatment Guideline.

C.1.c Moderate/severe TBI (M/S TBI)

M/S TBI is a traumatically induced physiological and/or anatomic disruption of brain function as manifested by at least one of the following (American Congress of Rehabilitation Medicine Head Injury Interdisciplinary Special Interest Group, 1993):

- altered state of consciousness or loss of consciousness for greater than 30 minutes,
- an initial GCS of 12 or less, and/or standardized structural neuro-imaging evidence of trauma, and/or
- post-traumatic amnesia (PTA) greater than 24 hours.

If the GCS is not available, the closest approximation to the patient's state at 30 minutes post-injury should be used.

C.1.d Other terminology

Once a patient has met the criteria defined above in C.1.a for mTBI or C.1.b for complicated mTBI, the treatment patterns and diagnostic tools of this guideline apply. The following terms are noted for information only.

- Acquired brain injury (ABI): ABI refers to any type of brain injury that occurs after birth and that is not related to a congenital disorder or degenerative disease. In addition to TBI, ABI also includes damage to the brain from internal factors such as lack of oxygen, brain bleed, exposure to toxins, infection, or pressure from a tumor. Although non-traumatic ABI may have symptoms and treatments in common with TBI, this guideline was developed specifically for TBI. It is possible that some of these treatments may be useful for other types of ABI.

- Concussion: There is some disagreement in the literature regarding definitions and terminology. “Concussion” is used synonymously with mTBI in many papers. The term is only referenced in this guideline when describing studies using the terminology.

- Post-Concussive Syndrome (PCS): PCS is an accepted diagnosis that is generally determined by the number of symptoms present after an mTBI and how long they persist. However, the symptoms used to determine the presence of PCS are frequently present in those without mTBI (Dean, O'Neill, & Sterr, 2012). In this guideline, once a person has been diagnosed with mTBI, any of the treatments for continuing symptoms may be used. Thus, the diagnostic category of PCS is not necessary and should not be used in isolation to access the treatments in this guideline.

C.2 Prevention

Prevention of injuries such as TBI is an essential component of any medical treatment guideline or injury management program. TBI is a dynamic condition, and patients may deteriorate over time in the areas of physical and mental health, cognition, employment, and activities of daily living (ADLs). The following guideline-specific definitions of the various types and levels of prevention are necessary to prevent the deterioration from a healthy state to pathology and to successfully intervene at the levels of disablement described in section C.4, Disability.

- Primary prevention
  The goal is the prevention of disease in a susceptible, or potentially susceptible, population through specific measures, including general health promotion efforts. All health providers should remind individuals, supervisors, and employers of the primary measures for preventing recurring TBIs.

  Always use appropriate protective equipment on jobs that require protection, including following all of the employment policy and procedures related to the safety of the individual, co-workers, or external customers. Examples of primary prevention include:

  - Provide safety guidelines for employer premises;
  - Wear protective helmets, complying with the American National Standards Institute (ANSI), on jobs requiring protection from falling objects or electrical hazards;
  - Wear protective helmets and headwear when involved in contact, collision, and other sports such as biking, horseback riding, skating, skiing, and snowboarding;
  - Wear safety goggles or glasses on jobs that require protection from flying objects or debris;
  - Avoid walking on wet, slippery floors on the worksite, or wear the appropriate footwear for the conditions;
  - Ensure that scaffolding has appropriate railings and/or harnesses, and that they are in good working order;

- ○ Use ladders in accordance with Occupational Safety and Health Administration (OSHA) recommendations (e.g., make sure that ladders over 20 feet tall have cages);

- ○ Provide and use airbags, safety belts, etc., in motor vehicles;

- ○ Avoid alcohol and other drug use, including marijuana, during recreational activities such as boating, hunting, skiing, snowboarding, etc., while driving or operating equipment, when working from elevated surfaces, and at work;

- ○ Avoid distracted driving (e.g., driving while texting, using cell phone, etc);

- ○ Practice fatigue management techniques, such as limiting duty hours and night shifts, to maintain optimal energy levels for the required work tasks;

- ○ Weight management and regular exercise may decrease the likelihood of an injury as well as length of recovery when an injury occurs.

- Secondary prevention

  Secondary prevention includes efforts to decrease duration of illness, severity of disease, and sequelae through early diagnosis and prompt intervention.

  mTBI is one of the most common neurologic disorders. Health care providers may play a key role in improving outcomes following mTBI. Early diagnosis of individuals with mild and moderate/severe TBI is critical in helping to avoid secondary symptoms and problems in living. Individuals with a previous history of TBI, comorbid conditions, psychiatric disorders, cognitive disorders, and substance abuse are also at greater risk for poor outcome and represent an opportunity to reduce the effects of TBI. Such individuals should receive appropriate referrals for the comorbid conditions, and treatment of these comorbid conditions should be integrated into the individual's rehabilitation program. For mTBI, providing education about symptoms, their management, and their probable positive outcome is an essential component of treatment. Using the available diagnostic information as the basis for providing education and providing written instructions on the discharge sheet regarding high-risk activities and timing for return to regular activities may help to improve outcomes and prevent further injury. Written materials and internet references that provide appropriate education for individuals with TBI and family and/or support system about TBI care and prevention are available in English and Spanish from the Centers for Disease Control and Prevention.

  Workers who have sustained a recent TBI should be especially cautious about returning to work activities that may lead to a second TBI since second injuries occurring prior to a full recovery from the initial mTBI may have more serious consequences. Providers should practice secondary prevention by setting appropriate restrictions for these workers and workers who are suffering from impairment, such as dizziness, that could lead to falls in some work environments. (Refer to Section G, Return to work.)

- Tertiary prevention

  Tertiary prevention encompasses the effort to decrease the degree of disability and promote rehabilitation and restoration of function in individuals with chronic and irreversible diseases and to prevent disease and disability. Life-long management and follow-up services may be required for select individuals with TBI with persistent medical, cognitive, psychological, and/or functional skill deficits.

The majority of this guideline addresses secondary and tertiary prevention of disability for workers with TBI.

C.3 Interdisciplinary rehabilitation professionals

An interdisciplinary treatment team is an alliance of professionals from different medical or therapeutic disciplines (as described below) that provides a coordinated treatment program. The particular treatment needs of the individual with TBI will determine the disciplines that make up the team. Those with mTBI will generally require fewer disciplines involved in their care. (Refer to Section D, Overview.) The team establishes treatment priorities and goals and provides treatment. Team members contribute their respective skills, competencies, insight, and perspectives to the rehabilitation process. This includes education, communication, and alignment of expectations to optimize treatment outcomes. It is highly recommended that the individual with TBI participate in team planning, along with his or her family and/or support system, insurance carrier, case manager, and sometimes the employer or return-to-work specialist when addressing return-to-work planning. (Refer to Section G, Return to work.)

The most common disciplines, in alphabetical order, involved in the medical and rehabilitation treatment of TBI include but are not limited to:

- Behavioral psychologist: a psychologist with special training, credentials, and licensing who specializes in the area of behavior analysis and treatment.

- Behavioral analyst: a master's level, certified behavioral analyst who designs and supervises behavioral interventions. Behavioral assessments by an analyst do not substitute for neuropsychological assessments.

- Case manager: Case managers are initially trained under a variety of disciplines such as nursing, social work, and other health and human services fields and should be certified through the Commission for Case Manager Certification (CCMC). In order to achieve the best possible outcome for everyone involved, it is best to provide case management services in an environment in which the case manager, the client, the client's family and/or support system, and the appropriate service personnel are able to communicate directly (Case Management Society of America (CMSA), 2016). It is crucial that the case manager be thoroughly educated in the complexities of treating individuals with TBI.

  Case managers may perform Utilization Review (UR) as a part of case management duties, but UR alone is not case management.

  The primary functions of TBI case management are:

  - to obtain information through a comprehensive assessment of the injured individual and his/her family and/or support system;
  - to work with the health care team, the injured worker, and family and/or support system in development, monitoring, and implementation of a comprehensive case management plan. Plan reassessment should be completed on a regular basis;
  - to optimize access to appropriate health care services and maintain cost effectiveness;
  - to integrate and coordinate service delivery among all providers and to prevent fragmentation of services by facilitating communication and by involving the injured worker and family and/or support system in the decision-making process;
  - to educate and collaborate with the injured worker, family and/or support system, and the health care team when necessary about treatment options, compliance issues, and community resources;
  - to predict and avoid potential complications.

- Chiropractor: a credentialed and licensed doctor of chiropractic who assesses and treats human illness and injury, including, but not limited to: musculoskeletal injuries; movement dysfunction; impairments in strength, muscle tone, motor control, posture coordination, endurance, and functional mobility; neurological injuries; and loss of function. Chiropractic utilizes joint manipulation and spinal and joint rehabilitation, along with various therapies and modalities.
- Clinical pharmacist: a pharmacist with expertise in medication management. He/she might be useful for patients with multiple medication regimens.
- Clinical psychologist: a psychologist with special training, credentials, and licensing who specializes in the assessment and treatment of personality and psychological disorders, education and adjustment counseling, psychotherapy, and management of behavior.
- Driver rehabilitation specialist: an individual who is trained in the health care field and certified by the Association for Driver Rehabilitation and the American Occupational Therapy Association.
- Independent life skills trainer: an individual with documented training to develop and maintain an individual's ability to independently sustain him or herself physically, emotionally, and economically. Services may include: assessment, training, and supervision or assistance to an individual with self-care; medication supervision; task completion; communication skill building; interpersonal skill development; socialization; therapeutic recreation; sensory motor skills; mobility or community transportation training; reduction or elimination of maladaptive behaviors; problem solving skill development; benefits coordination; resource coordination; financial management; and household management.
- Music therapist: an individual who is board certified and trained to use music within a therapeutic relationship to improve cognitive, sensory, motor, communication, and behavioral functions that have been affected by neurologic disease.

- Neurologist: a physician with special training and credentials in the area of the nervous system who has successfully completed an approved residency in neurology.
- Neuro-ophthalmologist: an ophthalmologist or neurologist who has completed an approved residency in ophthalmology or neurology, who has completed a fellowship in neuro-ophthalmology, and who specializes in the treatment of visual disorders related to the nervous system.
- Neuro-otologist: a physician who has completed a fellowship in neurotology or oto-neurology.
- Neuropsychologist: a licensed psychologist with knowledge of and special training in brain-behavior relationships, including neuropsychological assessment, causality of neurobehavioral changes, and treatment and management of neurobehavioral disorders.
- Neuroscience nurse: a registered nurse (RN) who has certification in the treatment of individual and family and/or support system responses to nervous system function and dysfunction across the healthcare continuum.
- Neurosurgeon (neurological surgeon): a physician who has special training and credentials in the surgery of nervous system disorders and who has successfully completed an approved residency in neurological surgery.
- Nurse: an RN with specialty training, credentials, and licensing who specializes in the collection and assessment of health data, health teaching, and the provision of treatment that is supportive and restorative to life and well-being.
- Occupational therapist: a registered and licensed therapist who specializes in participation in activities of daily living (ADLs). He/she assesses and treats the physical, perceptual, behavioral, and cognitive skills needed to perform self-care, home maintenance, and community skills. He/she also provides patient and family and/or support system education.
- Occupational medicine physician: a physician who has education and training in occupational medicine and preferably qualifies for board certification.
- Optometrist: a specialist with training, credentials, and licensing who examines, assesses, diagnoses, and treats select abnormal conditions of the eye and adnexa. Optometric scope of practice varies from state to state. It is defined by statute and may include topical or systemic medical therapy. Neuro-optometrists are preferred.
- Ophthalmologist: a physician with training and credentials in the diagnosis and treatment of visual disorders, including related systemic conditions, who has successfully completed an internship and an approved residency in ophthalmology. Ophthalmologists are able to perform medical and surgical procedures on the eye, orbit, and adnexa. Neuro-ophthalmologists are preferred.
- Otolaryngologist: a physician who specializes in ear, nose, and throat medical treatment. He/she has completed a residency in otolaryngology.

- Physical therapist: a licensed therapist with expertise in managing movement dysfunction who specializes in the assessment and treatment of individuals with impairments, deficits and functional limitations in the areas of strength, muscle tone, motor control, posture, coordination, balance, endurance, and general functional mobility. He/she works to improve functional independence, as well as provide family and/or support system and patient education.
- Physiatrist / physical medicine and rehabilitation physician: a physician with special training, credentials, and licensing in the field of physical medicine and rehabilitation. He/she has successfully completed an approved residency.
- Psychiatrist/neuropsychiatrist: a physician with special training, credentials, and licensing who specializes in the field of mental health and psychological disorders. He/she has successfully completed an approved residency in psychiatry. A neuropsychiatrist is a psychiatrist who has specialized training, credentials, and licensing in neurologically based behavioral, cognitive, and emotional disturbances, including specialized training in TBI.
- Rehabilitation counselor: a bachelor's or master's level counselor who specializes in assisting individuals in the process of independent living, productive activity, and vocational pursuits. This includes assistance with financial resources, housing, community resources, social skills, vocational evaluation and treatment, integration back into the workforce, and patient and family and/or support system counseling.
- Rehabilitation nurse: an RN who has certification in rehabilitation nursing. Rehabilitation nursing is a specialty practice area within the field of nursing. It involves recognizing, reporting, and treating human responses of individuals and groups to present or future health problems resulting from changes in functional ability and lifestyle (Association of Rehabilitation Nurses (ARN), 2016).
- Rehabilitation psychologist: a specialty within psychology requiring additional training that focuses on interdisciplinary teamwork to achieve optimal physical, psychological, and interpersonal functioning for those with chronic or traumatic injuries (American Board of Professional Psychology, 2017).
- Social worker: a master's level, licensed social worker who specializes in patient and family relationships, as well as housing, financial resources, and society reintegration.
- Speech-language pathologist: a certified, licensed, and master's or doctoral level therapist who specializes in the assessment and treatment of individuals in the areas of communication (speech, language, social skills, voice), cognition, swallowing, and family and/or support system patient education.
- Therapeutic recreation specialist: a bachelor's or master's level therapist who specializes in the assessment and treatment of individuals in the areas of planning and management of leisure activities, time management, mental health through recreation, and community access.

C.4 Disability

The World Health Organization (WHO) conceptualizes disability as the interaction of health conditions with environmental factors (such as social and legal structures) and personal factors (including age, education, and coping styles).

For the purposes of this guideline, we are adopting the International Classification of Functioning, Disability, and Health (ICF).

This model recognizes the interaction between the health condition and three major components: body functions and structures, activity, and participation. These in turn are influenced by environmental and personal issues. The following definitions are used:

- Body functions: physiological functions of body systems, including psychological functions.
- Activity limitations: difficulties an individual may have in executing activities.
- Participation restrictions: problems an individual may experience in involvement in life situations.
- Disability: activity limitations and/or participation restrictions in an individual with a health condition, disorder, or disease.

Because of the nature of TBI and the nature of learning and memory, functional skills often cannot be generalized across work environments. Therefore, the assessment of function, evaluation, and treatment should not only consider the injured worker but also include evaluations of the individual's "real world" environment, conducted by qualified practitioners.

D. Overview

The overview is intended to assist providers in caring for patients post mTBI. Related evidence statements and supporting literature can be found at the end of this section. Recommended considerations should be accomplished in a timely manner.

Payers and providers should refer to specific treatment and diagnostic sections to determine coverage for payment.

D.1 Prognosis and risk factors

In general, 75–90% of people with mTBI fully recover in less than 90 days. Those who suffer an mTBI may continue to report symptoms for several months or years (Carroll et al., 2004; Hou et al., 2012; Weightman, Bolgla, McCulloch, & Peterson, 2010).

A number of factors appear to increase the risk for symptom prolongation:

- Glasgow Coma Scale score of less than 15 at 2 hours post-injury (National Institute for Health and Clinical Excellence (NICE), 2007);
- work risk factors, such as very demanding or stressful vocations or being employed in the current job for a short period of time;
- age above 40 years;
- injury complicated by the presence of intracranial lesions, current or previous;
- history of prior brain injury, cognitive impairment, learning disabilities, or developmental delay;
- associated orthopedic, soft tissue, or organ injuries;
- pre-injury issues with general health or psychosocial well-being;
- psychological factors such as depression, post-traumatic stress disorder, or anxiety (see evidence statement below);
- pre-injury history of migraines or other recurrent headaches.

CT or MRI findings that do not necessitate surgery nor result in significant initial neurologic findings on physical exam may still result in a complex recovery. All patients with any CT or MRI findings should be evaluated by providers specializing in brain injury care. Upon initial presentation, in-hospital observation may be required (Ontario Neurotrauma Foundation, 2013). These patients are usually labeled complicated mTBI and will often need care under the Division's Moderate/Severe Traumatic Brain Injury Medical Treatment Guideline.

D.2 First 2 weeks of post-injury care

- Patient education regarding the expectation for recovery is an important component of initial care. Although initially symptoms are common, these can usually be managed with conservative measures and avoidance of aggravating factors.

Because recovery is expected in the majority of cases, it is important to initially focus the patient on the likelihood of full recovery over a relatively short period of time (Ontario Neurotrauma Foundation, 2013). Common post-injury complaints are listed below.

- There should be a detailed, focused neurological exam by a physician experienced in mTBI within the first week with documentation of symptoms and risk factors. By seven days post-injury, a complete history and neurologic exam must be performed by a physician knowledgeable in mTBI protocols. The exam should define any symptoms that are continuing and also identify risks for persistence of mTBI symptoms (Ontario Neurotrauma Foundation, 2013).

Common mTBI symptoms include the following (Prince & Bruhns, 2017):

- headaches;
- sleep disturbances;
- dizziness;
- nausea;
- visual disturbances;
- photophobia;
- phonophobia/hyperacusis;
- tinnitus;
- attention and memory problems;
- slow processing of information;
- difficulty multi-tasking;
- increased distractibility;
- losing one's train of thought;
- feeling foggy;
- fatigue, likely multi-factorial.

In order to decrease symptoms of distress and concern over normal reactions to mTBI injury, the second visit should allow for expanded time if there are any remaining symptoms. Patients often express cognitive problems (e.g., difficulty with attention, memory, or solving problems) or emotional issues (e.g., increased intolerance or irritability) secondary to the mTBI. The provider must realize that these symptoms may arise from other secondary problems related to the injury. For example, if there is significant cervical spasm or myofascial pain in the neck, this may cause or contribute to the severity of headaches. Also, it is not uncommon for patients to have mild vestibular problems and/or issues with visual tracking. Patients frequently report the symptoms associated with these abnormalities as dizziness or difficulty with reading and comprehension.

Also, non-brain related injuries may contribute to difficulty with physical activities or to sensation of pain, which interferes with reading, attention, and sleep.

Small studies of mTBI have noted that PTSD can increase the risk for long-term symptoms (Haarbauer-Krupa et al., 2017; Warren et al., 2015). Several studies evaluating models for mTBI predictors have noted that years of education, pre-injury psychiatric disorders, and prior TBI were strong predictors of 6-month post-concussive symptoms, and these should be considered as risk factors for patients with continuing symptoms. In the same manner, patients should be screened for psychological issues in addition to PTSD (Cnossen et al., 2017; Lingsma et al., 2015).

Detailed questioning in all of these areas is important. It is equally important to report when no symptoms are present in these common areas of mTBI complaints.

The essential areas to address in the initial two weeks post-injury are:

- obtaining sufficient sleep;
- avoiding drinking alcohol or use of medication not prescribed by the provider;
- identifying and treating stress including anxiety, depression, and other psychological symptoms;
- conservative treatment of headaches and other minor pain (Ontario Neurotrauma Foundation, 2013).

D.3 Weeks 2-8 post-injury symptom management

- All patients with concerning clinical findings on exam should be referred expeditiously to a physician specialist. However, a referral to a physician specialist is usually not required for most patients with symptoms not accompanied by neurological findings on exam due to the high-expected recovery rate for uncomplicated mTBI.
- It is recommended that the first set of early treatment includes sleep hygiene recommendations; limited use of caffeine, tobacco, and alcohol; progressive return to normal work activity and exercise; prevention of subsequent head injuries; and reassurance and self-management.
- When symptoms persist beyond seven days, a number of conservative measures aimed at the causes identified in the thorough physical exam can be effective.
- Early conservative treatments for the following conditions include:
  - Pain: Over the counter medication for headaches and neck pain should be encouraged. Ergonomic positioning of the head/neck at work or home may also be important. For headaches persisting beyond four weeks or causing incapacitating symptoms, refer to the headache portion of this guideline for a number of available treatments.

- Photophobia: Lights may disturb patients with mTBI. FL-41 tinted lenses, neutral tinted lenses, and/or other ambient lighting changes may be beneficial in managing this symptom.
- Hyperacusis: Some patients may suffer from acute sensitivity to sounds encountered in everyday life. In these situations, the use of ear filters that do not compromise safety are likely to be beneficial.
- Sleep disturbances: Problems with sleep should be addressed early and followed throughout the course for mTBI. Lack of sleep may be a primary instigator of cognitive complaints and is common in mTBI. Patients should be advised regarding normal sleep hygiene measures. These include: avoiding use of computers or mobile phones for several hours before bedtime, limiting use of caffeine or alcohol, and following a regular schedule for going to bed and arising. Use of a sleep diary may assist in adjusting sleep times. Persistent sleep disturbance may also be addressed with cognitive behavioral therapy (Ontario Neurotrauma Foundation, 2013). Refer to Section F.4, Sleep disturbances.
- Cognitive complaints: In most cases, persistent cognitive complaints are associated with other risk factors such as additional medical problems, negative self-beliefs or expectations, or low coping skills. When symptoms persist beyond 2 weeks and are exerting any influence on daily functioning, they must be addressed by the physician.

  In mTBI, it is rarely appropriate to supplement treatment with medication for cognitive issues. If medication is prescribed, the provider should follow the patient closely, especially when prescribing medication with a risk for long-term addiction.

  Use of calendars or reminders on mobile phones or computers are likely to be useful during the initial stage of recovery. The patient's support system may also provide assistance.
- Balance and visual problems: Balance and vestibular complaints, such as dizziness and disequilibrium, and visual changes may be subtle and not detected using common neurological testing.

  The provider should consider limited treatment by qualified personnel if the vestibular or visual symptoms continue beyond the first 2 weeks. Limited treatment can usually be provided by a therapist with a specialty in these areas (e.g., vestibular therapist).

  Visual symptoms may be addressed with visual tracking rehabilitation in a limited number of visits. The efficacy of visual training / vision therapy without the guidance of a specialist is unproven. Therefore, it should be provided by a trained therapist such as a vestibular therapist.
- Hearing loss or tinnitus: Any reported hearing loss requires evaluation. If tinnitus persists, no specific treatment during the acute recovery period is usually recommended; however, evaluation by a specialist is recommended for persistent symptoms.

- Psychological concerns: It is appropriate to screen patients for anxiety, depression, stress, and post-traumatic stress disorder and to begin treatment if one of these is identified.
- Fatigue: Fatigue associated with TBI is distinct from tiredness or sleepiness. Treatment for fatigue should include exploration of other accompanying issues. Patient-reported fatigue can also have a psychological basis, so it is important to account for the impact of stress and/or psychiatric diagnoses on the patient's fatigue. Treatment may require a combination of rest, sleep, and change of task. Blue light therapy has been shown to be useful to relieve complaints of fatigue and could be suggested for morning and afternoon use in those with fatigue.
- Persistent symptoms without likely identifiable pathologic findings: These should be acknowledged and providers may initially treat them with the simple conservative measures described. Not all reported symptoms in mTBI require prolonged or complex treatment.

D.4 Assessment of current function

This may be done by open-ended questioning supplemented with a reliable, generally accepted functional self-report assessment tool, such as the Rivermead Post Concussion Symptoms and Neurobehavioral Symptom Inventory (Management of Concussion-Mild Traumatic Brain Injury Working Group, 2016; Ontario Neurotrauma Foundation, 2013). The Rivermead Post Concussion Symptoms and Neurobehavioral Symptom Inventory is not to be used as a diagnostic tool. Functional status evaluations not only assist the provider in choosing appropriate return-to-work modifications, they also establish the efficacy, or lack thereof, for current treatment. See Positive Patient Response under General Guideline Principles above. Payers may temporarily discontinue coverage of treatment if providers are not documenting patient functional improvement or progress. Payers are required to request that providers document improvement or lack thereof before discontinuing coverage.

D.5 Resumption of normal activities

The provider should individualize recommendations for rest and timelines for resumption of modified and normal activities based on the individual circumstances of the patient and his/her work. It is suggested that the patient receive recommendations for decreased cognitive and physical activities during the first 24 hours, particularly if those activities increase any symptoms for the patient such as headache and/or photophobia. In many cases, the patient should return to limited work activities after the first 24 hours with limitations on intensive physical or cognitive activities. General guidelines have suggested that the progress of activities be based on the intensity or recurrence of physical symptoms by the patient. However, the provider will need to weigh all this information in conjunction with the specific work load for the patient.

Literature supports an individualized approach. One study looked at young patients (11-18 years old) with mTBI and compared the treatment of rest or usual care for those patients with signs of injury based on neurocognitive and balance testing and those only reporting symptoms. The patients with signs of injury on testing benefited from the rest. In contrast, those with only symptoms were less likely to benefit from rest, and they were more likely to remain symptomatic three days after injury when prescribed rest (Sufrinko et al., 2017). A recent review of the literature found no quality studies but suggested that low level of exercise could benefit athletes post mTBI (Sawyer, Vesci, & McLeod, 2016). Of note, in a randomized trial of adults with mTBI who received emergency room discharge instructions of two kinds of rest (cognitive rest or gradual return to duty), there was no difference between the groups regarding time off work or school, change in the post-concussion symptom score, or follow up physician visits. 30% had some symptoms at 4 weeks (Varner et al., 2017). Other reviews and consensus statements confirm the lack of evidence for long-term rest or specific non-individualized return to activity (Collins et al., 2016; Kamins et al., 2017; McCrory et al., 2017). Literature suggests that people who have had multiple TBIs may recover more slowly and thus may take more time to return to normal function.

D.6 Return to work or study

Most patients can return to work within the first week when modified duty is available. The provider should carefully consider the patient's reported symptoms and order modifications to address these. Psychological factors also need to be considered when evaluating the appropriateness of returning the patient back to work. Restricting work during the initial stages of recovery may be indicated to promote recovery. Initially, many patients may need reduced hours at work, rest breaks, and reduced task assignments. Both physical and cognitive duties should be non-stressful initially, with a gradual increase in activity based on improvement and/or resolution of symptoms. The individual should be competent in most basic ADLs before return to work is considered. The provider may need to engage a return-to-work specialist or employer contact to obtain a job description and assess the patient's ability to return to the workforce. Safety sensitive positions such as responsibilities that require driving or work on ladders, at heights, or across scaffolding may require reduced duties for some time until adverse symptoms which might affect job duties have abated. Repeated evaluation of both symptoms and cognitive status is recommended to help guide management considerations. Physiologic changes on a variety of diagnostic tests after sports concussion appear to persist longer than clinical changes. Clinical assessment should be used to determine relevant activity and work (Kamins et al., 2017).

D.7 Further testing

Studies support the concept that for most patients, neuropsychological testing is not advocated and is not required for mTBI during the first 30 days and that full neuropsychological battery can be delayed (Ontario Neurotrauma Foundation, 2013). However, if the provider has clearly delineated psychological complaints such as post traumatic symptoms, anxiety, or other areas that may require testing, neuropsychological or psychological testing may be recommended earlier (Ponsford et al., 2012). If earlier testing is thought to be necessary to verify or establish specific information in a case, it should assess specific issues such as patient's concerns, behavioral deficits, and/or cognitive deficits. It should also consider if secondary psychological issues may be interfering with cognitive functions. Serial testing may be helpful in tracking the patient's status over time.

One study documented productivity loss in patients with mTBI and persistent post-concussion symptoms and comorbid psychiatric condition (Silverberg, Panenka, & Iverson, 2018). Thus, treatment of psychological conditions is important for full functional recovery.

Screening psychological tests focused on anxiety, stress, depression, and/or post traumatic symptoms, such as those adopted by the Division of Workers' Compensation Quality Performance and Outcome Payments (QPOP, see Rule 18-8) program may be performed by primary care providers at any time.

D.8 8-12 weeks post-injury care

If a patient has persistent symptoms or complaints at 60 days and the initial portion of this guideline has been completed, it is suggested that a referral be made to a neurologist or physiatrist with extensive experience in mTBI treatment. It is important for the primary provider to remember that many frequently reported symptoms may be related to other physiologically based diagnoses, psychological issues, or pain issues. The considerations that exist for chronic pain patients also may be present for these patients. The Division's Chronic Pain Disorder Medical Treatment Guideline may be more appropriate for patients with multiple injuries.

When continuing symptoms persist:

- Repeat detailed neurological examination by 90 days post-injury.
- Complete neuropsychological testing, if not already performed (Ontario Neurotrauma Foundation, 2013).
- Refer to other qualified specialists, such as neuropsychologists, ophthalmologists, or neuro-otologists when continuing symptom complaints suggest additional pathology.
- Reassure patients that for most people with mTBI, persistent symptoms are unlikely to significantly interfere with most daily living activities and can be ameliorated with rehabilitation techniques.
- Reinforce the positive prognosis with the injured worker. Overall, the need for long-term treatment of a patient with mTBI is uncommon.

In approximately 10-25% of patients, chronic symptoms requiring treatment are associated with mTBI (Ontario Neurotrauma Foundation, 2013; Yue et al., 2017). In individuals with mTBI, neurological recovery is generally achieved at one year post-injury or sooner, but functional changes occur beyond one year. In the absence of secondary or tertiary complications like hydrocephalus, seizures, initial abnormal MRI findings, or extra-axial fluid collections (e.g., subdural or epidural fluid collections), ongoing improvement with eventual stability of symptoms is the general expectation after mTBI. Deterioration over time after mTBI is uncommon. In situations where patients have worsening complains or continuing symptoms affecting function after mTBI, other issues such as psychosocial issues, sleep disturbance, pain, or other medical issues should be considered in the differential diagnosis.

D.9 Multiple mTBIs versus chronic exposure to concussive forces

Studies on chronic traumatic encephalopathy (CTE) are based on the respective number of recalled traumatic brain events and autopsy findings. Currently, a diagnosis of CTE can only be made post mortem. The applicability of these data outside of sports-related injury, in which a stereotypic application of force may have occurred multiple times and without opportunity for recovery, is not known. These limitations do not allow for a reasonable determination of the type or number of previous events that might correlate to permanent damage.

Thus, any cases alleging multiple events as causative for permanent neurological impairment will need to be determined on an individual basis. A comprehensive diagnostic evaluation should be completed to rule out dementias or other neurological factors.

Tables of evidence statements and supporting literature for the Overview

Evidence statements regarding prognosis and risk factors			
Good evidence	Evidence statement	Citation	Design
	Psychosocial factors such as pre-injury general health are important determinants of recovery from acute mild head injury and may be as predictive or more predictive of recovery than such phenomena as abnormal CT findings.	(Cassidy et al., 2014)	Systematic review of observational studies
	TBI is associated with an important increase in risk of all-cause mortality six months and more after injury. This includes death from suicide, assault, and unintentional injuries. The increase in risk is approximately threefold, and it appears to be independent of sociodemographic factors such as income and marital status.	(Fazel, Wolf, Pillas, Lichtenstein, & Langstrom, 2014)	Longitudinal cohort study from a population registry database

Evidence statements regarding prognosis and risk factors			
Some evidence	Evidence statement	Citation	Design
	While neuropsychological testing scores resolve in complicated and uncomplicated mTBI patients during the year after injury, a significant level of physical, cognitive, and emotional symptoms persist for some patients 1 year after injury when compared to symptoms reported by patients who had been admitted to hospital emergency departments with non-head injuries.	(Dikmen et al., 2017)	Prospective cohort study
	Patients who have been seen in an emergency department for an uncomplicated mTBI do as well on a battery of standard neuropsychological tests as patients who have been treated in an emergency department for non-head injuries when these tests are administered one month after the date of injury.		

Studies regarding prognosis and risk factors not resulting in evidence statements
In one study, 16% of patients with mTBI had lower executive function at 1 year. This was related to post-concussion symptoms, mood, and self-report (Barker-Collo et al., 2015). Another study noted that those with symptoms at 1 year had significant psychological risk factors at 1 month (Losoi et al., 2016). Perceived injustice, a belief that one has been treated unfairly and disrespectfully, is also associated with persistent post-concussive symptoms (G. L. Iverson, Terry, Karr, Panenka, & Silverberg, 2018). An additional study identified worse performance on complex attention, cognitive flexibility, processing speed, and executive function for those with PTSD and mTBI compared to PTSD alone or controls (Dretsch et al., 2017).

Studies regarding prognosis and risk factors not resulting in evidence statements
A study of young military members experiencing reported post-concussion symptoms in a questionnaire found that depression, traumatic stress, loss of consciousness greater than 15 minutes, post traumatic amnesia 24 hours or more, initial normal CT scans, and poor effort or symptom magnification were all associated with positive post-concussion symptoms. The study emphasized for the need for clinical evaluations rather than sole reliance on checklists (Lange et al., 2013). Other studies confirm the association of increased self-reported symptoms with injury-related stress and premorbid mental and physical health issues (Cassidy et al., 2014).

Evidence statements regarding vestibular symptoms and treatment			
Some evidence	Evidence statement	Citation	Design
	In patients with a sport-related concussion who have persistent dizziness, neck pain, and/or headache 10 days after injury and who are suspected by a physician of having vestibular involvement or cervical spine involvement, an 8 week program of combined cervical physiotherapy and vestibular rehabilitation is likely to improve the rate of medical clearance for return to sport.	(K. J. Schneider et al., 2014)	Randomized clinical trial

Evidence statements regarding psychological treatment			
Some evidence	Evidence statement	Citation	Design
	From a small study: 5 individual sessions, 1.5 hours long, of Cognitive Behavioral Therapy (CBT) initiated for patients diagnosed with acute stress disorder early after TBI are significantly more effective than supportive counseling in preventing chronic PTSD in patients who develop acute stress disorder following mTBI.	(Bryant, Moulds, Guthrie, & Nixon, 2003)	Single-blind randomized clinical trial

Evidence statements regarding fatigue			
Strong evidence	Evidence statement	Citation	Design
	Subjective fatigue is more prevalent following mTBI than in healthy controls. It is important to note that studies differ in how fatigue is defined, how it is tested for, and how results are interpreted. This leads to uncertainty in estimates of the frequency of fatigue.	(Mollayeva et al., 2014)	Systematic review of prognostic studies of TBI
Good evidence	Evidence statement	Citation	Design
	Baseline fatigue, medical comorbidity, and litigation are likely to be risk factors for fatigue in patients recovering from mTBI.	(Mollayeva et al., 2014)	Systematic review of prognostic studies of TBI
	Some post-traumatic symptoms such as fatigue are not specific to head injury but also occur with non-head injuries such as fractures, sprains, and other injuries which are not associated	(Cassidy et al., 2014)	Systematic review of observational studies

Evidence statements regarding fatigue			
	with TBI.		
Some evidence	Evidence statement	Citation	Design
	A blue light therapy device with a wavelength of 465 nm, used in the morning upon awakening, can alleviate the severity of fatigue associated with TBI, but the benefits do not persist after the use of the light has been discontinued.	(Sinclair, Ponsford, Taffe, Lockley, & Rajaratnam, 2014)	Randomized clinical trial

Evidence statements regarding early symptoms			
Some evidence	Evidence statement	Citation	Design
	There is little symptomatic or functional gain for patients who have persisting symptoms, such as headaches, fatigue, blurred vision, sleep disturbance, and the like 10 days after an mTBI, and are referred for an early single follow-up office visit with a specialist.	(Matuseviciene, Eriksson, & DeBoussard, 2016)	Randomized clinical trial
	Early and active individual rehabilitation treatment initiated within 2 to 8 weeks after an mTBI injury for patients with post-concussion symptoms does not significantly reduce post-concussion symptoms or improve life satisfaction one year after injury, compared with a non-intervention control group.	(Elgmark Andersson, Emanuelson, Bjorklund, & Stalhammar, 2007)	Single-blind randomized clinical trial

Evidence statements regarding return to work			
Some evidence	Evidence statement	Citation	Design
	Predictors of delayed return to work include a lower level of education, nausea or vomiting on admission to an emergency room, extracranial injuries in addition to mTBI, and severe pain early after injury. Most workers with mTBI return to work within 3 to 6 months after injury, but there is a small percentage (5% to 20%) who face persisting problems 1 to 2 years after injury.	(Cancelliere et al., 2014)	Systematic review of observational studies

Evidence statements regarding persistent mTBI symptoms			
Good evidence	Evidence statement	Citation	Design
	In the setting of mTBI, patients are likely to report their pre-injury status as more favorable than it was likely to have been since they tend to report fewer pre-injury problems with common phenomena such as misplacing car keys and forgetting where they parked than are reported by healthy uninjured volunteers.	(Cassidy et al., 2014)	Systematic review of observational studies
Studies not resulting in evidence statements			
Many symptoms reported after mTBI are also frequently reported after other traumatic injuries and are not pathognomonic for mTBI. Pure self-evaluation questionnaires regarding function may not accurately reflect long-term changes and can be affected by IQ. In general, return to normal function can be expected (Heitger, Jones, Frampton, Ardagh, & Anderson, 2007).			

Evidence statements regarding chronic traumatic encephalopathy (CTE)			
Some evidence	Evidence statement	Citation	Design
	A history of repeated mTBI is a risk factor for the development of chronic traumatic encephalopathy, and among football players, the number of seasons of play may be correlated with the severity of disease.	(McKee et al., 2013)	Descriptive study of autopsy findings

E. Diagnosis

E.1 Initial diagnostic procedures

E.1.a History of injury

In order to establish the TBI diagnosis and treatment plans/goals, it is a generally accepted and widely used practice for a qualified practitioner to obtain a thorough history of the injury. Recommended data obtained in the history-taking generally should include:

- Identification data: Identification data should include name, address, age, gender, and marital/relationship status.
- Precipitating event: Information regarding the detailed circumstances of the TBI should include where and when the injury occurred, how the injury occurred, what the individual was doing at the time of the injury, and what happened. This may necessitate acquiring information from other sources if the patient does not have full recall. Reports from first responders should be obtained. If possible, collaborative information (e.g., witnesses, paramedic report, etc.) should be obtained to seek details of the event and the injured person's behavioral and cognitive responses immediately following the injury. The presence of alcohol and/or drug use at or prior to the time of the injury should be noted. All of this history should be used when establishing the presence of a TBI caused by a work-related event.

  If the injury occurred as a result of a motor vehicle crash, information should be obtained as to: the speed of the vehicle; position or location of the injured worker; use of restraints or helmet; degree of damage to the vehicle; all other involved vehicles, if known; involvement of EMS system, if any; and acute or sub-acute accident-related physical complaints or injuries, including other people involved, if known. The crash outcome regarding non-TBI complaints/injuries may enhance an understanding of the forces involved in the accident and will minimize the possibility of unrecognized physical injury. The accident report and any police records should be obtained and reviewed if available.

  If the injury occurred as a result of a fall, information should be obtained regarding the type of fall, distance of the fall, type of surface, etc. The goal is to provide a review of the biomechanical forces involved in the event.
- Alteration in consciousness: History should include a review of chief complaints, presenting problems, and symptoms, with the goal of obtaining additional information regarding the alteration of consciousness associated with the index injury. Generally accepted data should include information about duration of alteration of mental status, including consciousness, degree and length of retrograde and PTA, as well as cognitive, behavioral, and physical impairments, with collateral sources of information when possible. Information should be collected regarding various time intervals for the following:

- Current status: This is a report of the individual's current condition, symptoms, complaints, functional problems, etc.
- Initial status: This is a report of the individual's neurological condition at the time of the injury, symptoms, complaints, functional problems, etc. The GCS, when performed in the field and the emergency department, may aid in grading the severity of TBI. Individuals with mTBIs may have a normal score on the GCS. Serial GCS scores may be helpful when intoxication may be a factor. It may be helpful to ask the patient to describe in detail the first event they remember after the injury in order to assess PTA or loss of time sequence and what events they remember immediately prior to the injury (Ruff et al., 2009). When evaluating alteration in mental state at the time of the injury, it is also important to consider the individual's emotional reaction to the distressing event. As a practical example, the provider should contemplate whether the feeling of "being dazed" could be a manifestation of emotional numbing. It is possible to have dazing due to TBI including emotional reactions (e.g., numbing and/or detachment) or even acute pain in relation to the event. The diagnosis of acute stress disorder should be considered in evaluating individuals with possible mTBI.
- Evolution of neurological status: This is a report of change in the individual's recovery between the time of the injury and the present, including symptoms, complaints, and functional problems. The individual's report of when he/she was able to return to independent activity is relevant to understanding the course of the injury. A family and/or support system member's history of the patient's ability to perform his/her usual duties is often helpful. Other measures of functional activity that are standardized and can be repeated during treatment may also be useful.

- Review of medical records: In addition to the individual's self-report, practitioners should attempt to obtain and review any external sources of data, including police reports, ambulance reports, emergency department records, eyewitness reports, pre-injury medical records, etc. The practitioner should utilize this information to establish or verify the probable degree of trauma involved in the incident and the consistency between these reports and current symptoms.
- Medical/health history: Taking a history is a generally accepted practice and should include a history of past and current illnesses, injuries, previous TBIs or other disabilities, seizures/epilepsy, stroke, cerebrovascular disease, developmental/intellectual disabilities, neurodegenerative disorders, any previous intracranial pathology (such as infections, tumors, congenital malformations), pain, previous surgeries of any kind, mental health and medication history, sleep disorders, educational history, and other medical/health data. A report from family and/or support system members or other persons knowledgeable about the individual with TBI relevant to pre-injury as compared to post-injury function should be obtained.
- Activities of daily living (ADLs): A thorough history should be taken of daily activities. Basic ADLs include: self-care and personal hygiene, communication, ambulation, attaining all normal living postures, travel, non-specialized hand activities, sexual function, sleep, and social and recreational activities. Instrumental activities of daily living (IADLs) are complex self-care activities that may be delegated to others (e.g.,

financial management, medications, meal preparation). This assessment should delineate the changes in the individual's ability to perform ADLs prior to and after the injury and any assistance needed from family members or others.

- Family history: Family history should include psychiatric, including substance use and abuse, medical-legal involvement, and medical history of illness or disability within the family that is relevant to the individual's condition.
- Social history
  - Living situation: This should include marital history, family and/or support system members, household makeup, significant others, etc.
  - Occupational history: This should include the name of the individual's current employer, job title, primary job duties, special licenses or certifications, length of employment, prior places and dates of employment, and previous work-related injuries and their outcomes.
  - Developmental history: This should include educational history, highest level of education obtained, learning disabilities or disorders, any developmental delay, abuse, or neglect, etc.
  - Avocations: This should include common non-occupational activities, including leisure activities such as sports, hobbies, and personal interests.
  - Substance use history: This should be obtained (particularly if there is data to suggest substance abuse was involved in the injury) along with information related to the amount and duration of alcohol, drug, and marijuana use, licit and illicit, including prescription drug use and/or abuse.
  - Legal history: DUIs, violence, speeding/reckless driving violations, and other medical/legal issues.
- Review of systems: This is a generally accepted practice and should include a complete review of body systems and functions.
- Pain diagnosis: This is recommended, especially during the first visit to document all body parts involved. This should include a pain diagram completed by the patient, if able.
- Psychiatric history: Psychiatric history should be assessed at the initial visit and at follow-up visits. Depression and anxiety are common conditions pre-injury and following TBI, and symptoms may be subtle or unapparent unless directly assessed. Individuals may not always present with complaints of sadness or anxiety, but instead they may express feeling other symptoms that are commonly seen in clinical depression or anxiety, particularly disturbances of sleep and energy. Many individuals also tend to focus on somatic complaints that do not always correlate with objective findings. Therefore, it is crucial to question the individual, family and/or support system, and pre-injury medical records about significant changes in appetite, sleep disturbances (including nightmares), decreased interest in pleasurable activities, loss of energy, diminished ability to think or concentrate, irritability, suicidal ideation, history of suicide attempts, psychiatric

hospitalizations, mental health treatment, and feelings of emptiness, worthlessness, and excessive guilt.

E.1.b Physical examination

This is a well-accepted practice and should be performed by a qualified practitioner. A thorough trauma exam should be done during the initial exam and the first follow-up visit to ensure all complaints are addressed. The exam should include a complete cervical spine exam. It is hypothesized that dysfunction of the brain stem secondary to TBI may significantly contribute to the usual balance and sleep complaints accompanying mTBI.

E.1.c Neurological examination

A neurological examination should be performed by a qualified practitioner and should include a mental status examination. A comprehensive neurological examination includes, but is not limited to, mental status, cranial nerves, motor status, sensory status, balance and coordination, and gait and station. The mental status examination involves both formal and informal observations. It includes observations about the individual's presentation, social/behavioral decorum, personal hygiene, ability to provide a history, and ability to follow directions. A formal (structured) cognitive examination should be performed to the extent indicated by the situation. It includes an assessment of the individual's alertness, orientation, attention, concentration, memory, affect, mood, thought process and content, language, ability to perform simple calculations, and higher order assessments of reasoning, judgment, and insight (Guskiewicz, Perrin, & Gansneder, 1996; Guskiewicz & Register-Mihalik, 2011). Using a standard approach for all visits assists serial functional assessment.

E.1.d Neuropsychological evaluation

This is the evaluation of cognitive processes and behavior using psychological and neuropsychological testing to assess central nervous system function and to diagnose specific behavioral or cognitive deficits or disorders. Neuropsychological assessments are generally accepted and widely used as a valuable component of the diagnosis and management of individuals with TBI. They include sensitive tests that are used to detect cognitive deficits, severity of impairment, and improvement over time. Neuropsychological assessment assists in the differential diagnosis of neurobehavioral disorders and the cumulative effect of multiple TBIs.

Neuropsychological assessments may be utilized to formulate how the individual's underlying TBI impacts behavior and the ability to function effectively in daily life. These assessments are also used as a basis for formulating rehabilitation strategies and may provide information related to prognosis and outcome.

Neuropsychological assessments utilize standardized testing procedures. Test reliability and validity are important considerations. Examiners should be aware that abnormal cognitive function may occur in the setting of chronic pain, psychological disorders, sleep deprivation, medication use, malingering, developmental/intellectual disabilities, acute or chronic substance abuse, and comorbid or pre-existing cognitive or neurologic disorders. In cases where comorbid diagnoses are suspected, formal psychological evaluation should accompany the neuropsychological battery to assist in characterization and differentiation of diagnoses. Multiple sources of data (self-report information, medical history, Emergency Medical Services [EMS] records, psychosocial history, family report, etc.) are integrated with test performance factors to draw inferences about brain-behavior relationships. The individual's cultural background, race, age, primary language, and developmental and educational history should be considered. Neuropsychological testing may not be valid when English is not the patient's primary language. When practical, educational records including history of learning disability should be obtained and reviewed.

The specific neuropsychological tests used may vary according to the symptom presentation of the individual and the purpose of the evaluation. Tests usually assess the following cognitive domains: level of orientation, attention, language, memory, praxis, executive function, speed of processing, visual-spatial ability, recognition, personality, and function. All reports should include a clinical interview that notes the patient and family medical / psychiatric / substance abuse history, developmental milestones, educational history, psychosocial issues, and current medical conditions and treatment. Interpretation of these tests should always discuss the impact of information from the clinical interview that might affect test results, such as medications causing confusion or drowsiness, lack of sleep, anxiety, depression, and similar issues.

Based on the evidence listed in the table at the bottom of this subsection, early neuropsychological testing may not validly differentiate changes due directly to mTBI from changes due to experiencing a physically traumatic event. Therefore, neuropsychological testing is not typically recommended prior to three months post-injury.

However, there are permitted exceptions for earlier evaluation. Individuals with mTBI should be considered for testing, prior to three months when:

- the patient is not recovering well early in the course of treatment, or
- the patient has a cognitively demanding job or works in a safety sensitive position.

The referral for neuropsychological assessment prior to three months post mTBI may be advantageous for those patients meeting the indications above because it documents the attentional, memory, emotional status, other cognitive deficits and strengths, and preserved cognitive capabilities.

Neuropsychological consultation and/or assessment may be useful prior to three months for:

- documenting a post-injury baseline and the time course of improvements in attentional functioning, memory, and executive functions in order to contribute to treatment planning;
- providing relevant information regarding the individual's current functioning in domains such as speed of information processing, memory, and executive functions. A test battery that permits serial testing focused on attention/concentration skills, memory, speed of processing, executive functions, and emotional/personality status may be indicated.

In some cases, brief neuropsychological testing may be beneficial in increasing patient awareness of the presence of impaired functioning.

Validity testing is required for all neuropsychological testing to assess performance and symptoms. The testing can provide a baseline for following the injury and permits the adequate documentation of the severity of the injury and improvements over time.

Evidence statements regarding initial neuropsychological testing for mTBI			
Some evidence	Evidence statement	Citation	Design
	Patients who have been seen in an emergency department for an uncomplicated mTBI do as well on a battery of standard neuropsychological tests as patients who have been treated in an emergency department for non-head injuries when these tests are administered one month after the date of injury.	(Dikmen et al., 2017)	Prospective cohort study

E.1.e Neurodiagnostic tests

E.1.e.1 Imaging procedures

E.1.e.1.1 Skull x-rays

These are well-established diagnostic tools used to detect a fracture of the cranial vault.

Skull x-rays are generally accepted only if CT scans are not available or in cases where there is only a low suspicion of intracranial injury.

E.1.e.1.2 Computed axial tomography (CT)

For acute brain trauma, iodine contrast enhancement is not necessary. CT scans are noninvasive and will reveal the presence of blood, skull fracture, and/or structural changes in the brain. They do, however, expose the patient to higher doses of ionizing radiation than skull radiographs. CT scans provide somewhat limited information compared to MRI about intrinsic cerebral damage involving deep brain structures, although many types of intrinsic damages can be seen on CT scans.

CT is a well-established brain imaging x-ray study comprised of a mathematical reconstruction of the tissue densities of the brain, skull, and surrounding tissues. CT scans require the use of computer-based scanning equipment.

CT scans are widely accepted for acute diagnostic purposes and for planning acute treatment.

They are the screening image of choice in acute brain injury and are used to assess the need for neurosurgical intervention.

If fractures are suspected, CT scanning is preferred over skull x-rays because of its much higher sensitivity and accuracy and its ability to identify clinically significant fractures as well as potentially co-existent contusions or hemorrhages.

CT scans are recommended for abnormal mental status (GCS less than 13 on admission), focal neurologic deficits, or acute seizure. CT scans are recommended for the following patients (Amyot et al., 2015; MDCalc, 2018):

- High risk
    - GCS less than 15 at two hours post-injury;
    - suspected open or depressed skull fracture;
    - any sign of basilar skull fracture (e.g., hemotympanum, raccoon eyes, Battle's Sign, CSF oto-/rhinorrhea);
    - greater than or equal to two episodes of vomiting;
    - age equal to or greater than 60.
- Other risk
    - retrograde amnesia to the event greater than or equal to 30 minutes;
    - "dangerous" mechanism (e.g., pedestrian struck by motor vehicle, occupant ejected from motor vehicle, fall from greater than three feet or more than five stairs);
    - coagulopathy, including use of use of anticoagulant medication;
    - focal neurologic deficits;
    - acute seizure;
    - severe and persistent headache;
    - physical evidence of trauma above the clavicles and/or multiple trauma and/or basilar skull fracture;
    - drug or alcohol intoxication;
    - any recent history of TBI, including mTBI.

E.1.e.1.3 Magnetic resonance imaging (MRI)

MRI is a well-established brain imaging study for patients with TBI in which the individual is positioned in a magnetic field and a radio-frequency pulse is applied. Hydrogen proton energy emission is translated into visualized structures. Altered signal intensity compared to normals may indicate trauma or other disease.

CT is superior to MRI in detecting acute intracranial bleeds and remains the preferred initial imaging study in the first 24 hours following TBI.

MRI should not be used to diagnose mTBI. Initially, MRI scans are clinically useful in the following situations to:

- determine neurological deficits in TBI not explained by CT;
- evaluate prolonged intervals of disturbed consciousness or other prolonged alteration in mental status;
- define evidence of acute changes super-imposed on previous trauma or disease.

MRI scans are also useful to assess transient or permanent changes, to determine the etiology of subsequent clinical problems, and to plan treatment.

MRI may reveal an increased amount of pathology compared to CT. Due to their high contrast resolution, MRI scans are superior to CT scans for the detection of some intracranial pathology (e.g., axonal injury, subtle cortical contusions, small extra-axial fluid collections, etc.) but not bone injuries such as fractures. MRI is more sensitive than CT for detecting traumatic cerebral injury.

Specific MRI sequences and techniques are very sensitive for detecting acute traumatic cerebral injury. They may include, but are not limited to: diffusion weighted imaging (DWI), susceptibility weighted imaging, gradient echo weighted imaging, and fluid attenuated inversion recovery (FLAIR). Some of these techniques are not available on an emergency basis.

E.1.e.2 Vascular imaging tests

Vascular imaging tests reveal arterial or venous abnormalities in the chest, neck, head, or extremities (e.g., thrombosis, dissection, spasm, emboli, or tearing).

These tests are generally used if standard CT/MRI scans fail to demonstrate suspected vascular abnormalities. However, only rarely are they useful in mTBI. If needed, refer to the Division's Moderate/Severe TBI Medical Treatment Guideline.

Brain Acoustic Monitor: This device identifies turbulent blood flow in the brain. It is considered investigational for the purpose of detecting deficits requiring CT scanning in the emergency room. Based on the evidence listed in the table below, it is ***not recommended*** at the time of this guideline (Dutton et al., 2011).

Evidence against use of a brain acoustic monitor as an initial diagnostic procedure for TBI			
Some evidence	Evidence statement	Citation	Design
	A Brain Acoustic Monitor cannot reliably predict the development of post-concussive symptoms.	(Dutton et al., 2011)	Diagnostic cohort study

E.2 Further diagnostic procedures

E.2.a Electrodiagnostic studies

These are limited to electromyogram (EMG), nerve conduction studies, and multisensory evoked potentials including visual evoked potentials (VEP), somatosensory evoked potentials (SSEP), and brain stem auditory evoked responses (BSAER).

E.2.a.1 EMG and nerve conduction studies

These are generally accepted, well-established diagnostic procedures. These studies may be useful for individuals with brain injury and EMG associated suspected peripheral nervous system involvement. They are often used to differentiate peripheral versus central spinal cord or brain deficits. These electrodiagnostic studies are possibly complementary to other imaging procedures such as CT, MRI, and/or myelography. These studies provide useful correlative neuropathophysiologic information that is unattainable from standard radiologic studies.

E.2.a.2 Electroneuronography (EnoG)

EnoG is a well-established and generally accepted test that measures facial nerve function. This test measures the action potential of different branches of a facial nerve. It is used in individuals with TBI resulting in a facial paralysis and is key in determining the need for surgical intervention. This test is most useful within the first three weeks of facial nerve dysfunction. If the action potentials on the affected side are 90–100% less than those on the normal side, it suggests significant injury to the nerve and calls for surgical exploration. Individuals with TBI whose nerve is less than 90% decreased in function have a reasonably good outcome with observation alone.

E.2.a.3 Dynamic electromyographies

These are electrodiagnostic studies utilized to distinguish the voluntary capacity of a muscle from a spastic reaction. This aids the clinician in better planning specific rehabilitative treatment. This study is helpful in the differential diagnosis and diagnostic work-up of disordered muscle tone. This is a generally accepted procedure.

E.2.a.4 Evoked potential responses (EP)

EPs are generally accepted, well-established diagnostic procedures. EPs are central nervous system electrophysiologic responses to a stimulus, either externally generated via one or more sensory modalities or internally generated via the processing of information. Multisensory EP studies are limited to visually evoked potentials, brain stem auditory evoked potentials, somatosensory evoked potentials, and cognitive evoked potentials.

E.2.a.4.1 Auditory brainstem response (ABR)

ABR is a generally accepted diagnostic procedure useful in assessing damage to the brain stem, midbrain, and other neural structures that govern hearing and/or balance. A normal test does not rule out structural damage, and the test may be abnormal in middle ear and non-traumatic disease affecting the auditory pathway. Waves one, three, and particularly five are most useful in assessing injury. While amplitude and the presence of wave are important, the latency and interwave latency are equally important. This test is often sensitive but non-specific. It may be useful in some cases and requires **prior authorization**.

E.2.a.4.2 Electroretinogram (ERG)

ERG is a generally accepted diagnostic procedure for occult retinal trauma accompanying TBI. Most traumatic retinal pathology presents as a field deficit detected by direct examination. ERG cannot detect mild changes in retinal function, and normal results should not be taken as evidence against ocular dysfunction. ERG requires **prior authorization**.

E.2.a.4.3 Cognitive event-related potential

Event-related potential provides no diagnostic information in mTBI that cannot be obtained through other diagnostic procedures and is ***not recommended in mTBI***. It may be justified if other neurological diagnoses are suspected. It requires **prior authorization**.

E.2.a.4.4 Somatosensory evoked potential (SSEP)

SSEP provides no information in mTBI that cannot be obtained through other diagnostic means. SSEP is ***not recommended in mTBI***. It may be used when other diagnoses are suspected. It requires **prior authorization**.

E.2.a.4.5 Visual evoked potential (VEP)

VEP is a generally accepted diagnostic procedure. Pattern reversal monocular VEP recording may detect pathology in the anterior-posterior visual pathway from the retina to the occipital cortex. It may be indicated in the event of compromised acuity or visual field defect. The VEP may occasionally be normal in cases of severe structural damage if there is enough preserved central visual field. Unfortunately, VEP is highly susceptible to artifact and has a low specificity for structural injury to the visual pathways. Therefore, **prior authorization** is required.

E.2.a.4.6 Vestibular evoked myogenic potentials (VEMP)

Refer to Section E.2.i, Neuro-otology.

E.2.b Electroencephalography

E.2.b.1 Electroencephalography (EEG)

EEG is a well-established diagnostic procedure that monitors brain wave activity using scalp electrodes and provocative maneuvers such as hyperventilation and photic strobe for the purpose of seizure diagnosis. Information generated includes alterations in brain wave activity such as frequency changes (non-specific) or morphologic (seizures). EEG is not generally indicated in the immediate period of emergency response or during acute evaluation and treatment. Following initial assessment and stabilization, the individual's course should be monitored. If during this period there is failure to improve or the medical condition deteriorates, an EEG may be indicated to assess seizures, focal encephalopathy due to persistent effects of hemorrhage, diffuse encephalopathy due to the injury, or other complicating factors such as hydrocephalus or medications. A normal EEG does not definitively rule out a seizure disorder. If there is sufficient clinical concern that a seizure disorder may exist despite a normal EEG, then a 72-hour ambulatory EEG or inpatient video-EEG monitoring may be appropriate.

E.2.b.2 Quantified electroencephalography (QEEG) (Computerized EEG)

QEEG is a modification of standard EEG using computerized analysis of statistical relationships between power, frequency, timing, and distribution of scalp recorded brain electrical activity. These statistically generated values are then compared to those recorded from selected control and specific populations, generally using multiple regression analysis of multiple measurements and calculated parameters.

Recent studies suggest that in the future, QEEG may become a useful tool in the retrospective diagnosis of TBI and its severity, but this application remains investigational (Arciniegas, 2011; Coburn et al., 2006). QEEG is ***not recommended for diagnosing mTBI or M/S TBI***.

E.2.c Neuroimaging

Practitioners should be aware of the radiation doses associated with various procedures. Coloradans have a background exposure to radiation, and unnecessary CT scans or x-rays increase the lifetime risk of cancer death (Hendrick et al., 2011).

E.2.c.1 Structural imaging

E.2.c.1.1 Computed axial tomography (CT)

CT may be used to follow identified pathology or to screen for late pathology. Subsequently, CT scans are generally accepted when there is suspected intracranial blood, extra-axial blood, hydrocephalus, altered mental state, or a change in clinical condition, including development of new neurological symptoms or post-traumatic seizure (within the first days following trauma). Once the initial acute stage has passed, MRI scans are frequently ordered as opposed to CT.

Repeat CT scans are usually not necessary for most patients with mTBI (loss of consciousness and/or retrograde amnesia and Glasgow Coma Scale greater than 12). In one study, 95 mTBI adult patients were admitted to the hospital for observation and did not have a repeat CT if their Glasgow Coma Scale was 15 at 24 hours. Patients with repeat head trauma, coagulopathy, or other medical problems were excluded. No patients needed a neurosurgical intervention, and only 8% had repeat CTs (Anandalwar et al., 2016).

Another systematic review concluded that routine CT repetition rarely identified conditions needing surgical intervention (Stippler et al., 2012). Nevertheless, risk factors for a further bleed or neurological deterioration from the following conditions would warrant repeat CTs:

- skull fracture,
- coagulopathy or anticoagulation,
- age over 60,
- epidural hematoma,

- suspected open or depressed skull fracture,
- continuing severe headache,
- moderate to severe TBI (Stippler et al., 2012), and
- continuing TBI symptoms.

E.2.c.1.2 Magnetic resonance imaging (MRI)

MRI is the image of choice to detect the late, sub-acute, and chronic structural changes in the brain which underlie abnormal functioning. It is a well-accepted technique for follow-up imaging. Complications of TBI that may be explained by MRI include, but are not limited to: post-traumatic epilepsy, post-traumatic movement disorder, post-traumatic cranial neuropathy, post-traumatic infection, or failure to recover within the expected time frame. (Refer to Section E.2.c.3, Advanced MRI techniques, for more advanced imaging.)

Diffusion tensor imaging (DTI), susceptibility-weighted imaging, and magnetic transfer imaging: These have been used to explore the effects of mTBI. They remain research tools because, as of the time of this guideline, there are no studies validating their clinical use to differentiate patients with cognitive deficits from those without. They are ***not recommended to diagnose mTBI***. DTI may be useful for identifying pathology and guiding treatment in patients with documented physiological deficits, such as hemianopsia (Yeo, Kim, Kim, Kim, & Jang, 2012), but interpretation of results is very dependent upon the experience and skill of the neuroradiologist. DTI may be used when an accompanying MRI is ordered for purposes other than diagnosing mTBI. DTI may not be used in isolation to diagnose mTBI.

E.2.c.2 Dynamic imaging

In contrast to anatomical imaging procedures, the following procedures are designated to detect physiologic activity of the brain, including cerebral blood flow and cerebral metabolism. Both PET and SPECT scans can subject the patient to significant radiation levels (Shetty et al., 2016). **Prior authorization** is required for these procedures.

E.2.c.2.1 Single photon emission computed tomography (SPECT)

SPECT is not generally accepted as a diagnostic test for TBI of any severity and is considered investigational for diagnostic purposes. SPECT may not be used in isolation to diagnose mTBI. It is a functional image of the brain created by a flow tracer or a receptor-binding substance tagged with a radionuclide and injected intravenously into the individual. The radiotracer is assumed to accumulate in different areas of the brain proportionately to the rate of delivery of nutrients to that volume of brain tissue. Using a gamma camera and the techniques of CT, a 3-D image of the distribution of a radionuclide in the brain is obtained. SPECT may identify areas of decreased perfusion and provide a qualitative estimate of regional cerebral blood flow (CBF), which correlates with metabolism in many neurologic disorders. There is a variable correlation of SPECT with other measures, such as neuropsychological test findings. Its interpretation should take into account its low specificity, making the predictive value of SPECT no better than CT (Gowda et al., 2006).

Although it should not be used to diagnose mTBI, there is some evidence that SPECT may provide useful information in some cases in which the prognosis is in question, particularly if structural neuroimaging is normal (Jacobs, Put, Ingels, Put, & Bossuyt, 1996). Given its high sensitivity, SPECT may be useful when expected recovery from mTBI is not occurring within several months from the time of injury. Thus, the primary use of SPECT is as a tool for prognosis in patients with mTBI who are not progressing and have continued symptoms (Amyot et al., 2015; Van Der Naalt, 2015). A normal SPECT scan in this setting indicates a likelihood of resolution of symptoms within twelve months. However, due to its lack of specificity, an abnormal SPECT scan does not mean that symptoms will persist. Symptoms may resolve even when areas of abnormal perfusion continue to be seen on the SPECT scan (Belanger, Vanderploeg, Curtiss, & Warden, 2007; Kou et al., 2010).

In all severities of TBI, **prior authorization** is required and it is recommended that medical necessity and clinical usefulness for this study be justified (Wintermark et al., 2015).

E.2.c.2.2 Positron emission testing (PET)

PET is a functional brain imaging procedure. A tracer molecule tagged with a positron-emitting radioisotope is injected into the body. Biodistribution of the tracer is imaged, producing information about local cerebral glucose utilization and cerebral perfusion. This procedure requires on-site access to a cyclotron.

PET can reveal areas of decreased metabolism in the brain. Little information is available about its use and results in mTBI. In all severities of TBI, it is recommended that medical necessity and clinical usefulness for this diagnostic study be justified. It is not generally accepted as a diagnostic study and should not be used solely to diagnose the presence of TBI. Any requested use requires **prior authorization** (Belanger et al., 2007; Wintermark et al., 2015).

Evidence statements regarding follow-up diagnostic procedures			
Some evidence	Evidence statement	Citation	Design
	Although it should not be used to diagnose mTBI, SPECT may provide useful information in some cases in which the prognosis is in question, particularly if structural neuroimaging is normal.	(Jacobs et al., 1996)	Consecutive case series

E.2.c.3 Advanced MRI techniques

At the time of writing this guideline, all advanced MRI techniques are ***not recommended for diagnostic purposes*** (Douglas et al., 2015; Ellis et al., 2016; Ma, Zhang, Wang, & Chen, 2016; Toth, 2015). While they can identify anatomic physiologic variation, the changes cannot clearly be related to the need for specific treatment. They require **prior authorization** and justification of the medical necessity and clinical usefulness of the study.

E.2.c.3.1 Magnetic resonance (MR) spectroscopy

This is a noninvasive test that applies a burst of radio frequency energy to tissue inside an applied magnetic field. The resulting excitation and relaxation of nuclei generates a signal that carries information about the chemical environment of those nuclei. MR spectroscopy may detect changes in levels of n-acetyl-aspartate, an intermediate in neurotransmitter synthesis that is present in large amounts in normal functioning neurons but is decreased in damaged brain tissue. Its spectral signal may correlate with neuronal integrity and function and may show loss of function in tissue, which appears normal on conventional CT or MRI studies. MR spectroscopy may increase the sensitivity of MR imaging for traumatic lesions. This sensitivity may allow for increased correlation to more specific neuro-cognitive deficits and guide treatment planning. It may be useful information in determining long-term outcome. MR spectroscopy remains predominantly a research tool at this time and should not be used solely to diagnose the presence of TBI. MR spectroscopy requires **prior authorization** for patients with mTBI. It may be considered with adequate documentation of its medical necessity in unusual cases, such as in patients with a minimally conscious state, when the information will assist in clarifying the pathology to direct a therapeutic approach to the individual with TBI.

E.2.c.3.2 Functional MRI (fMRI)

This uses MRI to detect physiologic responses of brain tissue to various tasks. Blood oxygenation level dependent (BOLD) contrast is the most popular fMRI technique. It derives an image from differences in the magnetic properties, and therefore differences in MR decay parameters, of oxygenated and deoxygenated hemoglobin. A typical fMRI study compares images under two or more behavioral conditions, which may involve motor, cognitive, or visual tasks. Functional MRI studies have shown functional reorganization as a general response to TBI (Belanger et al., 2007). Alterations in patterns of cerebral activity seen on fMRIs may correlate with cognitive deficits in individuals with TBI, but the specificity of the test is not sufficient to make fMRI a diagnostic tool. At the time of this guideline, it is a research tool and ***not recommended for clinical use***. Recent publications report problems with the mathematical formulas used, relating false positives and false negatives (Sanders, 2009).

E.2.d Laboratory testing

Laboratory testing is a generally accepted, well-established procedure. In mTBI, laboratory tests are rarely indicated at the time of initial evaluation unless there is suspicion of systemic illness, infection, neoplasm, drug or alcohol intoxication, endocrine dysfunction, or underlying disease. A number of blood tests have been proposed to identify brain damage in mTBI. It is currently not clear that results from these tests can more accurately diagnosis mTBI or identify mTBI which requires treatment or follow up. Thus, they are ***not recommended*** at this time. Any individual with TBI on medication will require laboratory testing to monitor therapeutic drug levels and the effects on organ function.

Endocrine testing is frequently appropriate because hypopituitarism occurs in approximately 17% of mTBI cases (H. J. Schneider, Kreitschmann-Andermahr, Ghigo, Stalla, & Agha, 2007).

E.2.e Lumbar puncture

Lumbar puncture is a well-established diagnostic procedure for examining cerebrospinal fluid (CSF) in neurological disease and injury. The procedure should be performed by qualified and trained physicians under sterile conditions.

Lumbar puncture is contraindicated in acute trauma to the spinal column, certain infections, increased intracranial pressure due to space occupying lesions, and in some coagulation disorders or defects. Additionally, it should be avoided if there are cutaneous infections in the region of the puncture site. In individuals with suspected or known increased intracranial pressure, lumbar puncture should be preceded by fundoscopic examination and a CT scan or MRI.

E.2.f Nerve blocks – diagnostic

These are generally accepted procedures involving percutaneous needle injection techniques to a specific nerve. These diagnostic blocks are typically performed with quick-acting, short duration local anesthetics such as lidocaine or bupivacaine. Temporary diagnostic nerve blocks evaluate limb ROM, dystonia, or spasticity and assist in planning subsequent, specific therapy.

E.2.g Further neuropsychological assessment and testing

Neuropsychological assessment after three months is appropriate in the following situations when:

- input is needed to plan treatment to maximize long-term cognitive and overall functional outcomes;
- documentation of accommodations is needed to establish adjustments to the neurocognitive challenges;
- assessment will assist in increasing insight and be used to assist with supportive psychotherapy;
- there is a question of the individual's ability to perform work-related duties and/or there are safety issues (i.e., possible harm to self or others) or when the person's vocation necessitates more extensive testing prior to vocational re-entry or return to school/training;
- assistance is needed with differential diagnosis including the diagnosis of TBI;
- it is deemed necessary to evaluate and/or monitor effectiveness of treatment approaches (i.e., cognitive rehabilitation therapy, somatic therapies, or medication trials) in specific individuals;
- the patient's presentation is such that symptom validity testing and performance validity testing may be helpful in treatment planning;
- subjective complaints are disproportionate to the clinical history or objective findings as observed by provider(s);

- the degree of disability is disproportionate to the clinical history and objective findings as observed by provider(s);
- there are questions of competency, guardianship, or conservatorship.

Neuropsychological testing should be used to document the patient's level of effort and to provide data regarding symptom validity. Testing should not be used to diagnose malingering.

Neuropsychological testing may take into account validated testing in other areas without a direct relationship to psychological issues.

Evidence statements regarding neuropsychological assessment			
Some evidence	Evidence statement	Citation	Design
	There is an association between poor effort on verbal memory tests and poor effort on computerized tests of postural stability in patients with TBI who are being evaluated for disability ratings.	(Armistead-Jehle, Lange, & Green, 2017)	Retrospective review of consecutive charts

The following information may aid in delineating when a full neuropsychological battery is necessary versus more limited testing:

- mTBI three months post-injury: Serial testing with specialized tests that are sensitive to effort, speed of processing, memory, and executive functions will usually be appropriate for treatment planning and monitoring progress. The administration of a full neuropsychological test battery (typically including assessment of effort) may become necessary in this time period when:
    - there is no witnessed history of TBI, or there is other uncertainty regarding the diagnosis of mTBI;
    - the patient is not progressing and/or symptoms indicate mTBI may be more severe;
    - it is necessary to address issues on the initial indicators list.

E.2.h Psychological, psychiatric, or psychosocial evaluations

These are generally accepted and well-established diagnostic procedures with selective use in the TBI population. They have more widespread use after three months. Diagnostic testing may be indicated for individuals with symptoms of post-traumatic disturbances of sleep, mood, anxiety, psychosis, substance use, aggression/agitation, and pain, as well as depression, delayed recovery, chronic pain, recurrent painful conditions, and disability problems. An individual with a PhD, PsyD, or psychiatric MD/DO credentials may perform these evaluations if listed as an authorized user by the test publisher. Practitioners' familiarity with patients with TBI is preferred.

Psychosocial evaluations can help to determine if further psychosocial or behavioral interventions are indicated for patients diagnosed with TBI. The interpretations of the evaluation can provide clinicians with a better understanding of the patient in his or her social environment, thus allowing for more effective rehabilitation. Psychosocial assessment requires consideration of variations in experience and expression resulting from affective, cognitive, motivational, and coping processes, as well as other influences such as gender, age, race, ethnicity, national origin, religion, learning disability, language, or socioeconomic status.

A comprehensive psychological evaluation should attempt to identify both primary psychiatric risk factors (e.g., psychosis, active suicidality, lack of awareness) as well as secondary risk factors (e.g., moderate depression, job dissatisfaction) (Bruns & Disorbio, 2009). Significant personality disorders should also be taken into account in treatment planning.

Psychometric testing is a valuable component of a consultation to assist the physician and other members of the treatment team in making a more effective treatment plan. Psychometric testing can assist in enhancing general medical outcomes and in predicting a patient's likely adherence to and cooperation with medical treatment plans.

Several meta-analyses have evaluated the occurrence of depression and anxiety with non-penetrating TBI. Both anxiety and depression appear to occur at a rate about one-third higher than the general population (Osborn, Mathias, & Fairweather-Schmidt, 2014, 2016). Both conditions are likely to increase during the initial two to five years post-injury, although anxiety may decrease after five years (Osborn et al., 2014; Osborn, Mathias, & Fairweather-Schmidt, 2016). Patients with mild and moderate/severe TBI are both likely to suffer from psychological stress. Increased physical activity and decreased alcohol consumption may be useful to decrease symptoms (Osborn, Mathias, Fairweather-Schmidt, & Anstey, 2016). One study found that pre-injury alcohol abuse and longer PTA predicted symptoms lasting longer than six months (Hart et al., 2014).

Even in cases where no diagnosable psychological condition is present, these evaluations can identify social, cultural, coping, and other variables that may be influencing the patient's recovery process and may be amenable to various treatments, including behavioral therapy.

- Qualifications
    - A psychologist with a PhD, PsyD, or EdD credentials or a physician with psychiatric MD/DO credentials may perform the initial comprehensive evaluations. It is preferable that these professionals have experience in diagnosing and treating mTBI in injured workers.
    - Psychometric tests should be administered by psychologists with a PhD, PsyD, or EdD credentials or health professionals working under the supervision of a doctorate level psychologist. Administration and interpretation of psychological/neuropsychological measures must adhere to standards set forth by test publishers.

- Indications

  A psychological assessment may be necessary if symptoms do not correlate with a diagnosis of TBI. Complaints of cognitive dysfunction may also be associated with a variety of conditions that do not involve neurological disease, TBI, or mTBI. This includes conditions that may have been pre-existing or are concurrent, such as depression, anxiety, chronic pain, somatoform disorders, and factitious disorders. At times, a set of symptoms may not coincide with expected objective findings for those with a diagnosis of TBI. To identify non-neurological contributions to cognitive or other functional complaints, a psychological evaluation focusing on mental disorder diagnoses is appropriate when:

  - delayed recovery is present,
  - there is delayed access to appropriate care,
  - there is a question of whether a brain injury has occurred,
  - neuropsychological testing yields a pattern of test results that is not consistent with the clinical history,
  - neurologically improbable symptoms are present, or
  - it is necessary to assess for accompanying psychological components.

- Clinical evaluation

  Special note to health care providers: Most providers are required to adhere to the federal regulations under the Health Insurance Portability and Accountability Act (HIPAA). Unlike general health insurers, workers' compensation insurers are not required to adhere to HIPAA standards. Thus, providers should assume that sensitive information included in a report sent to the insurer could be forwarded to the employer. The Colorado statute provides a limited waiver of medical information regarding the work-related injury or disease to the extent necessary to resolve the claim. It is recommended that the health care provider either (1) obtain a full release from the patient regarding information that may go to the employer or (2) not include sensitive health information that is not directly related to the work-related conditions in reports sent to the insurer.

  The clinical evaluation should address the following areas:

  - History of injury

    The history of the injury should be reported in the patient's words or using similar terminology. Certified medical interpreters are preferred. Collateral information should be obtained as appropriate. This may include family, support systems, witnesses, and EMS records.

    - nature of injury
    - psychosocial circumstances of the injury

- current symptomatic complaints
- extent of medical corroboration
- treatment received and results
- compliance with treatment
- coping strategies used, including perceived locus of control, catastrophizing, and avoidance behaviors
- perception of medical system and employer
- history of response to prescription medications
- medication history related to this injury

○ Health history

- nature of injury
- medical history
- psychiatric history
- history of alcohol or substance abuse, including abuse of prescription medication
- ADLs
- previous injuries, including disability, impairment, and compensation
- complete medication history, including prescription and over-the-counter medications

○ Psychosocial history

- childhood history, including abuse/neglect and developmental/intellectual disability or delay
- educational history
- family history, including disability
- relationship/marital history and other significant adulthood activities and events
- legal history, including criminal and civil litigation
- employment history
- military duty: Because post-traumatic stress disorder (PTSD) might be an unacceptable condition for many military personnel to acknowledge, it may be prudent to screen initially for signs of depression or anxiety – both of which may be present in PTSD.
- symptoms of pre-injury psychological dysfunction

- current and past interpersonal relations, support, and living situation
- financial history

- Mental status exam including cognition, affect, mood, orientation, thinking, and perception. May include the Mini-Mental Status Examination or the Frontal Assessment Battery, if appropriate, and detailed neuropsychological testing.
- Assessment of any danger posed to self or others.
- Barriers to care should be considered as the patient may experience problems with transportation and access to appropriate care.
- Psychological test results, if performed.
- Current psychiatric/psychological diagnosis consistent with the standards of the American Psychiatric Association's most recent Diagnostic and Statistical Manual of Mental Disorders.
- Pre-existing psychiatric conditions. Treatment of these conditions is appropriate when the pre-existing condition affects recovery.
- Causality (to address medically probable cause and effect, distinguishing pre-existing psychological symptoms, traits, and vulnerabilities from current symptoms or aggravation of prior symptoms).
- Treatment recommendations with respect to specific goals, frequency, timeframes, and expected outcomes.

Evidence statements regarding psychometric testing			
Good evidence	Evidence statement	Citation	Design
	Psychometric testing can predict medical treatment outcome.	(Block, Ohnmeiss, Guyer, Rashbaum, & Hochschuler, 2001)	Prospective cohort study
		(Sinikallio et al., 2009)	Observational cohort study
		(Sinikallio et al., 2010)	Observational cohort study

E.2.i Neuro-otology: vestibular and audiological evaluations

Neurotologic evaluation is a widely used and generally accepted practice in cases of hearing loss, dizziness, balance problems, facial nerve injury, and cerebrospinal fluid leak. An individual with TBI may experience these symptoms. Any patient with complaints of vertigo or significant neurological findings on clinical exam, such as ataxia, should be referred to appropriate specialists expeditiously. Diagnostic testing for significant pathology usually requires the listed evaluations (audiometry, tympanometry, and vestibular function tests [E.2.i.3.1 – E.2.i.3.5]). It is recommended that all patients with mTBI and continual balance complaints and no clinical findings after 6 weeks be referred to clinicians with experience in balance assessment and training (see subsection E.2.i.3.6, Acquired visual dysfunction, below). Some tests may need to be repeated to clarify diagnosis.

E.2.i.1 Audiometry

Audiometry is a generally accepted and well-established procedure that measures hearing. An audiologist or skilled trained technician administers the test using an audiometer. The machine presents individual frequencies to the person with TBI (typically ranging from 125–8000 Hz) at different levels of loudness (in dB HL). The individual is asked to respond to the sound at its lowest detectable intensity (threshold). Normal thresholds are from 0-25 dB HL and are depicted on an audiogram. The audiologist or physician should determine the presence and type (non-organic, conductive, sensorineural, presbycusis, or mixed) of hearing loss based on the audiogram and other tests reasonably deemed necessary.

If available, obtain pre-injury baseline audiograms / audiometry studies to include a summary of past audiometric history, if known (e.g., prior hearing loss, prior tinnitus, prior vestibular problems, prior injury, etc.).

Baseline audiometry following TBI is indicated when the individual with TBI presents with hearing loss, dizziness, tinnitus, or facial nerve dysfunction.

Audiograms may be obtained in serial fashion to monitor inner ear function in response to time and treatment.

Specific audiometric testing can be done to assess the presence of tinnitus and complaints of unilateral hearing loss (Stinger test).

E.2.i.2 Tympanometry

Tympanometry is a generally accepted and well-established procedure that measures middle ear air pressures. It is used to help identify the presence of tympanic membrane perforations, ossicular abnormalities, and the presence of fluid in the middle ear.

E.2.i.3 Vestibular function tests

The most common type of vertigo is benign paroxysmal positional vertigo (BPPV), which usually does not require additional testing because it is diagnosed with the clinical Dix-Hallpike maneuver and treated with a variety of canalith repositioning maneuvers (CRM), such as Epley and Semont maneuvers (Fife et al., 2000). (Refer to Section F.3, Neuro-otology Treatment, Benign Paroxysmal Positional Vertigo [BPPV].) The following tests are used to verify the presence of vestibular dysfunction and specify the origin when possible.

E.2.i.3.1 Electro- or video-nystagmography (ENG/VNG)

This is a generally accepted and well-established procedure that measures inner ear/central balance function. The test measures eye movement responses to inner ear balance stimulation making use of the vestibulo-ocular reflex. There are several components to the ENG/VNG. They include oculomotor testing, positional and positioning nystagmus testing, and caloric testing. This series of tests may identify peripheral and central abnormalities, abnormalities in oculomotor function, positional nystagmus, and unilateral and bilateral vestibular dysfunction. The ENG/VNG can be helpful in identifying the affected ear. This test is often used in individuals with TBI complaining of dizziness or dysequilibrium and may help diagnose conditions such as labyrinthine concussion, vestibular hypofunction, and central vertigo. It is often used in conjunction with other tests such as the audiogram and clinical history to help arrive at a diagnosis.

E.2.i.3.2 Rotary chair testing

This is a generally accepted, although not commonly used, test that evaluates the ocular responses of the inner ear to rotation. It is used to identify the extent of bilateral vestibular loss and is more accurate than VNG caloric tests for this purpose. It is also useful in assessing the ability of vision to compensate for vestibular impairments and so provides prognostic information regarding recovery.

E.2.i.3.3 Video head impulse testing (vHIT)

This is a generally accepted, although not commonly used, test that evaluates the ocular responses of the inner ear to high acceleration head rotation. vHIT is used to evaluate the ability to maintain visual focus during head movement that can be impaired with moderate to high grade unilateral or bilateral vestibular injuries. It detects dysfunction of individual vertical semicircular canals in vestibular patients as accurately as scleral search coils but is non-invasive and easy to use (MacDougall, McGarvie, Halmagyi, Curthoys, & Weber, 2013). It is used to identify the extent of bilateral vestibular loss and is more accurate than VNG caloric tests for this purpose.

E.2.i.3.4 Computerized dynamic platform posturography

This is a generally accepted, although not commonly used, test that assesses the contributions of vision, somatosensation, and the inner ear to balance control. It separately evaluates the role of lower extremity motor control to balance. It can be used to determine whether a vestibular lesion is present, but it does not localize the lesion. The purpose of this procedure is to identify the integral components of a functional balance deficit that may help in treatment planning. This technique also may be useful in monitoring neurologic recovery in individuals with TBI and balance deficits. These functional methods of evaluation are considered generally accepted practices in the evaluation of persistent vestibular and balance deficits that may require specific treatment and remediation strategies. Non-physiologic findings on this exam can result from either symptom exaggeration, anxiety, psychiatric disorders, atypical results, or malingering and should not be interpreted as malingering without other evidence. One study demonstrated positive VNG testing in a number of cases where dynamic posturography was non-physiologic (Larrosa et al., 2013).

E.2.i.3.5 Electrocochleography (ECoG)

This is a well-established and generally accepted procedure that indriectly tests endolymphatic fluid pressures. It identifies the affected ear in cases of post-traumatic endolymphatic hydrops and post-traumatic perilymphatic fistula.

The inner ear has two fluid chambers – the perilymphatic and the endolymphatic. After TBI, it is not uncommon for patients to develop an increase in the endolymphatic fluid pressure; this condition is called hydrops. When the endolymphatic pressures are abnormally high, the inner ear membranes distend, and the ear malfunctions. Symptoms include hearing loss, sporatic dizziness, tinnitus, aural fullness, and sensitivity to sound.

The ECoG is a test that uses evoked potentials. The patient listens to a series of clicks. Monitors, including one sitting on the tympanic membrane, measure three potentials: the cochlear microphonic, the summating potential (SP), and the action potential (AP). An increase in the ratio of the summating potential of the action potential (SP/AP) suggests the presence of hydrops or perilymphatic fistula. The test varies in sensitivity and specificity. Diagnosis of endolymphatic hydrops requires a characteristic clinical picture with progressive hearing loss, fluctuating hearing, and recurrent vertigo episodes lasting for hours. (Refer to the Division's Moderate/Severe TBI Medical Treatment Guideline, section F.4.l, Neuro-otology: vestibular and audiology, under treatment of progressive otologic disorders.) In the absence of these clinical features, diagnosis should not be based solely on an abnormal ECoG test result.

E.2.i.3.6 Vestibular evoked myogenic potentials (VEMP)

This is a generally accepted test that evaluates the function of the saccule, one of the gravity-sensing organs of the inner ear. It is the only objective test of these organs. It is a form of auditory evoked response and is measured using the ABR and EMG equipment. A loud sound stimulus is introduced into the ear, and a vestibulo-colic reflex response from the saccule is recorded as a brief relaxation of the ipsilateral sternocleidomastoid muscle by EMG. A characteristic wave form is recorded for each ear that is analyzed for presence or absence, threshold, amplitude, and latency. Absence of a response in persons under age 60 suggests saccular damage. Reduced thresholds are indicative of semicircular canal dehiscence. It is not useful in diagnosing benign paroxysmal positional vertigo or vestibular migraine (Fife et al., 2017).

E.2.i.3.7 Acquired visual dysfunction

This is usually not the primary cause of imbalance. However, if ocular and/or visual abnormalities are found on testing, the patient may be further evaluated by a qualified optometrist or ophthalmologist with training and experience in TBI, balance disorders, and underlying neurology, preferably a neuro-ophthalmologist or neuro-optometrist. The goal is to 1) determine if there is a visual component or not, 2) determine if it is central or peripheral, 3) determine if the problem is a manifestation of an underlying vestibular disorder or a true vision problem, and 4) coordinate with the treating providers regarding most appropriate treatment.

E.2.i.3.8 Other clinical referrals

The treating physician may refer individuals with TBI who have balance problems to other clinicians with appropriate training in balance dysfunction, such as neuro-otologists, neurologists, and otolaryngologists, to assist in their assessment. The referrals may include, but are not restricted to: neuro-ophthamology, optometry, physical therapy, vestibular therapists, occupational therapy, and chiropractic therapy. There should be a coordinated approach between these disciplines and the physician specialist in the individual's treatment.

E.2.j Swallowing evaluation

Swallowing impairment or dysphagia may be due to neurologic, structural, or cognitive deficits and may result from head trauma. Dysphagia may result in aspiration, airway obstruction, pneumonia, inadequate nutrition, dehydration, weight loss, failure to thrive, and death. Dysphagia is uncommon in mTBI. If treatment is needed, refer to the Division's Moderate/Severe TBI Medical Treatment Guideline.

E.2.k Vision evaluation

There are standard examination techniques and ancillary tests to establish the diagnosis of visual disorders. It is a generally accepted practice for a qualified practitioner to provide a comprehensive vision evaluation. The qualified practitioner (optometrist, neuro-optometrist, ophthalmologist, neuro-ophthalmologist) should have training and experience in the neurology of TBI.

The comprehensive visual evaluation should assess afferent visual function (visual acuity, visual fields / peripheral vision), efferent function (ocular movement, fixational stability/instability, binocular alignment), and anatomic integrity of the eye and its adnexal structures. In doing so, the practitioner will obtain information about the functional status of the eyes and visual system including the presence or absence of refractive error; loss of visual acuity and/or visual field; oculomotor dysfunction with or without diplopia; ocular, orbital, and adnexal injuries; and other pathology involving intraocular structures. Vision evaluation may be necessary to evaluate acquired/traumatic central and peripheral nervous system disorders, visual acuity loss, visual field loss, nystagmus, ocular motility impairment, cranial nerve palsy, diplopia, suspected or noted ocular and visual pathology, pupillary disorders, and visual perceptual disorders.

The diagnosis/diagnoses determined following a comprehensive neuro-ophthalmic examination should be based upon objective findings that correlate with the known or suspected underlying neuro-pathology and symptoms. A simple description of symptoms may be used but should not be understood as explanatory or diagnostic, as the practitioner should seek to identify the underlying pathology.

Signs and symptoms of visual dysfunction commonly include, but are not limited to:

- Signs
    - ocular mis-alignment (strabismus),
    - nystagmus or other instability of fixation,
    - ocular discharge,
    - red or swollen eyes,
    - ptosis,

- lagophthalmos (inability to fully close the eyelid),
  - globe dystopia (lack of orbit alignment).
- Symptoms, including complaints of
  - blurred vision or loss of vision,
  - difficulty with visual tracking or scrolling,
  - focusing problems,
  - double vision,
  - having to close or cover an eye to improve vision,
  - problems with depth perception,
  - impaired peripheral vision,
  - headache or eye strain with use of eyes,
  - head tilt to improve vision,
  - dizziness or balance problems with use of eyes,
  - photophobia,
  - reduced attention or concentration for visual tasks.

Visual evaluation is indicated when signs or symptoms consistent with a visual problem are reported by the individual or observed by others. Significant signs and symptoms not directly or solely attributable to other causes (e.g., cognitive, vestibular, medication, psychological) indicate the need for vision evaluation as soon as reasonably possible post-injury. Mild signs and symptoms do not require referral but may be monitored for several weeks to allow for resolution or improvement.

In mTBI, self-reported photosensitivity and blurred vision are relatively common, but there is usually resolution by three months post-injury. Persistent functional related visual symptoms may require specialty evaluation.

A formal vision examination may be intermediate, extended, or comprehensive, depending on the nature of the deficits. The vision examination may include, but is not limited to: case history; visual acuity at a distance and near; refraction; color vision testing; pupillary examination; visual field by confrontation; Amsler grid testing; ocular motility examination; binocularity examination; accommodation testing; external/adnexal examination; intraocular pressure testing; and anterior and posterior segment examinations.

Ancillary diagnostic tests may include, but are not limited to: visual field testing (tangent screen campimetry, manual or automated perimetry), ultrasonography, fluorescein angiography, anterior segment and fundus photography, optical coherence tomography, electrodiagnostic studies, low vision assessment, and visual perceptual testing.

E.2.k.1 Visual field testing

This is a well-established technique to evaluate central and peripheral vision. It is indicated when a deficit is suspected by the practitioner or noted by the patient and should be considered in any patient with TBI and subjective visual field loss. Visual field testing beyond the basic examination should be performed using a procedure and tool that is well-established and standardized. Examples include computerized perimetry and Goldmann perimetry.

E.2.k.2 Ultrasonography

Ultrasonography is a well-established diagnostic test that is indicated for evaluation of ocular or orbital pathology. It is indicated for ocular lesions that are suspected but poorly visualized due to opaque ocular media or for further evaluation of ocular or orbital pathology.

E.2.k.3 Fluorescein angiography

This is a well-established diagnostic test to evaluate the retinal and choroidal circulation. It is indicated when lesions of one or both of these circulations are suspected.

E.2.k.4 Visual perceptual testing

This testing may be conducted informally by an ophthalmologist or optometrist or with a standardized battery of tests employed by a neuropsychologist. Testing consists of functional assessments to evaluate an individual's recognition and interpretation of visual sensory information. Visual perceptual testing is indicated for determination of the level of visual perceptual impairment and/or confirmation of suspected impairment. Perceptual areas assessed include visual memory, judgment of visual spatial relationships, visual discrimination, visual motor integration, visual figure-ground discrimination, and visual attention. Numerous tests are used for the evaluation of visual perception. Some of these tests are well-established. It is suggested that only tests with established norms be used in a standardized battery, and caution should be exercised in using other instruments. Visual perception testing should not be used in isolation to diagnose mTBI.

E.2.k.5 Low vision evaluation

Low vision evaluation is well-established and indicated in the presence of subnormal bilateral visual acuity or visual field. The goal is to provide vision aids for distance or near vision that improve visual functioning.

E.2.k.6 Electrodiagnostic studies

These are well-established and possibly indicated in the presence of reduced visual acuity or visual fields, ocular pathology, or suspected optic nerve or visual pathway deficit. (Refer to Section E.2.a, Electrodiagnostic studies, for further description.)

E.2.k.7 Optical coherence tomography

This is an interferometric technique, usually with near-infrared wavelengths, used to evaluate optic nerve and retinal structural integrity. This study should be used in conjunction with tests of visual function to establish the possible causes of visual deficits. Serial assessments can provide objective longitudinal data about retinal and optic nerve structure.

E.2.l Return-to-work assessment and special tests

A return-to-work procedure should be part of a company's policies and procedures, knowing that return to work can decrease anxiety, reduce the possibility of depression, and reconnect the worker with society. Evaluations used to define these abilities, such as the functional capacity evaluation (FCE) and the worksite analysis, should be objective. The professional performing the FCE and worksite analysis should be specifically trained and familiar with the unique presentation of the individual who has sustained a TBI. The ability to tolerate these evaluations and follow commands may be limited due to TBI and should not be construed as non-cooperative or suggestive of malingering.

Caution should be used in returning an individual to work and other activities too early. Both physical and cognitive duties should generally be non-stressful initially, with a gradual increase in activity based on improvement and/or resolution of symptoms. The individual should be competent in most basic ADLs before return to work is considered. Return to full duty depends on the rate of decrease of symptoms. Generally, if symptoms recur during increasing job duties or exertion, duties should be decreased accordingly. Because a prolonged period of time off work will decrease the likelihood of return to work, the first weeks of treatment are crucial in preventing and/or reversing chronicity and disability mindset. In complex cases, experienced nurse case managers or occupational therapists may be required to assist in return to work. Other services, including psychological evaluation and/or treatment and vocational assistance should be employed. Two evaluations that may be used are job site evaluations and alterations and FCEs.

E.2.l.1 Job site evaluations and alterations

For many patients with TBI, job alterations may be needed. These may be in the form of: (1) instructing the worker how specific duties might be performed to avoid excessive mental stress; (2) actual job worksite or duty changes; and/or (3) a formal job site evaluation and alterations at the worksite.

Job site evaluation and alteration should include input from the employee, the employer, and a health care professional with experience with TBI cases. The employee should be observed performing all job functions in order for the job site evaluation to be a valid representation of a typical workday.

A formal job site evaluation is a comprehensive analysis of the physical, mental, and sensory components of a specific job and may be important initially to determine causation. These components may include, but are not limited to: (a) postural tolerance (static and dynamic), (b) aerobic requirements, (c) ROM, (d) torque/force, (e) lifting/carrying, (f) cognitive demands, (g) social interactions, (h) interpersonal skills management, (i) visual perceptual challenges, (j) environmental requirements of a job, (k) repetitiveness, and (l) essential functions of a job.

Changes that provide a therapeutic benefit or relieve the patient's ongoing symptoms are part of the required medical treatment for TBI, and therefore, it is assumed that the insurer will be responsible for paying for reasonably necessary job site alterations.

Job descriptions provided by the employer are helpful but should not be used as a substitute for direct observation.

A job site evaluation may include observation and instruction of how work is done, what material changes should be made, and determination of readiness to return to work. Refer to the Division's Chronic Pain Disorder Medical Treatment Guideline.

Requests for a job site evaluation should describe the expected goals for the evaluation. Goals may include, but are not limited to:

- Provide a detailed description of the physical and cognitive job requirements;
- Make recommendations for and assess the potential for job site changes;
- Assist the patient in his/her return to work by educating on how he/she may be able to do his/her job more safely; and/or
- Give detailed work/activity restrictions.

Time frames

Time frames regarding job site evaluations and alterations	
Frequency	One time with additional visits as needed for follow-up.

E.2.l.2 Functional capacity evaluation (FCE)

FCE may be indicated to identify residual physical limitations. FCE is a comprehensive assessment of the various aspects of physical and cognitive function as they relate to the individual's ability to perform functional activities necessary for return to work. When cognitive, emotional, and/or behavioral sequelae are also present, a comprehensive FCE may provide indications of return-to-work readiness.

Components of the physical portion of the FCE may include, but are not limited to: musculoskeletal screen, cardiovascular profile/aerobic capacity, coordination, lift/carrying analysis, job specific activity tolerance, maximum voluntary effort, pain assessment, non-material and material handling activities, balance/dizziness, climbing, physical fatigue, endurance, and visual skills. The physical portion of any FCE should include all of the physical skills required for specific job placement.

Components of the cognitive portion of the FCE may include, but are not limited to: memory, executive skill function, attention and concentration, communication, speed of information processing, multi-tasking, new learning, and cognitive fatigue and endurance.

Components of the emotional portion of the FCE may include, but are not limited to: temperament, ability to manage stress, adaptation to change, mood changes, toleration of feedback, and anger control.

Components of the behavioral portion of the FCE may include, but are not limited to: appropriate social and behavioral interactions. This may present as inability to complete or cooperate with the tests, inconsistent or erratic behavior, or the inability to get along with coworkers and supervisors.

FCEs include tools that are an extension of the basic medical examination and may be useful for the determination of impairments, functional/cognitive restrictions, determination of progress, and planning and monitoring of the rehabilitation program. Whenever possible, FCEs should be supplemented with information from neuropsychology, speech therapy, occupational therapy, and physical therapy to determine physical, cognitive, and psychological abilities in order for the patient to function safely and productively in a work setting. FCEs are typically conducted in four to six hours, but for individuals who have sustained a TBI, additional time may be required or it may be necessary to conduct the evaluation in two or three separate sessions to allow for the potential variability of cognitive and physical fatigue. Total time for an FCE would rarely exceed eight to ten hours.

When an FCE is being used to determine return to a specific job site, the provider is responsible for fully understanding the job duties. A job site evaluation is frequently necessary. FCEs cannot be used in isolation to determine work restrictions. The authorized treating provider must interpret the FCE in light of the individual patient's presentation and medical and personal perceptions. FCEs should not be used as the sole criteria to diagnose malingering.

FCEs may be beneficial in the TBI population to assist in return to work.

Time frames

Time frames regarding functional capacity evaluation	
Frequency	2 times. When the patient is unable to return to the pre-injury position and further information is desired to determine permanent work restrictions. A repeat FCE may be needed if additional treatment is deemed necessary after the first FCE. **Prior authorization** is required for more than 3 FCEs.

F. Treatment

Due to the complex nature of the brain, individuals with mTBI may require coordinated interdisciplinary treatment. Usually, the impairment(s) and functional limitations are appropriately treated by more than one therapeutic discipline. Treatment should include functional, outcome-oriented, and community reintegration goals. Treatment session duration and frequency will vary depending on the individual's tolerance and may evolve over time.

All treatment plans begin with shared decision making with the patient. Before initiation of any therapeutic procedure, an authorized treating provider, employer, and insurer must consider these important issues in the care of the injured worker:

- Patients undergoing therapeutic procedure(s) should be released or returned to modified or restricted duty during their rehabilitation at the earliest appropriate time. Refer to Section G, Return to work, for detailed information.
- Reassessment of the patient's functional improvement status should be documented after each treatment. If patients are not responding within the recommended time periods, alternative treatment interventions, further diagnostic studies, or consultations should be pursued. Continued response to treatment should be monitored using objective measures such as:
    - Return to work or maintaining work status;
    - Fewer restrictions at work or performing activities of daily living (ADLs);
    - Decrease in usage of medications related to the work injury; and
    - Measurable functional gains, such as: increased range of motion; documented increase in strength; increased ability to stand, sit, or lift; or patient completed functional evaluations.
- Clinicians should provide and document education to the patient. No treatment plan is complete without addressing issues of individual and/or group patient education as a means of facilitating self-management of symptoms.
- Neuropsychological testing should be performed on all patients with mTBI requiring treatment beyond 3 months.

Interdisciplinary care among all of the disciplines providing care to the patient is required for treatment of TBI.

F.1 Post-traumatic headache treatments

Definition and background

Headaches are one of the most common symptoms seen in general medical practices. Following TBI, 50% or more of injured individuals experience headache throughout the first year post-injury (Lucas, 2015). The majority of these are self-limited, but headache persisting for more than three months may occur. Evolving brain pathology is unlikely to be responsible for post-traumatic headache, which is seen more commonly after mTBI than after moderate/severe TBI. Involvement of extracranial structures, including cervical dysfunction, may be the mechanism of headache persistence following TBI. (Refer to the Division's Cervical Spine Injury Medical Treatment Guideline when appropriate.)

Headaches are more common in those with a prior history of headaches and may be associated with other symptoms such as dizziness, memory problems, or weakness. Migraines and cervicogenic headaches are the most common type of post-injury headache.

Supporting literature and evidence tables

Evidence statements regarding acupuncture for headache			
Good evidence	Evidence statement	Citation	Design
	True acupuncture has small positive effects in reducing headache frequency in adults with episodic or chronic tension-type headache over 6 months when compared to no treatment / routine care or "sham" (placebo) acupuncture.	(K. Linde, Allais, Brinkhaus, Fei, Mehring, Shin, et al., 2016)	Systematic review and meta-analyses of randomized clinical trials
	True acupuncture has small positive effects in reducing migraine frequency over 6 months when compared to "sham" (placebo) acupuncture, small positive effects after treatment compared to prophylactic drug treatment, and moderate positive effects in reducing migraine frequency after treatment compared to no treatment / routine care in adults with episodic migraines.	(K. Linde, Allais, Brinkhaus, Fei, Mehring, Vertosick, et al., 2016)	Systematic review and meta-analyses of randomized clinical trials

Evidence statements regarding exercise, manipulation, and patient education for headache			
Good evidence	Evidence statement	Citation	Design
	Therapeutic patient education has small to moderate positive effects in improving quality of life and in reducing headache disability and the frequency of migraines in patients with migraines when compared to controls or usual care.	(Kindelan-Calvo et al., 2014)	Systematic review and meta-analyses of randomized clinical trials
Some evidence	Evidence statement	Citation	Design
	6 to 8 sessions of upper cervical and upper thoracic manipulation over 4 weeks are significantly more effective in reducing headache intensity, disability, headache frequency and duration, and medication intake than mobilization combined with exercises in patients with cervicogenic headache, and the effects are maintained at 3 months.	(Dunning et al., 2016)	Single-blind randomized clinical trial
	Spinal manipulation is effective for treatment of cervicogenic headaches. Exercise is equally efficacious as manipulation and can be used in combination with manipulation. The usual course of treatment was 3–6 weeks and effects were still found at 1 year.	([Cochrane] Bronfort et al., 2004)	Systematic review of clinical trials

Summary of evidence regarding manipulation for cervicogenic headaches
There is good evidence that cervicogenic headaches may benefit from manipulation based on the combined studies above with some level of evidence.

Evidence statements regarding pharmaceutical treatment for headache			
Strong evidence	Evidence statement	Citation	Design
	Aspirin is better than placebo for acute migraine headaches.	([Cochrane] Kirthi, Derry, Moore, & McQuay, 2010)	Meta-analysis of randomized clinical trials
	Topiramate at a dose of 100 mg/day is more effective than placebo in reducing the frequency of migraine headache.	([Cochrane] Mattias Linde, Mulleners, Chronicle, & McCrory, 2013)	Meta-analysis of clinical trials
	Sumatriptan is more effective than placebo for rapid relief of acute migraine headache in adults. The subcutaneous route of administration at a dose of 4 mg or 6 mg is likely to be more effective than the oral route of either 50 or 100 mg. There is insufficient evidence to support the oral dose of 25 mg, although it may be effective as well. The intranasal route of 20 mg is supported by the evidence, but there is insufficient support for the 10 mg route. There is insufficient evidence regarding the rectal route of 25 mg due to limited data, but it is also a reasonable option under appropriate circumstances.	(C. J. Derry, Derry, & Moore, 2014)	Meta-analyses of randomized clinical trials
	Propranolol is superior to placebo for migraine	([Cochrane] K. Linde & Rossnagel,	Meta-analysis of clinical trials

Evidence statements regarding pharmaceutical treatment for headache			
	prophylaxis.	2004)	
Good evidence	Evidence statement	Citation	Design
	Amitriptyline is beneficial for chronic tension headaches.	(Bendtsen, Jensen, & Olesen, 1996)	Randomized crossover trial
	Acetaminophen at a dose of 1000 mg/day is effective for acute migraines.	(S. Derry, Moore, & McQuay, 2010)	Meta-analysis of randomized clinical trials
	A single dose of 200-400 mg of ibuprofen is effective for acute migraines.	([Cochrane] Rabbie, Derry, Moore, & McQuay, 2010)	Meta-analysis of randomized clinical trials
	Valproate is more effective than placebo in reducing the frequency of migraine headache.	([Cochrane] Mattias Linde et al., 2013)	Meta-analysis of clinical trials
	Adding an antiemetic to aspirin makes it more effective for headache and associated symptoms.	([Cochrane] Kirthi et al., 2010)	Meta-analysis of randomized clinical trials

Indications/recommendations for post-traumatic headache treatment

Every effort should be made to eliminate the “cause” and treat headaches and other symptoms as early as possible. A headache diary should be completed by the patient. This will help identify modifying factors (Toward Optimized Practice (TOP) Headache Working Group, 2016). Migraines not present prior to injury should be termed migraine-like headaches and may not respond to traditional migraine treatment.

- Initial management

  Management of post-traumatic headache should be tailored to the class of headache into which it fits. Less common headache diagnosis may be present and require unique clinical options. Migraine patients should be provided with the migraine’s diet advisories and restrictions as appropriate. Relaxation techniques, stress management, biofeedback, and good sleep hygiene can all assist in decreasing headaches (Toward Optimized Practice (TOP) Headache Working Group, 2016). Both traumatic and non-traumatic headaches may be made worse by overuse of analgesics and cause chronic daily headache, otherwise known as medication overuse headaches. Treatment should be directed toward modifying causative factors with re-establishment of activities and away from rumination on the injury.

Education, medication adjustment, and interdisciplinary team approaches may be necessary. Chronic daily headache should be considered as a diagnosis in patients whose daily headache may be in response to iatrogenic complications of other medications or substances. Patients who are prescribed analgesics or who use caffeine, alcohol, or nicotine chronically may experience chronic daily headaches as serum levels of these substances fluctuate. These patients may require treatment to carefully titrate these substances. Patients with a blow to the side of the head, with chronic neck/shoulder pain, or with bruxism may develop temporal mandibular joint pain that will result in headache. Patients with sinus involvement, sometimes evidenced on early CT imaging, may develop chronic headache pain that requires treatment of the underlying sinus pathology. A sedating antidepressant such as amitriptyline may alleviate the insomnia that often complicates headache. See the Headache Treatment Algorithm below. Referral to a specialist may be necessary if initial treatment is not effective.

- Non-pharmacologic treatments

Widely accepted treatments for post-traumatic headache may include, but are not limited to: interdisciplinary treatment, pharmacology, joint manipulation, physical therapy, massage, acupuncture, biofeedback, psychotherapy (i.e., cognitive behavioral therapy), and diet.

Manipulation is appropriate for cervicogenic headaches. There is good evidence that cervicogenic headaches may benefit from manipulation based on the studies listed in the evidence table above. This may be appropriate when cervical trauma has not caused instability. However, if headache follows trauma, imaging should be done before manipulation. Refer to the Division's Cervical Spine Injury Medical Treatment Guideline for parameters.

Acupuncture may be useful as prophylaxis for migraines. See related evidence statement in the table above. These procedures should only be continued if functional gains are documented.

Psychological evaluation is a generally accepted intervention to identify factors for delayed recovery associated with pain and the potential need for cognitive assessment. Refer to the Division's Chronic Pain Disorder Medical Treatment Guideline for specific time frames.

Special procedures may be useful for specific or intractable head pain syndromes including nerve blocks for neuralgia, trigger point injections for myofascial pain syndromes (refer to Section F.4.j, Muscle tone and joint restriction management including spasticity, in the Division's Moderate/Severe TBI Medical Treatment Guideline), and the use of dental splinting for temporomandibular joint syndrome.

Repeat imaging is generally not required unless there has been a change in symptoms (Shetty et al., 2016).

- Pharmaceutical treatment

  The etiology of the headache should be carefully determined prior to initiation of any drug regimens. See the evidence table above for evidence statements regarding specific medications. Prescribers should take into account the significant side effects and contraindications associated with these medications.

  Tension type headaches should generally be treated with limited analgesics (NSAIDS or acetaminophen) initially and/or accompanied by physical therapy modalities for neck and shoulder treatments.

  The following drugs are ***not recommended***. Petasites hybridus root (butterbur) is ***not recommended*** due to the difficulty assuring the quality (Toward Optimized Practice (TOP) Headache Working Group, 2016). Opioid treatment should be avoided (Bendtsen et al., 2010). Opioids are ***not recommended for headache treatment or control*** (Toward Optimized Practice (TOP) Headache Working Group, 2016). Combination therapies using caffeine and barbiturates should not be used as a first line of therapy or on a chronic basis due to a likely rebound and the drug combination.

  There also is inadequate evidence to support the use of selective serotonin reuptake inhibitors (SSRIs) or serotonin-norepinephrine reuptake inhibitors (SNRIs) to prevent tension headaches (Banzi et al., 2015).

  The recommendations below in the Headache Treatment Algorithm take into account the American Academy of Neurology, the American Headache Society's latest guideline recommendations, and the Institute of Heath Economics (Holland et al., 2012; Silberstein et al., 2012; Toward Optimized Practice (TOP) Headache Working Group, 2016).

- Frequent re-occurrence and maintenance

  Emergency treatment or inpatient admission is sometimes required when intravenous medications (e.g., dihydroergotamine or other IV medications) and close monitoring are necessary to control migraine or analgesia rebound, especially in individuals with severe depression, suicidal ideation, or complicated medical problems. An individualized interdisciplinary outpatient treatment program may be appropriate when: greater than two disciplines are necessary; there is significant dysfunction secondary to headache; the individual has not returned to work for greater than 3 months; or treatment is geographically inaccessible.

Long-term maintenance plans are necessary in chronic headache management. Medications may be necessary for an indefinite period; however, a distinction should be made between headache conditions that were pre-existing and those caused by the TBI. In mTBI, most cases will not result in debilitating frequent headaches. If the patient is suffering from debilitating headaches, a full review of the diagnosis, triggering events, and psychosocial issues should take place. All headache treatment modalities should be focused on independence and return to function. Even if headaches are permanent, it is expected that the individual will be functional and able to return to work.

Headache Treatment Algorithm

Initial Evaluation

HEADACHES INTERFERING WITH FUNCTION INCLUDING MIGRAINES

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History and Physical Evaluation

Establish Diagnosis

Lab Studies

Possible Brain and Cervical Imaging

↓

Initiate Treatment

Pharmacological - Preventives	Pharmacological - Abortives	Non-Pharmacological
To be used if 2+ headaches/week or increased headache severity or duration	Limit use to prevent medication overuse headache	Education and identification of triggers Medication if terminated rebound present
Tricyclic antidepressants: amitriptyline and/or nortriptyline	NSAIDs or acetaminophen	Physical therapy
Beta blockers Calcium channel blockers	Sumatriptan and other “triptans” for migraine type headaches	Biofeedback
SNRIs and SSRIs may also be useful for some patients (such as venlafaxine)	An anti-emetic may accompany the medications in either of the above cells (examples include: metoclopramide, promethazine, and prochlorperazine)	Acupuncture (refer to the Division’s Chronic Pain Disorder Medical Treatment Guideline)
Anti-epileptic drugs Topiramate Divalproex/Valproate Gabapentin		Psychology including cognitive behavioral therapy
Others with possible effect ACE inhibitors, angiotensin receptor blockers, a-agonists, and memantine		Biofeedback relaxation training
		Joint manipulation therapy (refer to the Division’s Cervical Spine Injury Medical Treatment Guideline for time parameters)

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Headache control		
Good		Sub-optimal
Continue treatment 3–6 months, then taper. Preventive medications as appropriate.		Reassess diagnosis, optimize treatment, and identify other contributors. Referral to additional specialists as needed.

- Botulinum toxin injections

Definition and background
Botulinum toxin can be considered in a very small subset of patients with chronic migraines 12–15 days/month who have failed all other conservative treatment, including trials of at least three drug classes, and who have committed to any lifestyle changes related to headache triggers (Jackson, Kuriyama, & Hayashino, 2012).

Supporting literature and evidence tables

Evidence statements regarding botulinum toxin injections for migraine			
Some evidence	Evidence statement	Citation	Design
	Botulinum toxin is more effective than placebo in the prophylaxis of chronic migraine with headache frequency of 15 or more days per month.	(Aurora et al., 2011)	Randomized clinical trial followed by open-label study

Evidence against botulinum toxin injections for cervical pain and cervicogenic headache			
Good evidence	Evidence statement	Citation	Design
	Botulinum toxin is not different from placebo for cervical pain and is not likely to be clinically more effective than placebo for cervicogenic headache.	(Langevin et al., 2011)	Meta-analysis of randomized clinical trials
		(M. Linde et al., 2011)	Crossover randomized clinical trial

Indications/recommendations for botulinum toxin injections

For chronic migraines not responsive to other treatment and occurring at least 12 days per month or for cervical dystonia, a trial injection must result in documented functional improvement.

Botulinum injections are no longer generally recommended for cervicogenic or other headaches based on the evidence listed above on of lack of effect (Langevin et al., 2011; M. Linde et al., 2011). Botulinum injections are not routinely recommended, but they may be used in unusual cases.

Time frames

Time frames regarding botulinum injections for migraine	
Maximum duration	4 per year.

F.2 Visual treatment

Definition and background

Visual treatment is appropriate to consider for mTBI. Visual impairments may occur secondary to mTBI and in one or more of the following categories:

- visual acuity and visual field function;
- ocular motor control and ocular alignment;
- visual perception.

Note: Visual rehabilitation is also performed for dizziness. (Refer to Section F.3, Neuro-otologic treatment, under Vestibular rehabilitation for details.)

Supporting literature and evidence tables

Studies not resulting in evidence statements
Prevalence of mTBI visual findings, including eye movement disorders and accommodation, appears to be approximately 30 – 60% in blast induced mTBI (Capo-Aponte, Urosevich, Temme, Tarbett, & Sanghera, 2012). Other studies of populations such as athletes confirm presence of visual issues in mTBI (Ventura, Balcer, Galetta, & Rucker, 2016). Currently, there are no easy to perform clinical measures to clearly identify these conditions in the primary care settings. These findings generally decrease as cognition improves (Ventura et al., 2016).

Indications/recommendations for visual treatment

An ophthalmologist, neuro-ophthalmologist, neurologist, occupational therapist, certified vision therapist, or optometrist may treat visual impairment resulting from TBI. Treatment of visual impairments should be based on a comprehensive evaluation and diagnosis. When possible, therapy should be provided in an interdisciplinary integrated approach for the purposes of best outcomes and greatest convenience for the patient.

Treatment should be functionally-based and goal-directed. Individuals should be evaluated at intervals depending on his/her impairment, and progress should be clearly documented. Reliance on unvalidated outcome measures, such as performance on tests of "eye teaming" or "eye tracking," should be avoided.

- Visual acuity and visual field function

  These are determined by the eye, optic nerve, optic chiasm, optic tracts, optic radiations, and visual cortex. If visual acuity deficits are caused by optic nerve trauma, the best data argues against the use of corticosteroid in almost all cases, in part because of the risk of increased morbidity and mortality from a concomitant head injury (Steinsapir & Goldberg, 2011). Surgery may be indicated if the trauma results in progressive visual acuity loss in the setting of demonstrable compression of the nerve or if a hematoma is present within the optic nerve sheath. These cases are extremely rare. If visual acuity or visual field deficits are caused by intracranial visual pathway damage, acute treatment should be directed toward the specific injury.

  Vision aids may be prescribed for those individuals with documented visual acuity or visual field loss after the acute injury. Lenses may be used to improve visual acuity. Tinted FL41 lenses may be useful to treat photophobia and glare sensitivity (Digre & Brennan, 2012; Katz & Digre, 2016).

  The use of optical and digital compensatory devices may benefit some individuals with documented visual field loss from visual pathway disorders that affect the visual fields in both eyes.

  Depending on the level of adaptation to the visual field loss, some individuals may need training and education in strategies to improve compensation. Efforts to use visuospatial interventions to improve visual field loss directly without developing compensatory visual scanning are ***not recommended***. The use of computers as a primary and independent form of visual treatment has limited application due to: (1) limitations in the rationale and specific application of software programs to address the needs of the individual with TBI; and (2) difficulty with generalization of learned computer skills into functional environments. Integrated computer-based treatment (i.e., both individualized cognitive and interpersonal therapies) may improve functioning within the context of an interdisciplinary, neuropsychological rehabilitation program. Sole reliance on repeated exposure and practice on computer-based tasks without extensive involvement and intervention by a therapist is ***not recommended***. Virtual reality tools may prove useful for ADL assessment and training; however, they are experimental at the time of this guideline, as there are no strong studies supporting its success ([Cochrane] Laver, George, Thomas, Deutsch, & Crotty, 2011; Schultheis, Himelstein, & Rizzo, 2002). Computerized visual restoration therapy programs or other computerized visual treatment programs, such as virtual reality, are ***not recommended*** due to lack of proven clinically meaningful efficacy and cost (McFadzean, 2006; Pelak, Dubin, & Whitney, 2007; Reinhard et al., 2005; Schreiber et al., 2006).

- Disorders involving ocular motility and binocular vision

  These should be treated according to the underlying diagnosis. Ocular motility includes: ductions, versions, smooth pursuit, saccade, vergence, and vestibular eye movements. Disorders of binocular vision include strabismus with double vision and disturbances of accommodation and vergence.

  Treatment may include the use of lenses, prisms, vision rehabilitation, and/or surgery. For individuals with disorders of ocular motor and ocular alignment that result in diplopia, the following should be considered based on severity and duration of impairments: monocular eye patching, occlusion of central or peripheral vision, prisms lenses, or strabismus surgery.

  Lenses may be used to help accommodation. Because of the interaction between accommodation and vergence, lenses may also at times be used to assist in the treatment of a vergence disorder.

  Prisms may be prescribed to provide an immediate improvement in diplopia and other disorders with symptoms. If diplopia is not stable, then appropriate patching (partial selective occlusion) may be more prudent. If deficits are permanent, prisms may be worn indefinitely.

  Individuals may be instructed in orthoptic techniques to address problems related to strabismus, particularly in cases with cranial nerve palsy.

  Strabismus surgery may be useful in certain circumstances if the deficit is stable for several months. An immediate improvement is usually noted after the first surgery, but additional surgeries may be necessary.

- Visual perception

  Problems should be treated with a goal to improve visual processing skills and promote adaptation and compensation to the relevant problem.

  Visual perceptual therapy may be required for some individuals as part of their overall rehabilitation treatment and is overseen by an authorized treating provider with experience in TBI. The therapy may be provided by specialists with experience in visual perceptual disorders. They may be from various disciplines, including, but not limited to, occupational therapy, speech therapy, neuropsychology, optometry and ophthalmology, neurology, and neuro-ophthalmology.

- Visual inattention

  This is inattention of a visual spatial region. Treatment may include the use of prisms and scanning techniques. Visuospatial rehabilitation with scanning is recommended for individuals with visuospatial perceptual deficits associated with visual neglect following TBI and especially after right parietal stroke. Scanning training is recommended as an important, even critical, intervention element for individuals with severe visual perceptual impairment that includes visual neglect after right hemispheric stroke and TBI (Haskins, 2012). Efforts to use visuospatial interventions to improve visual field loss directly without developing compensatory visual scanning are ***not recommended***.

Time frames

Time frames regarding all vision therapy (orthoptic therapy)	
Time to produce effect	4 hours of treatment should result in a measurable functional improvement.
Frequency	Outpatient: Once weekly with a daily home exercise program. In-patient: determined by the rehabilitation team, considering the patient's medical needs and best possible outcomes. Frequency of treatment is dependent on in-patient versus outpatient and the medical condition of the individual.
Optimum duration	12 hours.
Maximum duration	20 hours. Throughout the treatment process, exams are performed to evaluate status. When progress is no longer occurring, then therapy should be stopped unless there are mitigating circumstances. If after 20 hours of treatment there is documented progress but the individual is not at maximum therapeutic gain, then additional therapy may be indicated. Additional therapy should take into consideration the overall rehabilitation plan for the individual.

These time frames are not meant to be applied to each section separately. The time frames are to be applied to the totality of all vision rehabilitation regardless of the type or combination of therapies being provided.

F.3 Neuro-otologic treatment: vestibular and audiologic

Definition and background

For patients with dizziness causing nausea or affecting balance, treatment of these conditions may be necessary before other rehabilitative therapy can be accomplished.

Supporting literature and evidence statements

The following recommendations were based on consensus. Supporting literature and evidence statements are also included in the subsections below when available.

Indications/treatment for neuro-otology: vestibular and audiology

- Post-traumatic tinnitus

  Individuals with TBI may experience debilitating tinnitus (ringing in the ears). Tinnitus may be associated with pressure or noise related trauma and ossicular or perilymphatic fistula disorder (Kreuzer et al., 2014). Tinnitus can be evaluated with specific audiometric testing techniques. Patients may benefit from anti-depressants, anti-seizure medicines, and anxiolytics. In many situations, devices are recommended. These may include hearing aids, maskers, and tinnitus trainers. Tinnitus trainers require a 30-day trial to determine the effectiveness of masking. More sophisticated devices that use music as opposed to masking are ***not recommended*** due to no proof of their superiority ([Cochrane] Hobson, Chisholm, & El Refaie, 2010).

- Hyperacusis

  Individuals with TBI may experience significant sensitivity to sound. This is more common in association with tinnitus. These individuals may benefit from devices such as tinnitus trainers, musician's plugs, and simple noise plugs. Continuous exposure to broadband sound may also be used (Lindsey, 2014).

- Benign paroxysmal positional vertigo (BPPV)

  BPPV is the most common cause of post-traumatic vertigo. It is an otologic disorder in which particles normally adherent to the gravity sensors of the ear become displaced into the semicircular canals, which cause the sensation of spinning. It is characterized by recurrent, brief spells of vertigo triggered by head movements such as getting in and out of bed, rolling over in bed, tipping the head upward, or bending over. It is diagnosed by the Dix Hallpike maneuver and treated with canalith repositioning maneuvers (CRM) specific to the affected semicircular canals. Patients treated by CRM should be re-evaluated within the first month to ensure resolution of symptoms. Recurrences are common after trauma. These may be treated by repeating the CRM, home exercises, or referral to physical therapy.

  Some individuals may require an exercise-based approach following, or instead of, the CRM. Home exercises are safe and effective in this disorder.

Time frames

Time frames regarding vestibular rehabilitation for benign paroxysmal positional vertigo	
Frequency	1 to 3 sessions with repeated CRM at each session and follow-up at 1 month.

Time frames regarding vestibular rehabilitation for benign paroxysmal positional vertigo	
Optimum duration	1 month with re-evaluation.
Maximum duration	Reoccurrence can occur randomly for many years following trauma. Home exercises are necessary for those with frequent recurrences. Some patients are unable to perform home exercises, so repeated visits for CRM may be required.

- Semicircular canal dehiscence

  This is an abnormal communication between the CSF space in the skull and perilymph surrounding the inner ear. It can result from blunt head trauma with fracture of the bone separating these spaces. Symptoms include vertigo brought on by loud sounds or straining and autophony, which is the magnification of internal bodily sounds (chewing, eye movement, joint movement, heartbeat) in the affected ear. Vestibular suppressants and avoidance of provoking sounds can be used; surgery is required in severe cases.

- Vestibular migraine

  Individuals experiencing an exacerbation of migraine after TBI frequently have an associated dizziness. Treatment includes trigger avoidance, vestibular suppressants, and migraine prophylactic medications such as calcium channel blockers, anti-seizure medication, beta blockers, and SSRIs. (Refer to Section F.1, Post-traumatic headache treatment.)

- Vestibular rehabilitation

  Individuals with TBI may experience loss of inner ear balance function resulting in dizziness and imbalance. This can result from labyrinthine concussion, penetrating injuries, injury to the eighth cranial nerve, and explosive pressure changes. Patients may compensate for vestibular deficits more quickly with vestibular rehabilitation than without it.

  Persistent postural perceptual dizziness: This is a condition in which patients continue to experience persistent dizziness due to mis-calibration of the sensorimotor, cerebellar, and vestibular inputs. This condition may be comorbid with anxiety. Treatment with aggressive vestibular rehabilitation and either SSRI or SNRI may be beneficial.

  Symptoms of vestibular system dysfunction following TBI may be due to damage of central or peripheral structures. These symptoms may include vertigo, eye-head dyscoordination affecting the ability to stabilize gaze during head movements, and imbalance affecting stability in standing or walking. Dizziness is commonly associated with TBI. Dizziness and balance disorders may or may not co-exist in the same individual with TBI.

  Vestibular rehabilitation is performed by qualified practitioners, e.g., audiologists, otologists, trained nurses, vestibular therapists, physical therapists (preferably neurology certified) or occupational therapists.

Evidence statements regarding vestibular rehabilitation			
Good evidence	Evidence statement	Citation	Design
	Vestibular rehabilitation incorporating visual motion performed by the patient alone with brief instruction from a health care provider reduces dizziness and improves function.	([Cochrane] McDonnell & Hillier, 2015)	Meta-analysis of randomized clinical trials
Some evidence	Evidence statement	Citation	Design
	2 to 6 sessions of Mulligan sustained natural apophyseal glides (SNAGs) or Maitland mobilizations over 6 weeks are significantly more effective in reducing the intensity and frequency of cervicogenic dizziness than a placebo intervention in patients with chronic cervicogenic dizziness. The effects are maintained at 12 weeks post treatment.	(Reid, Rivett, Katekar, & Callister, 2014)	Double-blind randomized clinical trial
	An 8-week program of combined cervical physiotherapy and vestibular rehabilitation is likely to improve the rate of medical clearance for return to sport for patients with a sport-related concussion who have persistent dizziness, neck pain, and/or headache 10 days after injury and who are suspected by a physician of having vestibular involvement or cervical	(K. J. Schneider et al., 2014)	Randomized clinical trial

Evidence statements regarding vestibular rehabilitation			
	spine involvement.		

Studies not resulting in evidence statements
One study of patients with mTBI 4 years after the incident found 30% continuing complaints of balance problems (Kleffelgaard, Roe, Soberg, & Bergland, 2012). A patient with mTBI may complain of continuing dizziness with minor clinical findings. It is suggested that these patients be referred to a vestibular therapist or physical or occupational therapists with vestibular training and experience.

- Balance disorders

  Balance disorders occur frequently following TBI. This may be due to a peripheral vestibular lesion or central vestibular lesion secondary to trauma, fracture, hemorrhage, or intracranial pressure changes (Kleffelgaard et al., 2012).

  Balance is a complex motor control task, requiring integration of sensory information, neural processing, and biomechanical factors. It is the ability to control the center of gravity (COG) over the base of support in a given sensory environment.

  Assessment includes evaluation of the motor system, ROM, and sensory systems that affect the person's ability to maintain equilibrium. Movement strategies to maintain balance require functional ROM and adequate strength. Sensory information from the vestibular, visual, and somatosensory systems are integrated at the central level between the two sides of the body and three sensory systems. These key areas are associated with maintenance of balance or posture. Central motor planning is essential for proper strategies that are then transmitted to the peripheral motor system for execution. Deficits at the central level, peripheral motor level, or peripheral sensory level will affect balance and equilibrium.

  Common clinical tests used to evaluate balance include the Balance Error Scoring System (BESS), Berg Balance Scale (BBS), Community Balance and Mobility Scale (CB&M), Clinical Test of Sensory Interaction on Balance (CTSIB), Motion Sensitivity Quotient, Sensory Organization Test (SOT), tandem gait task from the Sport Concussion Assessment Tool-3, Functional Gait Assessment (FGA), and an instrumented gait speed assessment. The disadvantage to most of these tests is that they were developed for specific age groups and may not have been studied for TBI (Valovich McLeod & Hale, 2015). However, the CB&M has been studied for TBI (Inness et al., 2011; Pape, Williams, Kodosky, & Dretsch, 2016). Self-report instruments are also available to evaluate balance: ABC scale for dizziness, Dizziness Handicap Inventory (DHI), Vertigo Handicap Questionnaire (VHQ), and the Vestibular Disorder Activities of Daily Living Scale (VADL) (Valovich McLeod & Hale, 2015).

  Sources of imbalance symptoms include vestibular, ocular, and cervicogenic. Vestibular-ocular type may have visual abnormalities on testing and impaired clinical balance. It is usually treated with a vestibular rehabilitation program. Visual or ocular motor training alone has no demonstrated benefit, and treatment should be done using an interdisciplinary approach. Cervicogenic imbalance is associated with neck pain and headaches associated with head movement. It is usually treated with head and neck proprioceptive re-training and cervical manual therapy (Ellis, Leddy, & Willer, 2015).

The dynamic systems model recognizes that balance and dynamic equilibrium are the result of the interaction between the individual, the functional task, and the environment. Emphasis of treatments performed by a qualified physical or occupational therapist in vestibular and balance dysfunction are head exercises for habituation of vertigo, eye-head coordination exercises for improvement of gaze stabilization, and sensorimotor retraining to remediate postural dyscontrol in all functional movement positions (Ellis et al., 2015). Exercises may be directed at habituation, desensitization by repeat exposure; substitution, alternative strategies; or adaption, improved use of remaining functioning vestibular system (Valovich McLeod & Hale, 2015).

Special equipment for vestibular treatment in the clinic may include dynamic platform posturography or a foam/dome apparatus for sensory integration and balance as well as tilt or rocker boards. Other virtual reality devices used in isolation are not suggested for use with this treatment because therapist intervention and supervision are important for success. No special equipment is needed at home unless identified by the treating professional and documented as medically necessary.

Individuals with central traumatic vestibular lesions take longer to improve than those with dizziness from other causes. Studies indicate that at six months, only one-third of individuals with unilateral loss from trauma were symptom-free as compared with other causes. At 18 months, many individuals continued to show symptoms. Of those with central vestibular loss, 60-70% had persisting symptoms at five years and half were unable to return to work (Marzo, Leonetti, Raffin, & Letarte, 2004).

For additional related complaints, refer to the Division's Moderate/Severe TBI Medical Treatment Guideline treatment section for neuro-otology.

Time frames

Time frames for vestibular rehabilitation for balance disorders	
Time to produce effect	6 to 12 weeks depending on severity.
Frequency	1-2 times per week initially for training, with 2-4 follow-up visits to reinforce treatment. Individuals are expected to perform self-directed exercises twice daily at home, but they may require supervision for guidance and safety.
Optimum duration	For mTBI, 12 visits.

F.4 Sleep disturbances

Definition and background

Sleep disturbances are a frequent occurrence in each spectrum of TBI severity, although milder injuries are associated with greater impairment than moderate or severe injuries (Wickwire et al., 2016). Pooled polysomnography data from meta-analyses have demonstrated reduced sleep efficiency (the ratio of time spent asleep compared to the amount of total time in bed), shorter total sleep duration, and increased time awake after sleep onset (Grima, Ponsford, Rajaratnam, Mansfield, & Pase, 2016). These reported objective findings correlate with subjective reports of greater daytime sleepiness and reduced perceived sleep quality (Grima et al., 2016). Sleep-wake disturbances can have a significant impact on functional recovery in patients with TBI and exacerbate secondary symptoms such as pain, headaches, and mood disturbances.

Supporting literature and evidence tables

Evidence statements regarding mTBI sleep disturbance			
Good evidence	Evidence statement	Citation	Design
	Online cognitive behavioral treatment (CBT) programs are comparable to both face-to-face CBT programs as well as pharmacologic therapy in reducing insomnia severity and sleep efficiency.	(Zachariae, Lyby, Ritterband, & O'Toole, 2016)	Meta-analysis of randomized clinical trials
Some evidence	Evidence statement	Citation	Design
	Blue light therapy significantly reduces self-reported fatigue and daytime sleepiness symptoms and may be helpful in some patients with TBI.	(Sinclair et al., 2014)	Randomized clinical trial

Studies not resulting in evidence statements
Wrist actigraphy has been validated as a surrogate for sleep patterns and is utilized frequently in sleep-related clinical trials (Wickwire et al., 2016). Obstructive sleep apnea (OSA) can develop in up to 35% of patients with TBI and should be identified and effectively treated if present (Castriotta et al., 2007). Untreated OSA can not only lead to poor neurocognitive performance and delayed recovery but also to adverse medical outcomes such as diabetes, hypertension, and ischemic heart disease due to restless sleep from repeated arousals and hypoxemia (Somers & Javaheri, 2005).

Indications/recommendations for sleep disturbances

Although physiologic sleep is most effectively measured by polysomnography (PSG), it is often not feasible or necessary to undertake such overnight testing. Subjective self-reporting questionnaires that have been validated against objective measures are the Pittsburgh Sleep Quality Index and the Epworth Sleepiness Scale (Lequerica et al., 2014; Wickwire et al., 2016). These tests are useful tools that can evaluate sleep patterns. Sleep diaries are another subjective tool that may be used to assess self-reported sleep patterns, although there is a paucity of research validating sleep diaries with objective testing. Objective testing measures to assess sleep-related behaviors include actigraphy and PSG. However, the treating clinician must consider the feasibility of such testing in this population.

Obstructive sleep apnea (OSA) should be identified and effectively treated if present (see studies listed in table above). Patients with OSA will complain of excessive daytime sleepiness, fatigue, and morning headaches. Bed partners may note that patients snore or appear to choke/gasp for air during the night. OSA should be suspected in patients with symptoms and/or with elevated risk factors such as obesity, a crowded oropharyngeal airway, increased neck circumference, and hypertension (Strohl, 2017). As mentioned above, PSG can be used to diagnose sleep apnea and other sleep related disorders.

Patients identified as having OSA should be treated with a positive airway pressure device such as continuous positive airway pressure (CPAP), bilevel positive airway pressure (BiPAP), or autotitrating positive airway pressure (APAP). Patients should also be counseled regarding weight loss strategies if indicated. Frequent evaluations are important to evaluate for adherence to therapy. This may be accomplished through patient interview and review of downloaded data from their device. Objective testing is usually not indicated unless symptoms do not resolve after several weeks of therapy.

In addition to OSA, clinicians should have a low threshold to obtain PSG in patients with TBI and hypersomnia (to rule out narcolepsy) or complaints suspicious for periodic limb movement disorder (uncomfortable urge to move legs and arms during inactivity) (Tarsy & Silber, 2017). Several small studies have suggested that sleep-related movement disorders and parasomnias occur at an increased rate in patients with TBI (Lim & Baumann, 2017). If present, mild symptoms of periodic limb movement disorder may be treated with sleep hygiene measures and behavioral therapies previously discussed.

Other sleep disorders should be ruled out when appropriate symptoms are present before proceeding with the following treatments.

- Counseling on sleep hygiene

  Non-pharmacologic treatments for sleep-wake disturbances following TBI, including modification of sleep hygiene, should be undertaken prior to instituting pharmacologic therapy. Clinicians should be sure to take a comprehensive medical history to include sleep patterns (such as taking naps during the day) and an occupational history to identify any high-risk job duties such as commercial driving or piloting. Patients suffering from a sleep-wake disorder should first receive basic behavioral sleep hygiene and stimulus control counseling.

Counseling should include the following:

- Set an alarm clock to wake up at a fixed time each morning, including weekends (Bootzin & Perlis, 1992).
- Try not to force sleep (Stepanski & Wyatt, 2003).
- Avoid caffeinated beverages after lunch and maintain consistent eating schedules, particularly dinner (Stepanski & Wyatt, 2003).
- Avoid alcohol.
- Avoid smoking or other nicotine intake, particularly during the evening (Stepanski & Wyatt, 2003).
- Adjust the bedroom environment as needed to decrease stimuli (e.g., reduce ambient light, turn off the television or radio) (Stepanski & Wyatt, 2003).
- Avoid prolonged use of light-emitting screens (laptops, tablets, smartphones, ebooks) before bedtime (Stepanski & Wyatt, 2003).
- Resolve concerns or worries before bedtime (Stepanski & Wyatt, 2003).
- Exercise regularly for at least 20 minutes, preferably more than 4 to 5 hours prior to bedtime (Stepanski & Wyatt, 2003).
- Avoid daytime naps, especially if they are longer than 20 to 30 minutes or occur late in the day (Stepanski & Wyatt, 2003).
- Go to bed only when sleepy (Bootzin & Perlis, 1992).
- Do not watch television, read, eat, or worry while in bed. Use bed only for sleep and sex (Bootzin & Perlis, 1992).
- Get out of bed if unable to fall asleep within 20 minutes and go to another room. Return to bed only when sleepy. Repeat this step as many times as necessary throughout the night (Bootzin & Perlis, 1992).

Additional conservative measures include the following (Silber et al., 2013; Tarsy & Silber, 2017):

- Mental alerting activities, such as working on a computer or doing crossword puzzles, at times of rest or boredom.
- Avoidance of aggravating factors, including consideration of withdrawal of possibly predisposing medications (antidepressants, antihistamines, dopamine-blocking antiemetics, and neuroleptic agents).
- Moderate regular exercise (Aukerman et al., 2006).
- Reduced caffeine intake.

  - For symptomatic relief: walking, bicycling, soaking the affected limbs, and leg massage, including pneumatic compression.

- Cognitive behavioral therapy

  Patients with sleep disturbances refractory to these basic counseling measures may benefit from a cognitive behavioral treatment (CBT) program for insomnia. When utilizing internet delivered CBT, the clinician should institute a program of a minimum of six weeks duration and consider including some measure of personal support as opposed to fully automated programs. Additionally, these programs require technical resources which may not be feasible in all patients and a formal in-person CBT program may be more appropriate.

  The general components of an effective CBT program may include the following (Currie, Wilson, Pontefract, & deLaplante, 2000):

  - Basic education regarding sleep and the nature and causes of chronic insomnia should be reviewed.

  - Behavioral therapy targeted problems with sleep maintenance and sleep onset using sleep restriction and stimulus control (see sleep hygiene and stimulus control recommendations). These interventions are designed to reestablish the bed as a dominant cue for sleep onset, regulate sleep-wake schedules, and consolidate sleep over a short period of time. Specifically, sleep restriction induces a state of mild sleep deprivation, which accelerates sleep onset and improves quality of sleep by establishing a "sleep window" for which patients stay in bed. To start, patients should use a sleep diary to determine the total amount of hours spent in bed as well as the amount of hours spent asleep. The amount of time the patient actually spends asleep will determine their initial window and the patient will only spend this specified amount of time in bed. For example, if a patient spends 8 hours in bed on average every night but only 6 hours is spent sleeping, then the patient's initial window would be 6 hours. Patients can then increase or decrease the time spent in bed by 20 to 30 minutes weekly depending on their sleep efficiency (time spent asleep/total time in bed). If sleep efficiency is >90%, then the patient can increase their time in bed. If sleep efficiency is <80% the patient should decrease time spent in bed. Sleep restriction allows the patient to learn to associate the bed with sleep and sex only.

  - Relaxation training, such as the imagery method, provided as an additional coping skill for patients. Guided imagery helps to inhibit cognitive stimulation by distracting patients and helps to refocus their attention on pleasant scenes that evoke positive emotions. Patients should practice these exercises every night to help them fall asleep.

  - Cognitive components designed to assist patients in exploring how their thoughts affect their sleep behaviors and emotions. Patients should be guided through cognitive restructuring procedures focused on reducing negative self-talk and negative attitudes that can be maladaptive.

  - Sleep hygiene measures as previously mentioned should be continuously reinforced.

- Pharmacologic therapy for insomnia

  The use of sleep-inducing agents such as benzodiazepines and nonbenzodiazepine hypnotics should generally be avoided as randomized clinical trials directly assessing their effects on insomnia and sleep-wake disorders are scarce. However, they may be useful for the first few weeks for some patients with mTBI and for anxiety.

- Fatigue and day time sleepiness
  - Blue light therapy: Blue light therapy should be administered for 30 to 45 minutes in the morning, within two hours of awakening, with a device containing 66 light-emitting diodes (LED). Patients can self-administer light therapy at home. They should be instructed to sit in front of the light panel with the center approximately 50cm (1.5 feet) in front the eyes and look into the light source for a few seconds at least every few minutes.
  - Pharmacologic agents for fatigue: Although there is a paucity of evidence demonstrating the effectiveness of Modafinil for treatment of fatigue, it may be beneficial for the short-term treatment of excessive daytime sleepiness (Jha et al., 2008). Armodafinil, the enantiomer of Modafinil with a slightly longer time to peak serum concentration, may be effective for the short-term treatment of patients with excessive daytime sleepiness despite good sleep efficiency on PSG (Menn, Yang, & Lankford, 2014). The use of these wakefulness-promoting agents should be restricted to short term use (4 to 6 weeks) in conjunction with nonpharmacologic therapy measures.

F.5 Cognitive treatment

Definition and background

In mTBI, acute cognitive deficits are common. In the majority of injured individuals, spontaneous cognitive improvement is expected within the first three months, frequently within days or weeks (McCrea et al., 2009).

For patients needing treatment, therapists or speech-language pathologists may work with the individual with mTBI in order to teach individuals adaptive skills, compensatory techniques, or new ways of solving problems that assist them in coping more effectively during recovery. The interdisciplinary treatment team approach is particularly beneficial in these cases, and it is strongly encouraged, especially during the first 12 months post-injury. The team may include specialists in neurology, rehabilitative medicine, neuropsychology, and ocular-motor, vestibular, and balance functioning.

"Cognitive rehabilitation is a systematic, functionally oriented service of therapeutic cognitive activities, based on an assessment and understanding of the person's brain-behavior deficits. Services are directed to achieve functional changes by (1) reinforcing, strengthening, or reestablishing previously learned patterns of behavior, or (2) establishing new patterns of cognitive activity or compensatory mechanisms for impaired neurological systems" (Harley et al., 1992).

All cognitive rehabilitation should be focused on functional goals relative to the individual patient's needs in performing activities of daily living and work. Progress toward achievement of specific goals should continually be monitored during treatment. Strategies should always be task or goal specific or demonstrate generalization of the learned concepts to the daily living activities of the specific patient with external cueing as necessary (Haskins, 2012). Compensatory or cognitive support strategies are useful in this population (Sohlberg & Mateer, 1987).

For most patients with mTBI, cognitive therapy will focus on memory, executive function, and in some cases attention. External memory compensation tools, such as memory notebooks, smart phones, and computers can be very helpful (Haskins, 2012). Self-talk strategies may be useful as patients with mTBI return to more complex executive function (Haskins, 2012). When patients with mTBI are required to perform skills requiring alternating or selective attention, specific strategies can be applied to improve the success rate.

Supporting literature and evidence tables

Evidence statements regarding mTBI and cognitive treatment			
Good evidence	Evidence statement	Citation	Design
	Cognitive training has small to moderate positive effects in improving cognitive and functional outcomes in patients with mild to severe TBI who are at least 1-year post-acute TBI when compared to waiting list controls or standard rehabilitation.	(Hallock et al., 2016)	Systematic review and meta-analyses of randomized clinical trials
	mTBI without post-traumatic amnesia does not require routine rehabilitation.	(Turner-Stokes, Disler, Nair, & Wade, 2005)	Systematic review of randomized trials, quasi-randomized trials, and quasi-experimental studies

Evidence statements regarding mTBI and cognitive treatment			
Some evidence	Evidence statement	Citation	Design
	Routine scheduling for cognitive rehabilitation for uncomplicated mTBI is not likely to improve outcomes, and mTBI cases with a psychiatric history are more likely to benefit from routine assessment for cognitive rehabilitation treatment.	(Ghaffar, McCullagh, Ouchterlony, & Feinstein, 2006)	Randomized clinical trial

Studies not resulting in evidence statements
There is inadequate evidence to support that computerize cognitive rehabilitation adds any benefits over conventional rehabilitation for patients with mild to severe TBI or stroke (Bogdanova, Yee, Ho, & Cicerone, 2016; Haskins, 2012; Ponsford et al., 2014).

Indications for mTBI cognitive treatment

Not all patients with mTBI require cognitive treatment. Rehabilitation of cognitive impairments should be initiated if:

- the individual is not demonstrating the expected cognitive improvement;
- the individual exhibits more severe cognitive impairments on formal evaluation;
- the individual's vocation or other life circumstances necessitate the learning of compensatory strategies;
- there are safety issues in question (e.g., possible harm to self or others).

Recommendations for mTBI cognitive treatment

If therapy is required, use the time frames listed below. In individual cases, the physician may determine the need for further evaluation and treatment.

Computer-based treatment with active therapist involvement: Computer-based treatment must be accompanied by oversight from the treating provider either in person or by telehealth. Computer-based treatment is ***not recommended in isolation***.

Assistive technology: These devices must be used in consultation with specialists and within a rehabilitation therapy program by physical therapists, occupational therapists, and speech-language pathologists to determine which tools are most suitable for individual cases.

Time frames

Time frames regarding mTBI cognitive treatment	
Frequency	Weekly 1-hour sessions initially during the first month to determine specific goals and objective outcomes as part of the primary treatment and return-to-work evaluations. Once the patient has returned to normal function without impairing symptoms, visit frequency should decrease or treatment should be terminated.
Optimum duration	1 to 3 months. Additional sessions may be required as justified. For example, in cases with complicated mTBI or a number of comorbid conditions, treatment patterns may resemble that for moderate/severe injuries.

F.6 Psychological interventions

Definition and background

Early interventions that educate individuals, their family and/or support system, or the employer about the symptoms, natural history, prognosis, and management of mTBI symptoms are very important.

Psychological and educational interventions may include, or be performed in conjunction with, cognitive and behavioral treatment. Cognitive behavioral therapy (CBT) is a specialized goal-oriented systematic process used to problem solve that focuses on changing thought processes. It is usually provided by a trained therapist or psychologist.

The acute symptoms of mTBI (e.g., feeling dazed, disoriented, or confused) overlap with those of emotional trauma and acute stress disorder. Over the course of recovery, the symptoms of mTBI also overlap with a variety of psychological conditions, such as depression, anxiety, insomnia, and PTSD. Consequently, the possibility that the symptoms are neuropsychiatric rather than neuropsychological in origin should be evaluated when the degree of cognitive symptoms exceeds what would be expected given objective findings, the mechanism of injury, or acute signs of mTBI or if there is an unexplained, marked worsening of cognitive symptoms over time. A psychological evaluation is especially important if the injury occurred in an emotionally traumatic context or if there are clinical indications of another mental health disorder.

Supporting literature and evidence tables

Evidence statements regarding mTBI psychological/educational interventions			
Some evidence	Evidence statement	Citation	Design
	5 individual sessions, 1.5 hours long, of Cognitive Behavioral Therapy (CBT) initiated for patients diagnosed with acute stress disorder early after TBI are significantly more effective than supportive counseling in preventing chronic PTSD in patients who develop acute stress disorder following mTBI.	(Bryant et al., 2003)	Single-blind randomized clinical trial
	For patients with complicated mTBI and moderate TBI who have completed initial therapy, 12 weeks of telephone-based and in-person Cognitive Behavioral Therapy (CBT) interventions are no more effective than usual care for treating Major Depressive Disorder (MDD). Due to the differences noted between groups in this study, it is not possible to determine if telephone CBT is preferable to in-person CBT after initial treatment has been completed. However, telephone CBT allowed more participation by support persons, and this may be important to patients with mTBI. It is interesting that secondary data showed high satisfaction with CBT, 84%, and only 26% with usual care.	(Fann et al., 2015)	Single-blind randomized clinical trial

Studies not resulting in evidence statements
One study noted sustained improvement after 6 months of CBT with either face-to-face or telephone contact. This should always be performed within the construct of a more complete therapy program (Arundine et al., 2012).

Indications for mTBI psychological/educational interventions

Early intervention is appropriate in the acute stage of mTBI for patients at increased risk of prolonged symptoms to promote positive coping skills and to manage symptoms. Risk factors for prolonged symptoms include, but are not limited to:

- Glasgow Coma Scale less than 15 at 2 hours post-injury (National Institute for Health and Clinical Excellence (NICE), 2007);
- work risk factors, such as very demanding or stressful vocations or being employed in the current job for a short period of time;
- age above 40 years;
- injury complicated by the presence of intracranial lesions, current or previous;
- history of prior brain injury, cognitive impairment, learning disabilities, or developmental delay;
- associated orthopedic, soft tissue, or organ injuries;
- pre-injury issues with general health or psychosocial well-being;
- psychological factors such as depression, post-traumatic stress disorder, or anxiety – see evidence statement above.

The presence of other injuries requiring medical attention should not exclude anyone from appropriate psychological treatment.

During the first 12 weeks following mTBI, the following should always be treated:

- problems that are secondary to the injury (e.g., anxiety, depression, adjustment disorder, difficulties with self-acceptance, and difficulties in adapting to one's work demands due to diminished cognitive capacity), and
- post-traumatic stress disorder (PTSD). PTSD may be present in a minority of patients with mTBI and should be assessed early on and treated (Hoffman, Dikmen, Temkin, & Bell, 2012).
- It is also appropriate to consider intervention to address persistent specific problems that are directly caused by the injury (e.g., memory deficits).

Recommendations for mTBI psychological/educational interventions

Early intervention in the acute stage: Psychological treatment after the first 12 weeks, by physicians with experience in brain injury care, is recommended when recovery is hindered by symptoms caused by the injury or by symptoms secondary to it as indicated above. For psychological symptoms lasting longer than six months, refer to the Division's Moderate/Severe TBI Medical Treatment Guideline. Primary care providers should be made aware of these recommendations as often there is delay in treatment.

Treatment may include individual psychotherapy, marital/family therapy, group therapy, instruction in relaxation and related techniques, cognitive/behavioral therapy, medication management, social skills training, repetitive transcranial magnetic stimulation (rTMS) for treatment-resistant depression, and interventions/consultation in the community (McClintock et al., 2018). When cognitive interventions are needed, refer to Section F.5, Cognitive treatment.

Functional gains are to be documented and achieved with therapy. They may include, but are not limited to improved mood, irritability, frustration tolerance, concentration, memory, sleep quality, and interpersonal skills (such as empathy and capacity to effectively interact with family and/or support system members and co-workers).

- During the acute stage: Psychological interventions to educate regarding coping mechanisms for common symptom amelioration may include the individual and family and/or support system or alternatively close friends and co-workers.
- During the first 12 weeks: Mental health interventions to address PTSD should be evidence based and may include individual psychotherapy, cognitive/behavioral therapy, instructions in specific techniques such as relaxation training or biofeedback, instruction in symptom management, trauma resolution techniques (e.g., EMDR), group therapy, medications, and interventions in the community.

Time frames

Time frames regarding mTBI psychological/educational interventions	
Frequency	Weekly 1-hour sessions initially during the first month as part of the primary treatment and return-to-work evaluations. Once a patient has returned to normal function without impairing symptoms, visit frequency should decrease or treatment should be terminated.
Optimum duration	Optimum Duration: 1 to 3 months. Additional sessions may be required as justified.

F.7 Medications

Definition and background

Most mTBI cases do not require prescription medication as the majority of cases resolve without them (Management of Concussion-Mild Traumatic Brain Injury Working Group, 2016). The most common needs for medication in mTBI are anxiety, depression, nausea, and headaches (Management of Concussion-Mild Traumatic Brain Injury Working Group, 2016).

Indications/recommendations for medications

A number of patients with mTBI have a constellation of complaints including insomnia, headache, and depressive symptoms. When conservative measures are not effective and symptoms are still interfering with activity after seven to ten days, amitriptyline or an SSRI and low dose amitriptyline may be reasonable considerations (Management of Concussion-Mild Traumatic Brain Injury Working Group, 2016; Ontario Neurotrauma Foundation, 2013).

If other medication use can be justified based on specific patient needs, refer to the Division's Moderate/Severe TBI Medical Treatment Guideline, Section F.4.h, Medications. Specialists should generally be involved for TBI cases requiring multiple medications.

When medication is used for mTBI, a trial of tapering by 6-12 months post-injury is recommended.

- Acetaminophen

  Acetaminophen is an effective analgesic with anti-pyretic but not anti-inflammatory activity.

  Acetaminophen is generally well-tolerated. It causes little or no gastrointestinal (GI) irritation and is not associated with ulcer formation.

  However, acetaminophen can exacerbate headache when used chronically. Acetaminophen also has been associated with liver toxicity in overdose situations or in chronic alcohol use. Patients may not realize that many over-the-counter preparations contain acetaminophen. The total daily dose of acetaminophen is recommended not to exceed three grams per 24-hour period, from all sources, including narcotic-acetaminophen combination preparations.

  Time frames

Time frames regarding acetaminophen	
Optimum duration	7 to 10 days.

Time frames regarding acetaminophen	
Maximum duration	Long-term use as indicated on a case-by-case basis. Use of this substance long-term (for 3 days per week or greater) may be associated with rebound pain upon cessation.

- Non-steroidal anti-inflammatory drugs (NSAIDs)

  NSAIDs are useful for pain and inflammation. In mild cases, they may be the only drugs required for analgesia. Chronic use of NSAIDs is generally ***not recommended*** due to increased risk of cardiovascular events and GI bleeding.

  There are several classes of NSAIDs. The response of the injured worker to a specific medication is unpredictable. For this reason, a range of NSAIDs may be tried in each case, with the most effective preparation being continued.

  Patients should be closely monitored for adverse reactions. The FDA advises that many NSAIDs may cause an increased risk of serious cardiovascular thrombotic events, myocardial infarction, and stroke, which can be fatal. Administration of proton pump inhibitors, histamine 2 blockers, or prostaglandin analog misoprostol along with these NSAIDs may reduce the risk of duodenal and gastric ulceration in patients at higher risk for this adverse event (e.g., age > 60, concurrent antiplatelet or corticosteroid therapy). They do not impact possible cardiovascular complications (Hooper et al., 2004).

  NSAIDs are associated with abnormal liver function and renal function, including renal failure. Patients with hepatic or renal disease may need increased dosing intervals with chronic use.

  Due to the cross-reactivity between aspirin and NSAIDs, NSAIDs should not be used in aspirin-sensitive patients, and they should be used with caution in all patients with asthma.

  Topical NSAIDs may be more appropriate for some patients; see evidence statements in table below ([Cochrane] S. Derry, Moore, Gaskell, McIntyre, & Wiffen, 2016).

  NSAIDs may be associated with non-unions. Thus, their use with fractures is questionable (Jeffcoach et al., 2014).

  Certain NSAIDs may have interactions with various other medications. Individuals may have adverse events not listed above. Intervals for metabolic screening are dependent on the patient's age and general health status and should be within parameters listed for each specific medication. Complete blood count (CBC) and liver and renal function should be monitored at least every six months in patients on chronic NSAIDs and initially when indicated.

There is no evidence to support or refute the use of oral NSAIDs to treat neuropathic pain conditions ([Cochrane] Moore, Derry, Aldington, Cole, & Wiffen, 2015).

- Non-selective non-steroidal anti-inflammatory drugs: This includes NSAIDs and acetylsalicylic acid. Serious GI toxicity, such as bleeding, perforation, and ulceration can occur at any time, with or without warning symptoms, in patients treated with traditional NSAIDs. Physicians should inform patients about the signs and/or symptoms of serious GI toxicity and what steps to take if they occur. Anaphylactoid reactions may occur in patients taking NSAIDs. NSAIDs may interfere with platelet function. Fluid retention and edema have been observed in some patients taking NSAIDs.

  Time frames

Time Frames regarding non-selective non-steroidal anti-inflammatory drugs	
Optimum duration	1 week.
Maximum duration	1 year. Use of these substances long-term (3 days per week or greater) is associated with rebound pain upon cessation.

- Selective cyclo-oxygenase-2 (COX-2) inhibitors: COX-2 inhibitors differ from the traditional NSAIDs in adverse side effect profiles. The major advantages of selective COX-2 inhibitors over traditional NSAIDs are that they have less GI toxicity and no platelet effects. COX-2 inhibitors can worsen renal function in patients with renal insufficiency; thus, renal function may need monitoring.

  There is an absence of evidence concerning the relative safety of celecoxib at doses greater than 200 mg per day (Nissen et al., 2016). See also evidence statements in table below.

  COX-2 inhibitors should not be first-line for low risk patients who will be using an NSAID short-term. COX-2 inhibitors are indicated in select patients who do not tolerate traditional NSAIDs. Serious upper GI adverse events can occur even in asymptomatic patients. Patients at high risk for GI bleed include those who use alcohol, smoke, are older than 65 years of age, take corticosteroids or anti-coagulants, or have a longer duration of therapy. Celecoxib is contraindicated in sulfonamide allergic patients.

  Time frames

Time frames regarding selective cyclo-oxygenase-2 (COX-2) inhibitors	
Optimum duration	7 to 10 days.

Maximum duration	Chronic use is appropriate in individual cases. Use of these substances long-term (3 days per week or greater) is associated with rebound pain upon cessation.

Supporting literature and evidence tables

Evidence statements regarding nonsteroidal anti-inflammatory drugs (NSAIDs)			
Good evidence	Evidence statement	Citation	Design
	Celecoxib in a dose of 200 mg per day, administered over a long period, does not have a worse cardiovascular risk profile than naproxen at a dose of up to 1000 mg per day or ibuprofen at a dose of up to 2400 mg per day.	(Nissen et al., 2016)	Randomized noninferiority trial
	Celecoxib has a more favorable safety profile than ibuprofen or naproxen with respect to serious GI adverse events, and it has a more favorable safety profile than ibuprofen with respect to renal adverse events.		
	Topical NSAIDs are associated with fewer systemic adverse events than oral NSAIDs, e.g., reduced risk of gastrointestinal adverse effects by approximately one third.	([Cochrane] S. Derry et al., 2016)	Meta-analysis of randomized clinical trials

F.8 Communication and swallowing

Communication and swallowing issues are uncommon in mTBI. However, refer to the Division's Moderate/Severe TBI Medical Treatment Guideline if treatment is needed.

F.9 Therapeutic exercise

Definition and background

Therapeutic exercises, with or without mechanical assistance or resistance, may include a number of modalities as part of the integrated occupational therapy or physical therapy program. A therapeutic exercise program should be initiated at the start of any treatment program and coordinated in an interdisciplinary approach. Such programs should emphasize education, independence, and the importance of an on-going exercise regime.

Supporting literature and evidence tables

Studies not resulting in evidence statements
Both animal and human studies suggest therapeutic exercise has a direct relationship on recovery from a TBI (Archer, 2011; Barnes, Yaffe, Satariano, & Tager, 2003; S. Colcombe & Kramer, 2003; S. J. Colcombe, Kramer, McAuley, Erickson, & Scalf, 2004; Ferris, Williams, & Shen, 2007; Griesbach, Gomez-Pinilla, & Hovda, 2004; Griesbach, Hovda, Molteni, Wu, & Gomez-Pinilla, 2004; Griesbach, Tio, Vincelli, McArthur, & Taylor, 2012; Knaepen, Goekint, Heyman, & Meeusen, 2010; Kramer et al., 1999; Lojovich, 2010; Weuve et al., 2004).

Indications for therapeutic exercise

Indications include the need for:

- cardiovascular fitness,
- improved muscle strength,
- improved connective tissue strength and integrity,
- increased bone density,
- promotion of circulation to enhance soft tissue healing,
- improvement of muscle recruitment,
- improved proprioception and coordination, and
- increased ROM.

Recommendations for therapeutic exercise

Therapeutic exercise may be done as part of the overall occupational therapy or physical therapy program. It is not to be used in isolation. It should occur in an interdisciplinary treatment setting. As with all treatments, specific objective goals should be set initially and monitored during treatment.

The patient and/or caregiver should be instructed in and receive a home or community exercise program that is progressed as functional status improves.

Upon discharge from inpatient or residential rehabilitation, the patient and/or caregiver would be independent in the performance of the home exercise program and would have been educated in the importance of continuing such a program. Educational goals would be to maintain or further improve function and to minimize the risk for aggravation of symptoms in the future.

Time frames

Time frames regarding therapeutic exercise	
Time to produce effect	2 to 6 treatments.
Frequency	1 to 3 times per week.
Optimum duration	4 to 8 weeks and concurrent with an active daily home or community exercise program.
Maximum duration	8 to 12 weeks of therapist oversight. Home exercise should continue indefinitely.

F.10 Education

Definition and background

Education for individuals with TBI and their family and/or support system is appropriate, generally accepted, and widely used in TBI rehabilitation (Management of Concussion-Mild Traumatic Brain Injury Working Group, 2016). Shared decision making with the patient is preferred for patients with mTBI.

Supporting literature and evidence tables

Studies not resulting in evidence statements
Most mTBI cases will progress to recovery with sufficient education and not require interdisciplinary treatment (Zafonte, 2006). Education should be provided to patient with mTBI in printed material with verbal review. It should cover symptoms and expected outcomes, normalize symptoms (i.e., explain that current symptoms are to be expected), reassure about expected positive recovery, cover gradual return to activities and life roles, and give techniques to manage stress (Ontario Neurotrauma Foundation, 2013).

Indications for education

Education provided to the patient, family, and/or support systems is appropriate for all individuals with mTBI.

Recommendations for education

Education for individuals and their family and/or support system should include, but is not limited to:

- communication of basic information about the brain and the effects of TBI on behavior, cognition, communication, physical function, and emotional function;
- appropriate family and/or support system interventions;
- possible short-term and long-term outcomes.

Written information and material and referral to credible internet resources may be helpful as the individual and family and/or support system may not be able to remember the vast amount of information provided to them.

For similar reasons, they may need to be provided repeated or ongoing information. Further in-depth education may be required to maximize the individual's potential for functional living. Treatment plans should include individual and group education as a means of facilitating self-awareness, self-management, and prevention of secondary disability.

In order to maximize treatment outcomes and the durability of those outcomes, treatment providers are highly encouraged to provide: hands-on, personal consultations; education (written, verbal, internet); and support services to families.

Time frames

Time frames regarding mTBI education	
Frequency	Weekly 1-hour sessions initially during the first month as part of the primary treatment and return-to-work evaluations. Once the patient has returned to normal function without impairing symptoms, visit frequency should decrease or treatment should be terminated.
Optimum duration	1 to 3 months. Additional sessions may be required as justified.

F.11 Hyperbaric oxygen (HBO2)

Definition and background

HBO2 was initially thought to improve outcomes.

Supporting literature and evidence tables

Evidence statements regarding hyperbaric oxygen			
Good evidence	Evidence statement	Citation	Design
	HBO2 is unlikely to be beneficial in the setting of mTBI.	(Crawford, Teo, Yang, Isbister, & Berry, 2017)	Systematic review of randomized and nonrandomized studies of HBO2

Complications

Complications can occur, including tension pneumothrorax (Lee, Lieu, Chen, Hung, & Chen, 2012).

Recommendations for HBO2

Hyperbaric oxygen is ***not recommended*** acutely or chronically. Ongoing studies could affect this recommendation.

F.12 Interdisciplinary rehabilitation programs

Definition and background

Consider referral to an interdisciplinary program based on the results of a comprehensive neuropsychological and/or psychiatric assessment, which should be conducted post-injury in individuals with mTBI and delayed recovery and as soon as appropriate for more severe cases. *Informal* programs with community-based services are usually most appropriate for patients with mTBI. However, *formal* inpatient programs may be necessary as described below. The sequencing of treatment is based on the individual’s ability to tolerate and benefit from the specific therapies.

Supporting literature and evidence tables

Evidence statements regarding mTBI interdisciplinary rehabilitation programs			
Good evidence	Evidence statement	Citation	Design
	mTBI without post-traumatic amnesia does not require routine rehabilitation.	([Cochrane] Turner-Stokes et al., 2005)	Systematic review of randomized trials, quasi-randomized trials, and quasi-experimental studies

Indications/recommendations for mTBI interdisciplinary rehabilitation programs

Informal interdisciplinary programs in the workers' compensation system should be considered for patients who are currently employed, those who cannot attend all day programs, those with language barriers, or those living in areas not offering formal programs. Before treatment has been initiated, the patient, patient's family and/or support system, physician, and insurer should agree on the treatment approach, methods, and goals. Generally, the type of outpatient program needed will depend on the degree of impact the injury has had on the patient's medical, physical, psychological, social, and/or vocational functioning.

However, *formal* inpatient rehabilitation programs may be necessary for patients with mTBI with any of the following conditions: (a) high risk for medical instability; (b) moderate-to-severe impairment of functional status; (c) moderate impairment of cognitive and/or emotional status; (d) dependence on medications from which he or she needs to be withdrawn; and (e) the need for 24-hour supervision. For formal programs, refer to the Division's Moderate/Severe TBI Medical Treatment Guideline.

Patients with addiction and/or substance abuse problems or high dose opioid or other drugs of potential abuse may require inpatient and/or outpatient chemical dependency treatment programs before or in conjunction with other interdisciplinary rehabilitation. Guidelines from the American Society of Addiction Medicine are available and may be consulted relating to the intensity of services required for different classes of patients in order to achieve successful treatment.

G. Return to work & vocational rehabilitation

G.1 Return to work

Definition and background

In addition to the treatment strategies described below, practitioners should be familiar with how various state and federal statutes and regulations may impact return-to-work planning. These may include, but are not limited to, Family and Medical Leave Act (FMLA), Americans with Disabilities Act (ADA), Occupational Safety and Health Administration (OSHA), Federal Motor Carrier Safety Administration (FMCSA), and the Department of Transportation (DOT).

Supporting literature and evidence tables

Evidence statements regarding return to work			
Strong evidence	Evidence statement	Citation	Design
	In the setting of TBI, there is a negative association between psychiatric comorbidity (anxiety, depression, PTSD) and return to work; however, the magnitude of this effect has not been clearly established.	(Garrelfs, Donker-Cools, Wind, & Frings-Dresen, 2015)	Systematic review of observational studies

Studies not resulting in evidence statements
One study found a relationship between perceived self-efficacy in cognitive areas and life satisfaction. The same study found a relationship with employed or volunteer work and satisfaction (Cicerone & Azulay, 2007).

Indications/recommendations for return to work

During the first five days post-injury, symptoms can be severe and significantly disrupt normal daily function. Initial considerations should include lightening task load and allowing extra time to complete normal tasks. Thus, shortening the work day or adding breaks, along with decreasing responsibility for the first several weeks, are generally suggested. Driving, heavy lifting, working with dangerous machinery, using ladders, and heights may be restricted because of possible safety risk (Centers for Disease Control and Prevention, 2015).

Following mTBI, many individuals are able to resume normal work duties with secondary prevention precautions and education. They typically require little or no additional therapeutic intervention. A small percentage of individuals with mTBI - such as those with age greater than 40, prior TBI, loss of consciousness close to 30 minutes, or mental status changes lasting up to 24 hours - may require more assistance in return to work and accommodations. For individuals with mTBI, it may be necessary to temporarily reduce the time, amount, type, and/or intensity of their work duties or temporarily remain out of work entirely for a period of time, at the discretion of the clinician, and gradually increase hours and complex cognitive and physical duties based on symptomology.

For example, if workers with mTBI have any loss of consciousness or prolonged disorientation, providers should consider restricting higher risk job duties (such as working at heights, working with power tools, and operating heavy machinery) until they have been free from the symptoms, including dizziness and imbalance, for two consecutive weeks. Second impact syndrome (refer to Section C.2, Prevention) has been seen in younger age groups who suffer severe life threatening effects after a second TBI within a short time after the first TBI. Physicians should take this into account when writing work restrictions.

Return to full duty depends on the rate of decrease of symptoms. The individual should be competent in most basic ADLs before return to work is considered. Generally, if symptoms recur during increasing job duties or exertion, duties should be decreased slightly (Management of Concussion-Mild Traumatic Brain Injury Working Group, 2016). Very gradual return to activity over weeks may be necessary for cases with symptoms lasting longer than 15 minutes at the time of the injury, unconsciousness lasting minutes, or prolonged amnesia (Frey & Savage, 2009).

Physicians should be aware that symptoms in workers with mTBI may include cognitive deficits in memory, attention, and executive function, even if the worker has no complaints/symptoms. Memory, attention, and executive function should be tested by asking specific questions regarding recent events and having the individual perform specified tasks. Physicians should educate the individual with TBI and his/her supervisor to be aware of possible memory and attention deficits and to accommodate accordingly. Time to return to baseline function will differ according to the individual's pre-accident condition, age, and medication, as well as other pre-injury, injury, and post-injury factors.

Physicians should attempt to clearly and specifically document vocational restrictions and have a graded or gradual plan for re-entry to work and to communicate with the employer (e.g., supervisor, safety officer, employee health nurse). Having a significant physical disability, psychosocial impairment, cognitive impairment, or a history of alcohol and other substance abuse are factors that impede return to work. Other factors impeding return to work include difficulties regarding transportation, coordination, and vision. An interdisciplinary team approach may be recommended, which may include a neuropsychological assessment, vocational evaluation, job site analysis, early contact with employer, assessment of vocational feasibility, supervisor education, transferable skills analysis, skillful increased titration of job duties and demands, job coaching, physical therapy, occupational therapy, speech-language therapy, and psychological services.

In work situations where the employer is unable to accommodate and a return to the previous occupation is not suitable or appropriate, other options include volunteer placements or supported employment opportunities. See the above return-to-work literature table for a study on volunteer work and life satisfaction. Consider vocational re-training, individualized/specialized job placement services, and job coaching as needed.

Based on the evidence listed in the evidence table above, all patients with TBI should have psychological/neuropsychological evaluations and treatment as needed.

For individuals with mTBI who have persistent deficits or who have difficulty once back at work, a return-to-work program should occur, which requires a carefully designed and managed plan involving the person with TBI, his/her employer, and the treatment team. Physicians should consider evaluation and treatment for comorbid conditions such as chronic pain, stress level, pre-existing personality disorders, depression, anxiety, and/or substance abuse. Communication among all involved parties and the avoidance of fragmentation among treatment professionals is critical to successful outcome. Case management may be indicated to facilitate communication. Following return to work, maintenance support services are appropriate to best ensure the durability of the outcome.

G.1.a Recommended vocational rehabilitation assessment

According to Inter-Professional Clinical Practice Guidelines, a vocational evaluation should include some of the following (Stergiou-Kita, Dawson, & Rappolt, 2012):

- initial intake process, including:
  - pre-injury history;
  - educational and work histories;
  - current social status;
  - pre-injury job performance and performance evaluations; and
  - successes and failures in post-injury work trials;
- assessment of the person (individual’s perspective), including:
  - work goals, values, and meaning he/she attached to work pre- and post-injury;

- work performance, strengths, weaknesses, current work competency;
    - compensatory strategies and support needs;
    - readiness to work and anticipated challenges/barriers to work or return to work;
    - individual's own assessment of the costs and benefits of working;
    - individual's view of the implications of a decision not to work (e.g., insurance and benefits);
- assessment of an individual's functional status and level of independence;
- observations of an individual's work-related skills and behavior during performance in real work setting, or if unavailable, simulated work tasks;
- assessment of the physical workplace environment;
- assessment of supports (i.e., formal and informal) and opportunities within the workplace and the individual's support network including availability of accommodations and/or job modifications;
- assessment of the occupational/job requirements.

G.2 Driving

If evaluation and treatment for driving is needed, refer to the Division's Moderate/Severe TBI Medical Treatment Guideline.

G.3 Vocational rehabilitation

Definition and background

Vocational rehabilitation is a generally accepted intervention, but the Colorado Workers' Compensation statute limits its use.

Supporting literature and evidence tables

Studies not resulting in evidence statements
In one study, a brain injury vocational rehabilitation program was successful at returning 41% of clients to competitive employment. The majority of the cases were 2 years or more from date of injury and had injuries classified as severe (post-traumatic amnesia duration of 1 or more days). These cases were also without significant behavioral problems and able to function independently for ADLs. The program included cognitive training for those who had not previously received it and job trials with job coach support (Murphy et al., 2006).

Indications/recommendations for vocational rehabilitation

Initiation of vocational rehabilitation requires adequate evaluation of individuals with TBI for quantification of highest functional level, motivation, and achievement of MMI. Vocational rehabilitation should involve a comprehensive job analysis and a carefully planned return-to-work strategy with input from the treating physician and interdisciplinary team. In some instances, retraining may need to occur to access new job markets. (Refer to Section G, Return to work.)

G.4 Work conditioning

Definition and background

These well-accepted programs are work-related, outcome-focused, and individualized treatment programs. Objectives of the program include, but are not limited to, improvement of cardiopulmonary and neuromusculoskeletal functions (strength, endurance, movement, flexibility, stability, and motor control functions), patient education, and symptom relief. The goal is for patients to gain full or optimal function and return to work.

Supporting literature and evidence tables

The following recommendations were based on consensus.

Indications for work conditioning

These programs are usually initiated once re-conditioning has been completed, but they may be offered at any time throughout the recovery phase. It should be initiated when imminent return of a patient to modified or full duty is not an option but the prognosis for returning the patient to work at completion of the program is at least fair to good.

Recommendations for work conditioning

The service may include the time-limited use of modalities, both active and passive, in conjunction with therapeutic exercise, functional activities, general conditioning body mechanics, and re-training of lifting techniques. The patient should be assisted in learning to pace activities to avoid exacerbations.

Time frames

Time frames regarding work conditioning	
Length of visit	1 to 4 hours per day.
Frequency	2 to 5 visits per week.

Time frames regarding work conditioning	
Optimum duration	2 to 4 weeks.
Maximum duration	6 weeks. Participation in a program beyond 6 weeks should be documented with respect to need and the ability to facilitate positive symptomatic and functional gains.

G.5 Work simulation

Definition and background

Work simulation is a generally accepted program where an individual completes specific work-related tasks for a particular job and return to work.

Supporting literature and evidence tables

The following recommendations were based on consensus.

Indications/recommendations for work simulation

Use of this program is appropriate when modified duty can only be partially accommodated in the work place, when modified duty in the work place is unavailable, or when the patient requires more structured supervision. The need for work-place simulation should be based on the results of a functional capacity evaluation and/or job site analysis.

Time frames

Time frames regarding work simulation	
Length of visit	2 to 6 hours per day.
Frequency	2 to 5 visits per week.
Optimum duration	2 to 4 weeks.
Maximum duration	6 weeks. Participation in a program beyond 6 weeks should be documented with respect to need and the ability to facilitate positive symptomatic and functional gains.

H. Maintenance management

Most individuals following mTBI make a good neurological and functional recovery with minimal or no intervention, although the possibility of subtle residual impairments or functional limitations exists. Some individuals with mTBI experience impairments, functional limitations, and disabilities. Individuals with mTBI who have comorbid conditions and/or have experienced a longer period of confusion or loss of consciousness are more likely to have a poorer outcome and require longer treatment or maintenance care. For patients with mTBI with specific additional issues, further care may require treatment or follow-up with specialty services such as optometry, neuro-ophthalmology, neuro-otology, rehabilitation psychology, neuropsychology, and physical medicine and rehabilitation including brain injury medicine. Medical and rehabilitation providers are encouraged to educate individuals and their family and/or support systems regarding anticipated ongoing medical and rehabilitation needs.

Patients and families and/or support systems should understand that failure to comply with the elements of the self-management program or therapeutic plan of care may affect consideration of other interventions.

Periodic reassessment of the individual's condition will occur as appropriate. The overall maintenance plan should be reassessed at least annually by the authorized treating provider.

Programs should be individualized to specific needs and may include the following.

H.1 Exercise programs requiring gym memberships or special facilities

Definition and background

Some individuals with mTBI may have higher compliance with an independent exercise program at a health club or a community activity-based wellness program versus participation in a home program, although individuals with mTBI may require supervision or guidance.

Supporting literature and evidence tables

The following recommendations were based on consensus.

Indications/recommendations for exercise programs requiring gym membership or special facilities

All exercise programs completed through a health club facility should be approved by the treating therapist and/or physician and focus on the same parameters of an age-adjusted and diagnosis-specific program for aerobic conditioning, flexibility, balance, stabilization, and strength. Prior to purchasing a membership, a therapist and/or exercise specialist who has treated the individual should visit the facility with the individual to ensure proper use of the equipment. Periodic program evaluation and upgrading may be necessary by the therapist. The use of a personal trainer may be necessary.

Time frames

Time frames regarding exercise programs requiring special facilities: maintenance	
Frequency	Approximately 2 times per week. Regular attendance is necessary for continuation, with an exception for a medical or sufficient intervening cause.
Maximum maintenance duration	Continuation beyond 3 months after MMI should be based on functional benefit and compliance. At MMI, health club membership should not extend beyond 3 months if attendance drops below 2 times per week on a regular basis without a medical cause.

H.2 Home exercise programs and exercise equipment

Definition and background

Most patients have the ability to participate in a home exercise program after completion of a supervised exercise rehabilitation program.

Supporting literature and evidence tables

The following recommendations were based on consensus.

Indications/recommendations for home exercise maintenance programs

Programs should incorporate an exercise prescription including the continuation of an age-adjusted and diagnosis-specific program for aerobic conditioning, flexibility, stabilization, balance, and strength. Home exercise programs are most effective when done three to five times a week. For chronic pain, refer to the Division's Chronic Pain Disorder Medical Treatment Guideline.

Time frames

Follow-up evaluations in the home should occur to ensure compliance and to upgrade the home program.

H.3 Medication management

Definition and background

Medications may be necessary for long-term management of some individuals with mTBI.

Supporting literature and evidence tables

The following recommendations were based on consensus.

Indications/recommendations for medication maintenance management

Medications may be used for medical, physical, perceptual, cognitive, neuroendocrine, and psychological reasons, and they should be prescribed by physicians experienced in mTBI medication management. Reasons for possible medications and the types and names of medication are numerous, are individualized for each person, and are beyond the scope of these guidelines.

In situations where there are multiple providers for multiple clinical issues, coordination of the total medication regimen is essential. It is strongly recommended that changes in medication be discussed with the physician who is primarily managing the case.

As with all prescriptive regimens, physicians periodically reassess the efficacy and side effects of each medication. This is particularly true for individuals who are on long-term medication use. Physicians must follow patients who are on any chronic medication or prescription regimen for compliance, efficacy, and side effects. Individuals with mTBI are particularly susceptible to certain medication side effects, including compromised cognitive function, decreased seizure threshold, and other neurological effects. Follow-up visits should document the individual's ability to perform routine functions. Laboratory or other testing is usually required on a regular basis to monitor medication effects on organ function. For some, medications and drug levels should be closely monitored.

Individuals with mTBI may forget to take medications and/or have difficulty with complicated medication regimens. They may need assistance with medication management, such as reminders, medication boxes, assistance with filling medication boxes, or medication administration supervision. Some medications may need to be prescribed in small amounts or locked due to safety in patients who are impulsive, forgetful, inconsistent, or otherwise unsafe in independent medication management.

Time frames

Time frames regarding medication management: maintenance	
Frequency	Medication and medical management reviews may need to be monthly or more frequently if necessary for changes in medication. Frequency depends on the medications prescribed, with laboratory and other monitoring performed as appropriate.
Maintenance duration	As new medications become available and side effects of other medications are established, there may need to be changes in medical management.

H.4 Patient education management

Definition and background

Functional abilities and support systems for individuals with mTBI may change over time and frequently require additional support.

Supporting literature and evidence tables

The following recommendations were based on consensus.

Indications/recommendations for patient education maintenance management

Educational classes or sessions may be necessary to reinforce self-management techniques to help the individual adjust to life changes. This may be performed as formal or informal programs, either group or individual.

Time frames

Time frames regarding patient education management: maintenance	
Frequency	2 to 6 educational sessions during one 12-month period. Changes in life circumstances or the individual's condition may require greater frequency of educational sessions.

H.5 Cognitive/behavioral/psychological management

Definition and background

In some cases, additional treatment may be necessary, especially when support systems or employment has changed.

Supporting literature and evidence tables

The following recommendations were based on consensus.

Indications/recommendations for cognitive/behavioral/psychological maintenance management

For select patients with mTBI, longer supervised psychological/psychiatric treatment may be required, especially if there are ongoing medical procedures or complications. The treatment plan/progress must show severity.

Time frames

If counseling beyond six months is indicated, the management of psychosocial risks, functional progress, or functional stability to prevent deterioration must be documented. Treatment may be sporadic and may vary depending on the life change requirements of the patients with mTBI.

H.6 Neuromedical management

Definition and background

Some patients with mTBI will have ongoing medical issues requiring treatment on a regular basis.

Supporting literature and evidence tables

The following recommendations were based on consensus.

Indications/recommendations for neuromedical maintenance management

Examples of related medical diagnoses include, but are not limited to: neuro-endocrine dysfunction, urinary incontinence, heterotrophic ossification, seizures, and other conditions described in the treatment sections of this guideline.

Time frames

Time frames regarding neuromedical management: maintenance	
Frequency	Medical management visit frequency will depend on the severity of the medical condition but may occur monthly or more frequently.
Maximum maintenance duration	Visits should occur at least at 6-month intervals for extremely stable conditions.

H.7 Physical, occupational, and speech-language therapy

Definition and background

Exacerbation of symptoms or decline in functional status may require short-term intensive treatment to return the individual to maximized function.

Supporting literature and evidence tables

The following recommendations were based on consensus.

Indications/recommendations for PT/OT/ST

Therapy may be indicated on a continued basis if the therapy maintains objective physical function, decreases pain, or decreases medication use. In those situations, frequency and duration parameters as defined in this guideline apply. Changes in the individual's living situation, role, and responsibilities at home or work, support systems, and/or life's stressors may require monitoring to determine the impact on daily function. Short-term speech-language therapy emphasizing patient education, compensatory strategies, and functional goals measured objectively may be indicated. Participation in a PT, OT, or ST maintenance program must be documented with respect to need and the ability of the program to facilitate positive symptomatic gains or functional gains.

Time frames

For time frames to address changes, refer to Section F, Treatment.

H.8 Durable medical equipment: purchase, rental, and maintenance

Definition and background

It is recognized that some patients may require ongoing use of equipment for the purpose of maintaining MMI in the areas of strength, ROM, balance, tone control, functional mobility, ADLs, and/or analgesic effect.

Supporting literature and evidence tables

The following recommendations were based on consensus.

Indications for purchase or rental of durable medical equipment

Purchase or rental of this equipment should be done only if the assessment by the physician and/or therapist has determined the safety, effectiveness, compliance, and improved or maintained function by its application.

Recommendations for purchase, rental, and maintenance of durable medical equipment

It is generally felt that large expense purchases (such as spas, whirlpools, and special mattresses) are not necessary to maintain function for patients with mTBI, but gym memberships is encouraged to keep the patient as active as possible to prevent deterioration.

Periodic maintenance and replacement of the equipment may be indicated and should be considered in the maintenance plan.

Time frames

Time frames regarding durable medical equipment: maintenance	
Maximum maintenance duration	Not to exceed 6 months for rental of large equipment. Purchase and maintenance should occur if effective.

References

American Board of Professional Psychology. (2017). Rehabilitation psychology. Retrieved from https://www.abpp.org/Applicant-Information/Specialty-Boards/Rehabilitation-Psychology.aspx

American Congress of Rehabilitation Medicine Head Injury Interdisciplinary Special Interest Group. (1993). Definition of mild traumatic brain injury. *Journal of Head Trauma Rehabilitation, 8*(3), 86-87.

Amyot, F., Arciniegas, D. B., Brazaitis, M. P., Curley, K. C., Diaz-Arrastia, R., Gandjbakhche, A., . . . Stocker, D. (2015). A Review of the Effectiveness of Neuroimaging Modalities for the Detection of Traumatic Brain Injury. *J Neurotrauma, 32*(22), 1693-1721. doi:10.1089/neu.2013.3306

Anandalwar, S. P., Mau, C. Y., Gordhan, C. G., Majmundar, N., Meleis, A., Prestigiacomo, C. J., & Sifri, Z. C. (2016). Eliminating unnecessary routine head CT scanning in neurologically intact mild traumatic brain injury patients: implementation and evaluation of a new protocol. *J Neurosurg, 125*(3), 667-673. doi:10.3171/2015.9.JNS151379

Archer, T. (2011). Influence of physical exercise on traumatic brain injury deficits: scaffolding effect. *Neurotox Res, 21*(4), 418-434. doi:10.1007/s12640-011-9297-0

Arciniegas, D. B. (2011). Clinical electrophysiologic assessments and mild traumatic brain injury: state-of-the-science and implications for clinical practice. *Int J Psychophysiol, 82*(1), 41-52. doi:10.1016/j.ijpsycho.2011.03.004

Armistead-Jehle, P., Lange, B. J., & Green, P. (2017). Comparison of Neuropsychological and Balance Performance Validity Testing. *Appl Neuropsychol Adult, 24*(2), 190-197. doi:10.1080/23279095.2015.1132219

Arundine, A., Bradbury, C. L., Dupuis, K., Dawson, D. R., Ruttan, L. A., & Green, R. E. (2012). Cognitive behavior therapy after acquired brain injury: maintenance of therapeutic benefits at 6 months posttreatment. *J Head Trauma Rehabil, 27*(2), 104-112. doi:10.1097/HTR.0b013e3182125591

Association of Rehabilitation Nurses (ARN). (2016). Retrieved from https://rehabnurse.org/

Aukerman, M. M., Aukerman, D., Bayard, M., Tudiver, F., Thorp, L., & Bailey, B. (2006). Exercise and restless legs syndrome: a randomized controlled trial. *J Am Board Fam Med, 19*(5), 487-493.

Aurora, S. K., Winner, P., Freeman, M. C., Spierings, E. L., Heiring, J. O., DeGryse, R. E., . . . Turkel, C. C. (2011). OnabotulinumtoxinA for treatment of chronic migraine: pooled analyses of the 56-week PREEMPT clinical program. *Headache, 51*(9), 1358-1373. doi:10.1111/j.1526-4610.2011.01990.x

Banzi, R., Cusi, C., Randazzo, C., Sterzi, R., Tedesco, D., & Moja, L. (2015). Selective serotonin reuptake inhibitors (SSRIs) and serotonin-norepinephrine reuptake inhibitors (SNRIs) for the prevention of tension-type headache in adults. *Cochrane Database Syst Rev*(5), Cd011681. doi:10.1002/14651858.cd011681

Barker-Collo, S., Jones, K., Theadom, A., Starkey, N., Dowell, A., McPherson, K., . . . Group, B. R. (2015). Neuropsychological outcome and its correlates in the first year after adult mild traumatic brain injury: A population-based New Zealand study. *Brain Inj, 29*(13-14), 1604-1616. doi:10.3109/02699052.2015.1075143

Barnes, D. E., Yaffe, K., Satariano, W. A., & Tager, I. B. (2003). A longitudinal study of cardiorespiratory fitness and cognitive function in healthy older adults. *J Am Geriatr Soc, 51*(4), 459-465.

Belanger, H. G., Vanderploeg, R. D., Curtiss, G., & Warden, D. L. (2007). Recent neuroimaging techniques in mild traumatic brain injury. *J Neuropsychiatry Clin Neurosci, 19*(1), 5-20. doi:10.1176/jnp.2007.19.1.5

Bendtsen, L., Evers, S., Linde, M., Mitsikostas, D. D., Sandrini, G., Schoenen, J., & Efns. (2010). EFNS guideline on the treatment of tension-type headache - report of an EFNS task force. *Eur J Neurol, 17*(11), 1318-1325. doi:10.1111/j.1468-1331.2010.03070.x

Bendtsen, L., Jensen, R., & Olesen, J. (1996). A non-selective (amitriptyline), but not a selective (citalopram), serotonin reuptake inhibitor is effective in the prophylactic treatment of chronic tension-type headache. *J Neurol Neurosurg Psychiatry, 61*(3), 285-290.

Block, A. R., Ohnmeiss, D. D., Guyer, R. D., Rashbaum, R. F., & Hochschuler, S. H. (2001). The use of presurgical psychological screening to predict the outcome of spine surgery. *Spine J, 1*(4), 274-282.

Bogdanova, Y., Yee, M. K., Ho, V. T., & Cicerone, K. D. (2016). Computerized Cognitive Rehabilitation of Attention and Executive Function in Acquired Brain Injury: A Systematic Review. *J Head Trauma Rehabil, 31*(6), 419-433. doi:10.1097/htr.0000000000000203

Bootzin, R. R., & Perlis, M. L. (1992). Nonpharmacologic treatments of insomnia. *J Clin Psychiatry, 53 Suppl*, 37-41.

Bronfort, G., Nilsson, N., Haas, M., Evans, R., Goldsmith, C. H., Assendelft, W. J., & Bouter, L. M. (2004). Non-invasive physical treatments for chronic/recurrent headache. *Cochrane Database Syst Rev*(3), CD001878. doi:10.1002/14651858.CD001878.pub2

Bruns, D., & Disorbio, J. M. (2009). Assessment of biopsychosocial risk factors for medical treatment: a collaborative approach. *J Clin Psychol Med Settings, 16*(2), 127-147. doi:10.1007/s10880-009-9148-9

Bryant, R. A., Moulds, M., Guthrie, R., & Nixon, R. D. (2003). Treating acute stress disorder following mild traumatic brain injury. *Am J Psychiatry, 160*(3), 585-587. doi:10.1176/appi.ajp.160.3.585

Cancelliere, C., Kristman, V. L., Cassidy, J. D., Hincapie, C. A., Cote, P., Boyle, E., . . . Borg, J. (2014). Systematic review of return to work after mild traumatic brain injury: results of the International Collaboration on Mild Traumatic Brain Injury Prognosis. *Arch Phys Med Rehabil, 95*(3 Suppl), S201-209. doi:10.1016/j.apmr.2013.10.010

Capo-Aponte, J. E., Urosevich, T. G., Temme, L. A., Tarbett, A. K., & Sanghera, N. K. (2012). Visual dysfunctions and symptoms during the subacute stage of blast-induced mild traumatic brain injury. *Mil Med, 177*(7), 804-813.

Carroll, L., Cassidy, J. D., Peloso, P., Borg, J., von Holst, H., Holm, L., . . . Pépin, M. (2004). Prognosis for mild traumatic brain injury: results of the who collaborating centre task force on mild traumatic brain injury. *J Rehabil Med, 36*(0), 84-105. doi:10.1080/16501960410023859

Case Management Society of America (CMSA). (2016). Philosophy and guiding principles *Standards of Practice for Case Management* (pp. 12). Little Rock, Arkansas: Case Management Society of America.

Cassidy, J. D., Cancelliere, C., Carroll, L. J., Cote, P., Hincapie, C. A., Holm, L. W., . . . Borg, J. (2014). Systematic review of self-reported prognosis in adults after mild traumatic brain injury: results of the International Collaboration on Mild Traumatic Brain Injury Prognosis. *Arch Phys Med Rehabil, 95*(3 Suppl), S132-151. doi:10.1016/j.apmr.2013.08.299

Castriotta, R. J., Wilde, M. C., Lai, J. M., Atanasov, S., Masel, B. E., & Kuna, S. T. (2007). Prevalence and consequences of sleep disorders in traumatic brain injury. *J Clin Sleep Med, 3*(4), 349-356.

Centers for Disease Control and Prevention. (2015). *Report to congress on traumatic brain injury in the United States: Epidemiology and rehabilitation*. Atlanta, GA: National Center for Injury Prevention and Control; Division of Unintentional Injury Prevention.

Cicerone, K. D., & Azulay, J. (2007). Perceived self-efficacy and life satisfaction after traumatic brain injury. *J Head Trauma Rehabil, 22*(5), 257-266. doi:10.1097/01.HTR.0000290970.56130.81

Cnossen, M. C., Winkler, E. A., Yue, J. K., Okonkwo, D. O., Valadka, A., Steyerberg, E. W., . . . Manley, G. T. M. D. P. D. (2017). Development of a Prediction Model for Post-Concussive Symptoms following Mild Traumatic Brain Injury: A TRACK-TBI Pilot Study. *J Neurotrauma*. doi:10.1089/neu.2016.4819

Coburn, K. L., Lauterbach, E. C., Boutros, N. N., Black, K. J., Arciniegas, D. B., & Coffey, C. E. (2006). The value of quantitative electroencephalography in clinical psychiatry: a report by the Committee on Research of the American Neuropsychiatric Association. *J Neuropsychiatry Clin Neurosci, 18*(4), 460-500. doi:10.1176/jnp.2006.18.4.460

Colcombe, S., & Kramer, A. F. (2003). Fitness effects on the cognitive function of older adults: a meta-analytic study. *Psychol Sci, 14*(2), 125-130. doi:10.1111/1467-9280.t01-1-01430

Colcombe, S. J., Kramer, A. F., McAuley, E., Erickson, K. I., & Scalf, P. (2004). Neurocognitive aging and cardiovascular fitness: recent findings and future directions. *J Mol Neurosci, 24*(1), 9-14. doi:10.1385/JMN:24:1:009

Collins, M. W., Kontos, A. P., Okonkwo, D. O., Almquist, J., Bailes, J., Barisa, M., . . . Zafonte, R. (2016). Statements of Agreement From the Targeted Evaluation and Active Management (TEAM) Approaches to Treating Concussion Meeting Held in Pittsburgh, October 15-16, 2015. *Neurosurgery, 79*(6), 912-929. doi:10.1227/neu.0000000000001447

Crawford, C., Teo, L., Yang, E., Isbister, C., & Berry, K. (2017). Is Hyperbaric Oxygen Therapy Effective for Traumatic Brain Injury? A Rapid Evidence Assessment of the Literature and Recommendations for the Field. *J Head Trauma Rehabil*. doi:10.1097/htr.0000000000000256

Currie, S. R., Wilson, K. G., Pontefract, A. J., & deLaplante, L. (2000). Cognitive-behavioral treatment of insomnia secondary to chronic pain. *J Consult Clin Psychol, 68*(3), 407-416.

Dean, P. J., O'Neill, D., & Sterr, A. (2012). Post-concussion syndrome: prevalence after mild traumatic brain injury in comparison with a sample without head injury. *Brain Inj, 26*(1), 14-26. doi:10.3109/02699052.2011.635354

Derry, C. J., Derry, S., & Moore, R. A. (2014). Sumatriptan (all routes of administration) for acute migraine attacks in adults - overview of Cochrane reviews. *Cochrane Database Syst Rev*(5), CD009108. doi:10.1002/14651858.CD009108.pub2

Derry, S., Moore, R. A., Gaskell, H., McIntyre, M., & Wiffen, P. J. (2016). Topical NSAIDs for acute musculoskeletal pain in adults. *Cochrane Database Syst Rev*(6), CD007402. doi:10.1002/14651858.CD007402.pub3

Derry, S., Moore, R. A., & McQuay, H. J. (2010). Paracetamol (acetaminophen) with or without an antiemetic for acute migraine headaches in adults. *Cochrane Database Syst Rev*(11), CD008040. doi:10.1002/14651858.CD008040.pub2
Digre, K. B., & Brennan, K. C. (2012). Shedding light on photophobia. *J Neuroophthalmol, 32*(1), 68-81. doi:10.1097/WNO.0b013e3182474548
Dikmen, S., Machamer, J., & Temkin, N. (2017). Mild Traumatic Brain Injury: Longitudinal Study of Cognition, Functional Status, and Post-Traumatic Symptoms. *J Neurotrauma, 34*(8), 1524-1530. doi:10.1089/neu.2016.4618
Douglas, D. B., Iv, M., Douglas, P. K., Anderson, A., Vos, S. B., Bammer, R., . . . Wintermark, M. (2015). Diffusion Tensor Imaging of TBI: Potentials and Challenges. *Top Magn Reson Imaging, 24*(5), 241-251. doi:10.1097/rmr.0000000000000062
Dretsch, M. N., Lange, R. T., Katz, J. S., Goodman, A., Daniel, T. A., Deshpande, G., . . . Robinson, J. L. (2017). Examining Microstructural White Matter in Active Duty Soldiers with a History of Mild Traumatic Brain Injury and Traumatic Stress. *Open Neuroimag J, 11*, 46-57. doi:10.2174/1874440001711010046
Dunning, J. R., Butts, R., Mourad, F., Young, I., Fernandez-de-Las Penas, C., Hagins, M., . . . Cleland, J. A. (2016). Upper cervical and upper thoracic manipulation versus mobilization and exercise in patients with cervicogenic headache: a multi-center randomized clinical trial. *BMC Musculoskelet Disord, 17*, 64. doi:10.1186/s12891-016-0912-3
Dutton, R. P., Prior, K., Cohen, R., Wade, C., Sewell, J., Fouche, Y., . . . Scalea, T. M. (2011). Diagnosing mild traumatic brain injury: where are we now? *J Trauma, 70*(3), 554-559. doi:10.1097/TA.0b013e31820d1062
Elgmark Andersson, E., Emanuelson, I., Bjorklund, R., & Stalhammar, D. A. (2007). Mild traumatic brain injuries: the impact of early intervention on late sequelae. A randomized controlled trial. *Acta Neurochir (Wien), 149*(2), 151-159; discussion 160. doi:10.1007/s00701-006-1082-0
Ellis, M. J., Leddy, J. J., & Willer, B. (2015). Physiological, vestibulo-ocular and cervicogenic post-concussion disorders: an evidence-based classification system with directions for treatment. *Brain Inj, 29*(2), 238-248. doi:10.3109/02699052.2014.965207
Ellis, M. J., Ryner, L. N., Sobczyk, O., Fierstra, J., Mikulis, D. J., Fisher, J. A., . . . Mutch, W. A. (2016). Neuroimaging Assessment of Cerebrovascular Reactivity in Concussion: Current Concepts, Methodological Considerations, and Review of the Literature. *Front Neurol, 7*, 61. doi:10.3389/fneur.2016.00061
Fann, J. R., Bombardier, C. H., Vannoy, S., Dyer, J., Ludman, E., Dikmen, S., . . . Temkin, N. (2015). Telephone and in-person cognitive behavioral therapy for major depression after traumatic brain injury: a randomized controlled trial. *J Neurotrauma, 32*(1), 45-57. doi:10.1089/neu.2014.3423
Fazel, S., Wolf, A., Pillas, D., Lichtenstein, P., & Langstrom, N. (2014). Suicide, Fatal Injuries, and Other Causes of Premature Mortality in Patients With Traumatic Brain Injury A 41-Year Swedish Population Study. *JAMA Psychiatry, 71*(3), 326-333. doi:10.1001/jamapsychiatry.2013.3935
Ferris, L. T., Williams, J. S., & Shen, C. L. (2007). The effect of acute exercise on serum brain-derived neurotrophic factor levels and cognitive function. *Med Sci Sports Exerc, 39*(4), 728-734. doi:10.1249/mss.0b013e31802f04c7

Fife, T. D., Colebatch, J. G., Kerber, K. A., Brantberg, K., Strupp, M., Lee, H., . . . Gloss, D. S., 2nd. (2017). Practice guideline: Cervical and ocular vestibular evoked myogenic potential testing: Report of the Guideline Development, Dissemination, and Implementation Subcommittee of the American Academy of Neurology. *Neurology*. doi:10.1212/wnl.0000000000004690

Fife, T. D., Tusa, R. J., Furman, J. M., Zee, D. S., Frohman, E., Baloh, R. W., . . . Eviatar, L. (2000). Assessment: vestibular testing techniques in adults and children: report of the Therapeutics and Technology Assessment Subcommittee of the American Academy of Neurology. *Neurology, 55*(10), 1431-1441.

Frey, W. F., & Savage, R. C. (2009). *Journey Toward Understanding: Concussion & Mild Brain Injury* (Vol. 8): Brain Injury Association.

Garrelfs, S. F., Donker-Cools, B. H., Wind, H., & Frings-Dresen, M. H. (2015). Return-to-work in patients with acquired brain injury and psychiatric disorders as a comorbidity: A systematic review. *Brain Inj, 29*(5), 550-557. doi:10.3109/02699052.2014.995227

Ghaffar, O., McCullagh, S., Ouchterlony, D., & Feinstein, A. (2006). Randomized treatment trial in mild traumatic brain injury. *J Psychosom Res, 61*(2), 153-160. doi:10.1016/j.jpsychores.2005.07.018

Gowda, N. K., Agrawal, D., Bal, C., Chandrashekar, N., Tripati, M., Bandopadhyaya, G. P., . . . Mahapatra, A. K. (2006). Technetium Tc-99m ethyl cysteinate dimer brain single-photon emission CT in mild traumatic brain injury: a prospective study. *AJNR Am J Neuroradiol, 27*(2), 447-451.

Griesbach, G. S., Gomez-Pinilla, F., & Hovda, D. A. (2004). The upregulation of plasticity-related proteins following TBI is disrupted with acute voluntary exercise. *Brain Res, 1016*(2), 154-162. doi:10.1016/j.brainres.2004.04.079

Griesbach, G. S., Hovda, D. A., Molteni, R., Wu, A., & Gomez-Pinilla, F. (2004). Voluntary exercise following traumatic brain injury: brain-derived neurotrophic factor upregulation and recovery of function. *Neuroscience, 125*(1), 129-139. doi:10.1016/j.neuroscience.2004.01.030

Griesbach, G. S., Tio, D. L., Vincelli, J., McArthur, D. L., & Taylor, A. N. (2012). Differential effects of voluntary and forced exercise on stress responses after traumatic brain injury. *J Neurotrauma, 29*(7), 1426-1433. doi:10.1089/neu.2011.2229

Grima, N., Ponsford, J., Rajaratnam, S. M., Mansfield, D., & Pase, M. P. (2016). Sleep Disturbances in Traumatic Brain Injury: A Meta-Analysis. *J Clin Sleep Med, 12*(3), 419-428. doi:10.5664/jcsm.5598

Guskiewicz, K. M., Perrin, D. H., & Gansneder, B. M. (1996). Effect of mild head injury on postural stability in athletes. *J Athl Train, 31*(4), 300-306.

Guskiewicz, K. M., & Register-Mihalik, J. K. (2011). Postconcussive impairment differences across a multifaceted concussion assessment protocol. *Pm r, 3*(10 Suppl 2), S445-451. doi:10.1016/j.pmrj.2011.08.009

Haarbauer-Krupa, J., Taylor, C. A., Yue, J. K., Winkler, E. A., Pirracchio, R., Cooper, S. R., . . . Manley, G. T. (2017). Screening for Post-Traumatic Stress Disorder in a Civilian Emergency Department Population with Traumatic Brain Injury. *J Neurotrauma, 34*(1), 50-58. doi:10.1089/neu.2015.4158

Hallock, H., Collins, D., Lampit, A., Deol, K., Fleming, J., & Valenzuela, M. (2016). Cognitive Training for Post-Acute Traumatic Brain Injury: A Systematic Review and Meta-Analysis. *Front Hum Neurosci, 10*, 537. doi:10.3389/fnhum.2016.00537

Harley, J. P., C. Allen, Braciszewski, T. L., Cicerone, K. D., Dahlberg, C., Evans, S., . . . Smigelski, J. S. (1992). Guidelines for cognitive rehabilitation. *NeuroRehabilitation, 2*(3), 62-67. Retrieved from

Hart, T., Benn, E. K., Bagiella, E., Arenth, P., Dikmen, S., Hesdorffer, D. C., . . . Zafonte, R. (2014). Early trajectory of psychiatric symptoms after traumatic brain injury: relationship to patient and injury characteristics. *J Neurotrauma, 31*(7), 610-617. doi:10.1089/neu.2013.3041

Haskins, E. C. (2012). *Cognitive Rehabilitation Manual: Translating Evidence-Based Recommendations into Practice*. Reston, Virginia: American Congress of Rehabilitation Medicine.

Heitger, M. H., Jones, R. D., Frampton, C. M., Ardagh, M. W., & Anderson, T. J. (2007). Recovery in the first year after mild head injury: divergence of symptom status and self-perceived quality of life. *J Rehabil Med, 39*(8), 612-621. doi:10.2340/16501977-0100

Hendrick, R. E., Dodd, G. D., 3rd, Fullerton, G. D., Hendee, W. R., Borgstede, J. P., & Larke, F. (2011). The University of Colorado Radiology Adult Dose-Risk Smartcard. *J Am Coll Radiol, 9*(4), 290-292. doi:10.1016/j.jacr.2011.12.034

Hobson, J., Chisholm, E., & El Refaie, A. (2010). Sound therapy (masking) in the management of tinnitus in adults. *Cochrane Database Syst Rev*(12), CD006371. doi:10.1002/14651858.CD006371.pub2

Hoffman, J. M., Dikmen, S., Temkin, N., & Bell, K. R. (2012). Development of posttraumatic stress disorder after mild traumatic brain injury. *Arch Phys Med Rehabil, 93*(2), 287-292. doi:10.1016/j.apmr.2011.08.041

Holland, S., Silberstein, S. D., Freitag, F., Dodick, D. W., Argoff, C., Ashman, E., . . . the American Headache, S. (2012). Evidence-based guideline update: NSAIDs and other complementary treatments for episodic migraine prevention in adults: report of the Quality Standards Subcommittee of the American Academy of Neurology and the American Headache Society. *Neurology, 78*(17), 1346-1353. doi:10.1212/WNL.0b013e3182535d0c

Hooper, L., Brown, T. J., Elliott, R., Payne, K., Roberts, C., & Symmons, D. (2004). The effectiveness of five strategies for the prevention of gastrointestinal toxicity induced by non-steroidal anti-inflammatory drugs: systematic review. *Bmj, 329*(7472), 948. doi:10.1136/bmj.38232.680567.EB

Hou, R., Moss-Morris, R., Peveler, R., Mogg, K., Bradley, B. P., & Belli, A. (2012). When a minor head injury results in enduring symptoms: a prospective investigation of risk factors for postconcussional syndrome after mild traumatic brain injury. *J Neurol Neurosurg Psychiatry, 83*(2), 217-223. doi:10.1136/jnnp-2011-300767

Inness, E. L., Howe, J. A., Niechwiej-Szwedo, E., Jaglal, S. B., McIlroy, W. E., & Verrier, M. C. (2011). Measuring Balance and Mobility after Traumatic Brain Injury: Validation of the Community Balance and Mobility Scale (CB&M). *Physiotherapy Canada, 63*(2), 199-208. doi:10.3138/ptc.2009-45

Institute of Medicine. (2006). *Evaluating the HRSA Traumatic Brain Injury Program*. Washington, DC: The National Academies Press.

Iverson, G. L. (2009). Complicated vs uncomplicated mild traumatic brain injury: Acute neuropsychological outcome. *Brain Injury, 20*(13-14), 1335-1344. doi:10.1080/02699050601082156

Iverson, G. L., Terry, D. P., Karr, J. E., Panenka, W. J., & Silverberg, N. D. (2018). Perceived Injustice and Its Correlates after Mild Traumatic Brain Injury. *J Neurotrauma*. doi:10.1089/neu.2017.5402

Jackson, J. L., Kuriyama, A., & Hayashino, Y. (2012). Botulinum toxin A for prophylactic treatment of migraine and tension headaches in adults: a meta-analysis. *Jama, 307*(16), 1736-1745. doi:10.1001/jama.2012.505

Jacobs, A., Put, E., Ingels, M., Put, T., & Bossuyt, A. (1996). One-year follow-up of technetium-99m-HMPAO SPECT in mild head injury. *J Nucl Med, 37*(10), 1605-1609.

Jeffcoach, D. R., Sams, V. G., Lawson, C. M., Enderson, B. L., Smith, S. T., Kline, H., . . . University of Tennessee Medical Center, D. o. S. (2014). Nonsteroidal anti-inflammatory drugs' impact on nonunion and infection rates in long-bone fractures. *J Trauma Acute Care Surg, 76*(3), 779-783. doi:10.1097/TA.0b013e3182aafe0d

Jha, A., Weintraub, A., Allshouse, A., Morey, C., Cusick, C., Kittelson, J., . . . Gerber, D. (2008). A randomized trial of modafinil for the treatment of fatigue and excessive daytime sleepiness in individuals with chronic traumatic brain injury. *J Head Trauma Rehabil, 23*(1), 52-63. doi:10.1097/01.HTR.0000308721.77911.ea

Kamins, J., Bigler, E., Covassin, T., Henry, L., Kemp, S., Leddy, J. J., . . . Giza, C. C. (2017). What is the physiological time to recovery after concussion? A systematic review. *Br J Sports Med, 51*(12), 935-940. doi:10.1136/bjsports-2016-097464

Katz, B. J., & Digre, K. B. (2016). Diagnosis, pathophysiology, and treatment of photophobia. *Survey of Ophthalmology, 61*(4), 466-477. doi:10.1016/j.survophthal.2016.02.001

Kindelan-Calvo, P., Gil-Martinez, A., Paris-Alemany, A., Pardo-Montero, J., Munoz-Garcia, D., Angulo-Diaz-Parreno, S., & La Touche, R. (2014). Effectiveness of therapeutic patient education for adults with migraine. A systematic review and meta-analysis of randomized controlled trials. *Pain Med, 15*(9), 1619-1636. doi:10.1111/pme.12505

Kirthi, V., Derry, S., Moore, R. A., & McQuay, H. J. (2010). Aspirin with or without an antiemetic for acute migraine headaches in adults. *Cochrane Database Syst Rev*(4), CD008041. doi:10.1002/14651858.CD008041.pub2

Kleffelgaard, I., Roe, C., Soberg, H. L., & Bergland, A. (2012). Associations among self-reported balance problems, post-concussion symptoms and performance-based tests: a longitudinal follow-up study. *Disabil Rehabil, 34*(9), 788-794. doi:10.3109/09638288.2011.619624

Knaepen, K., Goekint, M., Heyman, E. M., & Meeusen, R. (2010). Neuroplasticity - exercise-induced response of peripheral brain-derived neurotrophic factor: a systematic review of experimental studies in human subjects. *Sports Med, 40*(9), 765-801. doi:10.2165/11534530-000000000-00000

Kou, Z., Wu, Z., Tong, K. A., Holshouser, B., Benson, R. R., Hu, J., & Haacke, E. M. (2010). The role of advanced MR imaging findings as biomarkers of traumatic brain injury. *J Head Trauma Rehabil, 25*(4), 267-282. doi:10.1097/HTR.0b013e3181e54793

Kramer, A. F., Hahn, S., Cohen, N. J., Banich, M. T., McAuley, E., Harrison, C. R., . . . Boileau, R. A. (1999). Ageing, fitness and neurocognitive function. *Nature, 400*(6743), 418-419.

Kreuzer, P. M., Landgrebe, M., Vielsmeier, V., Kleinjung, T., De Ridder, D., & Langguth, B. (2014). Trauma-associated tinnitus. *J Head Trauma Rehabil, 29*(5), 432-442. doi:10.1097/HTR.0b013e31829d3129

Lange, R. T., Brickell, T., French, L. M., Ivins, B., Bhagwat, A., Pancholi, S., & Iverson, G. L. (2013). Risk Factors for Postconcussion Symptom Reporting after Traumatic Brain

Injury in US Military Service Members. *Journal of Neurotrauma, 30*(4), 237-246. doi:10.1089/neu.2012.2685

Langevin, P., Peloso, P. M., Lowcock, J., Nolan, M., Weber, J., Gross, A., . . . Haines, T. (2011). Botulinum toxin for subacute/chronic neck pain. *Cochrane Database Syst Rev*(7), CD008626. doi:10.1002/14651858.CD008626.pub2

Larrosa, F., Dura, M. J., Menacho, J., Gonzalez-Sabate, L., Cordon, A., Hernandez, A., & Garcia-Ibanez, L. (2013). Aphysiologic performance on dynamic posturography in work-related patients. *Eur Arch Otorhinolaryngol, 270*(1), 93-97. doi:10.1007/s00405-012-1930-x

Laver, K. E., George, S., Thomas, S., Deutsch, J. E., & Crotty, M. (2011). Virtual reality for stroke rehabilitation. *Cochrane Database Syst Rev*(9), CD008349. doi:10.1002/14651858.CD008349.pub2

Lee, L. C., Lieu, F. K., Chen, Y. H., Hung, T. H., & Chen, S. F. (2012). Tension pneumocephalus as a complication of hyperbaric oxygen therapy in a patient with chronic traumatic brain injury. *Am J Phys Med Rehabil, 91*(6), 528-532. doi:10.1097/PHM.0b013e31824ad556

Lequerica, A., Chiaravalloti, N., Cantor, J., Dijkers, M., Wright, J., Kolakowsky-Hayner, S. A., . . . Bell, K. (2014). The factor structure of the Pittsburgh Sleep Quality Index in persons with traumatic brain injury. A NIDRR TBI model systems module study. *NeuroRehabilitation, 35*(3), 485-492. doi:10.3233/nre-141141

Lim, M. M., & Baumann, C. R. (2017, May 30, 2017). Sleep-wake disorders in patients with traumatic brain injury. Retrieved from http://www.uptodate.com/contents/sleep-wake-disorders-in-patients-with-traumatic-brain-injury

Linde, K., Allais, G., Brinkhaus, B., Fei, Y., Mehring, M., Shin, B. C., . . . White, A. R. (2016). Acupuncture for the prevention of tension-type headache. *Cochrane Database Syst Rev, 4*, CD007587. doi:10.1002/14651858.CD007587.pub2

Linde, K., Allais, G., Brinkhaus, B., Fei, Y., Mehring, M., Vertosick, E. A., . . . White, A. R. (2016). Acupuncture for the prevention of episodic migraine. *Cochrane Database Syst Rev*(6), CD001218. doi:10.1002/14651858.CD001218.pub3

Linde, K., & Rossnagel, K. (2004). Propranolol for migraine prophylaxis. *Cochrane Database Syst Rev*(2), CD003225. doi:10.1002/14651858.CD003225.pub2

Linde, M., Hagen, K., Salvesen, O., Gravdahl, G. B., Helde, G., & Stovner, L. J. (2011). Onabotulinum toxin A treatment of cervicogenic headache: a randomised, double-blind, placebo-controlled crossover study. *Cephalalgia, 31*(7), 797-807. doi:10.1177/0333102411398402

Linde, M., Mulleners, W. M., Chronicle, E. P., & McCrory, D. C. (2013). Topiramate for the prophylaxis of episodic migraine in adults. *Cochrane Database of Systematic Reviews*(6). doi:10.1002/14651858.CD010610

Lindsey, H. (2014). Help for Hyperacusis: Treatments Turn Down Discomfort. *The Hearing Journal, 67*(8), 22, 24, 26, 28. doi:10.1097/01.HJ.0000453391.20357.f7

Lingsma, H. F., Yue, J. K., Maas, A. I., Steyerberg, E. W., Manley, G. T., & Investigators, T.-T. (2015). Outcome prediction after mild and complicated mild traumatic brain injury: external validation of existing models and identification of new predictors using the TRACK-TBI pilot study. *J Neurotrauma, 32*(2), 83-94. doi:10.1089/neu.2014.3384

Lojovich, J. M. (2010). The relationship between aerobic exercise and cognition: is movement medicinal? *J Head Trauma Rehabil, 25*(3), 184-192. doi:10.1097/HTR.0b013e3181dc78cd

Losoi, H., Silverberg, N. D., Waljas, M., Turunen, S., Rosti-Otajarvi, E., Helminen, M., . . . Iverson, G. L. (2016). Recovery from Mild Traumatic Brain Injury in Previously Healthy Adults. *J Neurotrauma, 33*(8), 766-776. doi:10.1089/neu.2015.4070

Lucas, S. (2015). Posttraumatic Headache: Clinical Characterization and Management. *Curr Pain Headache Rep, 19*(10), 48. doi:10.1007/s11916-015-0520-1

Ma, J., Zhang, K., Wang, Z., & Chen, G. (2016). Progress of Research on Diffuse Axonal Injury after Traumatic Brain Injury. *Neural Plast, 2016*, 9746313. doi:10.1155/2016/9746313

MacDougall, H. G., McGarvie, L. A., Halmagyi, G. M., Curthoys, I. S., & Weber, K. P. (2013). The Video Head Impulse Test (vHIT) Detects Vertical Semicircular Canal Dysfunction. *PLoS One, 8*(4). doi:10.1371/journal.pone.0061488

Management of Concussion-Mild Traumatic Brain Injury Working Group. (2016). *VA/DoD clinical practice guideline for management of concussion/mild traumatic brain injury* (2nd ed.): Department of Veterans Affairs/Department of Defense.

Marzo, S. J., Leonetti, J. P., Raffin, M. J., & Letarte, P. (2004). Diagnosis and management of post-traumatic vertigo. *Laryngoscope, 114*(10), 1720-1723. doi:10.1097/00005537-200410000-00008

Matuseviciene, G., Eriksson, G., & DeBoussard, C. N. (2016). No effect of an early intervention after mild traumatic brain injury on activity and participation: A randomized controlled trial. *J Rehabil Med, 48*(1), 19-26. doi:10.2340/16501977-2025

McClintock, S. M., Reti, I. M., Carpenter, L. L., McDonald, W. M., Dubin, M., Taylor, S. F., . . . Treatments, A. P. A. C. o. R. T. F. o. N. B. a. (2018). Consensus Recommendations for the Clinical Application of Repetitive Transcranial Magnetic Stimulation (rTMS) in the Treatment of Depression. *J Clin Psychiatry, 79*(1). doi:10.4088/JCP.16cs10905

McCrea, M., Iverson, G. L., McAllister, T. W., Hammeke, T. A., Powell, M. R., Barr, W. B., & Kelly, J. P. (2009). An integrated review of recovery after mild traumatic brain injury (MTBI): implications for clinical management. *Clin Neuropsychol, 23*(8), 1368-1390. doi:10.1080/13854040903074652

McCrory, P., Meeuwisse, W., Dvorak, J., Aubry, M., Bailes, J., Broglio, S., . . . Vos, P. E. (2017). Consensus statement on concussion in sport—the 5th international conference on concussion in sport held in Berlin, October 2016. *Br J Sports Med*. doi:10.1136/bjsports-2017-097699

McDonnell, M. N., & Hillier, S. L. (2015). Vestibular rehabilitation for unilateral peripheral vestibular dysfunction. *Cochrane Database Syst Rev, 1*, CD005397. doi:10.1002/14651858.CD005397.pub4

McFadzean, R. M. (2006). NovaVision: vision restoration therapy. *Curr Opin Ophthalmol, 17*(6), 498-503. doi:10.1097/ICU.0b013e3280108544

McKee, A. C., Stern, R. A., Nowinski, C. J., Stein, T. D., Alvarez, V. E., Daneshvar, D. H., . . . Cantu, R. C. (2013). The spectrum of disease in chronic traumatic encephalopathy. *Brain, 136*(Pt 1), 43-64. doi:10.1093/brain/aws307

MDCalc. (2018). Canadian CT Head Injury/Trauma Rule. Retrieved from https://www.mdcalc.com/canadian-ct-head-injury-trauma-rule#next-steps

Menn, S. J., Yang, R., & Lankford, A. (2014). Armodafinil for the treatment of excessive sleepiness associated with mild or moderate closed traumatic brain injury: a 12-week,

randomized, double-blind study followed by a 12-month open-label extension. *J Clin Sleep Med, 10*(11), 1181-1191. doi:10.5664/jcsm.4196
Mollayeva, T., Kendzerska, T., Mollayeva, S., Shapiro, C. M., Colantonio, A., & Cassidy, J. D. (2014). A systematic review of fatigue in patients with traumatic brain injury: the course, predictors and consequences. *Neurosci Biobehav Rev, 47*, 684-716. doi:10.1016/j.neubiorev.2014.10.024
Moore, R. A., Derry, S., Aldington, D., Cole, P., & Wiffen, P. J. (2015). Amitriptyline for neuropathic pain in adults. *Cochrane Database Syst Rev*(7), Cd008242. doi:10.1002/14651858.CD008242.pub3
Murphy, L., Chamberlain, E., Weir, J., Berry, A., Nathaniel-James, D., & Agnew, R. (2006). Effectiveness of vocational rehabilitation following acquired brain injury: preliminary evaluation of a UK specialist rehabilitation programme. *Brain Inj, 20*(11), 1119-1129. doi:10.1080/02699050600664335
National Institute for Health and Clinical Excellence (NICE). (2007). *Head Injury: Triage, Assessment, Investigation and Early Management of Head Injury in Infants, Children and Adults*: National Institute for Health and Clinical Excellence.
Nissen, S. E., Yeomans, N. D., Solomon, D. H., Lüscher, T. F., Libby, P., Husni, M. E., . . . Lincoff, A. M. (2016). Cardiovascular Safety of Celecoxib, Naproxen, or Ibuprofen for Arthritis. *New England Journal of Medicine*. doi:10.1056/NEJMoa1611593
Ontario Neurotrauma Foundation. (2013). *Guidelines for concussion/mild traumatic brain injury & persistent symptoms* (2nd ed.).
Osborn, A. J., Mathias, J. L., & Fairweather-Schmidt, A. K. (2014). Depression following adult, non-penetrating traumatic brain injury: a meta-analysis examining methodological variables and sample characteristics. *Neurosci Biobehav Rev, 47*, 1-15. doi:10.1016/j.neubiorev.2014.07.007
Osborn, A. J., Mathias, J. L., & Fairweather-Schmidt, A. K. (2016). Prevalence of anxiety following adult traumatic brain injury: A meta-analysis comparing measures, samples and postinjury intervals. *Neuropsychology, 30*(2), 247-261. doi:10.1037/neu0000221
Osborn, A. J., Mathias, J. L., Fairweather-Schmidt, A. K., & Anstey, K. J. (2016). Anxiety and comorbid depression following traumatic brain injury in a community-based sample of young, middle-aged and older adults. *J Affect Disord, 213*, 214-221. doi:10.1016/j.jad.2016.09.045
Pape, M. M., Williams, K., Kodosky, P. N., & Dretsch, M. (2016). The Community Balance and Mobility Scale: A Pilot Study Detecting Impairments in Military Service Members With Comorbid Mild TBI and Psychological Health Conditions. *Journal of Head Trauma Rehabilitation, 31*(5), 339-345. doi:10.1097/htr.0000000000000179
Pelak, V. S., Dubin, M., & Whitney, E. (2007). Homonymous Hemianopia: A Critical Analysis of Optical Devices, Compensatory Training, and NovaVision. *Curr Treat Options Neurol, 9*(1), 41-47.
Ponsford, J., Bayley, M., Wiseman-Hakes, C., Togher, L., Velikonja, D., McIntyre, A., . . . Tate, R. (2014). INCOG recommendations for management of cognition following traumatic brain injury, part II: attention and information processing speed. *J Head Trauma Rehabil, 29*(4), 321-337. doi:10.1097/htr.0000000000000072
Ponsford, J., Cameron, P., Fitzgerald, M., Grant, M., Mikocka-Walus, A., & Schonberger, M. (2012). Predictors of postconcussive symptoms 3 months after mild traumatic brain injury. *Neuropsychology, 26*(3), 304-313. doi:10.1037/a0027888

Prince, C., & Bruhns, M. E. (2017). Evaluation and Treatment of Mild Traumatic Brain Injury: The Role of Neuropsychology. *Brain Sci, 7*(8). doi:10.3390/brainsci7080105
Rabbie, R., Derry, S., Moore, R. A., & McQuay, H. J. (2010). Ibuprofen with or without an antiemetic for acute migraine headaches in adults. *Cochrane Database Syst Rev*(10), CD008039. doi:10.1002/14651858.CD008039.pub2
Reid, S. A., Rivett, D. A., Katekar, M. G., & Callister, R. (2014). Comparison of mulligan sustained natural apophyseal glides and maitland mobilizations for treatment of cervicogenic dizziness: a randomized controlled trial. *Phys Ther, 94*(4), 466-476. doi:10.2522/ptj.20120483
Reinhard, J., Schreiber, A., Schiefer, U., Kasten, E., Sabel, B. A., Kenkel, S., . . . Trauzettel-Klosinski, S. (2005). Does visual restitution training change absolute homonymous visual field defects? A fundus controlled study. *Br J Ophthalmol, 89*(1), 30-35. doi:10.1136/bjo.2003.040543
Ruff, R. M., Iverson, G. L., Barth, J. T., Bush, S. S., Broshek, D. K., Policy, N. A. N., & Planning, C. (2009). Recommendations for diagnosing a mild traumatic brain injury: a National Academy of Neuropsychology education paper. *Arch Clin Neuropsychol, 24*(1), 3-10. doi:10.1093/arclin/acp006
Sanders, L. (2009). Trawling the brain: New findings raise questions about reliability of fMRI as gauge of neural activity. *Science News, 176*(13), 16-20.
Sawyer, Q., Vesci, B., & McLeod, T. C. (2016). Physical Activity and Intermittent Postconcussion Symptoms After a Period of Symptom-Limited Physical and Cognitive Rest. *J Athl Train, 51*(9), 739-742. doi:10.4085/1062-6050-51.12.01
Schneider, H. J., Kreitschmann-Andermahr, I., Ghigo, E., Stalla, G. K., & Agha, A. (2007). Hypothalamopituitary dysfunction following traumatic brain injury and aneurysmal subarachnoid hemorrhage: a systematic review. *Jama, 298*(12), 1429-1438. doi:10.1001/jama.298.12.1429
Schneider, K. J., Meeuwisse, W. H., Nettel-Aguirre, A., Barlow, K., Boyd, L., Kang, J., & Emery, C. A. (2014). Cervicovestibular rehabilitation in sport-related concussion: a randomised controlled trial. *Br J Sports Med, 48*(17), 1294-1298. doi:10.1136/bjsports-2013-093267
Schreiber, A., Vonthein, R., Reinhard, J., Trauzettel-Klosinski, S., Connert, C., & Schiefer, U. (2006). Effect of visual restitution training on absolute homonymous scotomas. *Neurology, 67*(1), 143-145. doi:10.1212/01.wnl.0000223338.26040.fb
Schultheis, M. T., Himelstein, J., & Rizzo, A. A. (2002). Virtual reality and neuropsychology: upgrading the current tools. *J Head Trauma Rehabil, 17*(5), 378-394.
Shetty, V. S., Reis, M. N., Aulino, J. M., Berger, K. L., Broder, J., Choudhri, A. F., . . . Bykowski, J. (2016). ACR Appropriateness Criteria Head Trauma. *J Am Coll Radiol, 13*(6), 668-679. doi:10.1016/j.jacr.2016.02.023
Silber, M. H., Becker, P. M., Earley, C., Garcia-Borreguero, D., Ondo, W. G., & Medical Advisory Board of the Willis-Ekbom Disease, F. (2013). Willis-Ekbom Disease Foundation revised consensus statement on the management of restless legs syndrome. *Mayo Clin Proc, 88*(9), 977-986. doi:10.1016/j.mayocp.2013.06.016
Silberstein, S. D., Holland, S., Freitag, F., Dodick, D. W., Argoff, C., Ashman, E., . . . the American Headache, S. (2012). Evidence-based guideline update: pharmacologic treatment for episodic migraine prevention in adults: report of the Quality Standards

Subcommittee of the American Academy of Neurology and the American Headache Society. *Neurology, 78*(17), 1337-1345. doi:10.1212/WNL.0b013e3182535d20

Silverberg, N. D., Panenka, W. J., & Iverson, G. L. (2018). Work Productivity Loss After Mild Traumatic Brain Injury. *Arch Phys Med Rehabil, 99*(2), 250-256. doi:10.1016/j.apmr.2017.07.006

Sinclair, K. L., Ponsford, J. L., Taffe, J., Lockley, S. W., & Rajaratnam, S. M. (2014). Randomized controlled trial of light therapy for fatigue following traumatic brain injury. *Neurorehabil Neural Repair, 28*(4), 303-313. doi:10.1177/1545968313508472

Sinikallio, S., Aalto, T., Koivumaa-Honkanen, H., Airaksinen, O., Herno, A., Kroger, H., & Viinamaki, H. (2009). Life dissatisfaction is associated with a poorer surgery outcome and depression among lumbar spinal stenosis patients: a 2-year prospective study. *Eur Spine J, 18*(8), 1187-1193. doi:10.1007/s00586-009-0955-3

Sinikallio, S., Aalto, T., Lehto, S. M., Airaksinen, O., Herno, A., Kroger, H., & Viinamaki, H. (2010). Depressive symptoms predict postoperative disability among patients with lumbar spinal stenosis: a two-year prospective study comparing two age groups. *Disabil Rehabil, 32*(6), 462-468. doi:10.3109/09638280903171477

Sohlberg, M. M., & Mateer, C. A. (1987). Effectiveness of an attention-training program. *J Clin Exp Neuropsychol, 9*(2), 117-130. doi:10.1080/01688638708405352

Somers, V., & Javaheri, S. (2005). Heart failure and arrythimias in obstructive sleep apnea. In M. H. R. Kryger, Thomas; Dement, William C. (Ed.), *Principles and Practice of Sleep Medicine (Fourth Edition)*. Philadelphia: W.B. Saunders.

Steinsapir, K. D., & Goldberg, R. A. (2011). Traumatic Optic Neuropathy: An Evolving Understanding. *Am J Ophthalmol, 151*(6), 928-933.e922. doi:10.1016/j.ajo.2011.02.007

Stepanski, E. J., & Wyatt, J. K. (2003). Use of sleep hygiene in the treatment of insomnia. *Sleep Med Rev, 7*(3), 215-225.

Stergiou-Kita, M., Dawson, D., & Rappolt, S. (2012). Inter-professional clinical practice guideline for vocational evaluation following traumatic brain injury: a systematic and evidence-based approach. *J Occup Rehabil, 22*(2), 166-181. doi:10.1007/s10926-011-9332-2

Stippler, M., Smith, C., McLean, A. R., Carlson, A., Morley, S., Murray-Krezan, C., . . . Kennedy, G. (2012). Utility of routine follow-up head CT scanning after mild traumatic brain injury: a systematic review of the literature. *Emerg Med J, 29*(7), 528-532. doi:10.1136/emermed-2011-200162

Strohl, K. (2017). "Overview of obstructive sleep apnea in adults". Retrieved from www.uptodate.com/contents/overview-of-obstructive-sleep-apnea-in-adults?

Sufrinko, A. M., Kontos, A. P., Apps, J. N., McCrea, M., Hickey, R. W., Collins, M. W., & Thomas, D. G. (2017). The Effectiveness of Prescribed Rest Depends on Initial Presentation After Concussion. *J Pediatr, 185*, 167-172. doi:10.1016/j.jpeds.2017.02.072

Tarsy, D., & Silber, M. H. (2017, Mar 03, 2017). Treatment of restless legs syndrome/Willis-Ekbom disease and periodic limb movement disorder in adults. Retrieved from https://www.uptodate.com/contents/treatment-of-restless-legs-syndrome-willis-ekbom-disease-and-periodic-limb-movement-disorder-in-adults

Toth, A. (2015). Magnetic Resonance Imaging Application in the Area of Mild and Acute Traumatic Brain Injury. In F. H. Kobeissy (Ed.), *Brain Neurotrauma: Molecular, Neuropsychological, and Rehabilitation Aspects*. Boca Raton (FL): CRC Press/Taylor & Francis; (c) 2015 by Taylor & Francis Group, LLC.

Toward Optimized Practice (TOP) Headache Working Group. (2016). *Primary care management of headache in adults: clinical practice guideline* (2nd ed.). Edmonton, AB: Toward Optimized Practice.

Turner-Stokes, L., Disler, P. B., Nair, A., & Wade, D. T. (2005). Multi-disciplinary rehabilitation for acquired brain injury in adults of working age. *Cochrane Database Syst Rev*(3), CD004170. doi:10.1002/14651858.CD004170.pub2

Valovich McLeod, T. C., & Hale, T. D. (2015). Vestibular and balance issues following sport-related concussion. *Brain Inj, 29*(2), 175-184. doi:10.3109/02699052.2014.965206

Van Der Naalt, J. (2015). Resting functional imaging tools (MRS, SPECT, PET and PCT). *Handb Clin Neurol, 127*, 295-308. doi:10.1016/B978-0-444-52892-6.00019-2

Varner, C. E., McLeod, S., Nahiddi, N., Lougheed, R. E., Dear, T. E., & Borgundvaag, B. (2017). Cognitive Rest and Graduated Return to Usual Activities Versus Usual Care for Mild Traumatic Brain Injury: A Randomized Controlled Trial of Emergency Department Discharge Instructions. *Acad Emerg Med, 24*(1), 75-82. doi:10.1111/acem.13073

Ventura, R. E., Balcer, L. J., Galetta, S. L., & Rucker, J. C. (2016). Ocular motor assessment in concussion: Current status and future directions. *J Neurol Sci, 361*, 79-86. doi:10.1016/j.jns.2015.12.010

Warren, A. M., Boals, A., Elliott, T. R., Reynolds, M., Weddle, R. J., Holtz, P., . . . Foreman, M. L. (2015). Mild traumatic brain injury increases risk for the development of posttraumatic stress disorder. *J Trauma Acute Care Surg, 79*(6), 1062-1066. doi:10.1097/TA.0000000000000875

Weightman, M. M., Bolgla, R., McCulloch, K. L., & Peterson, M. D. (2010). Physical therapy recommendations for service members with mild traumatic brain injury. *J Head Trauma Rehabil, 25*(3), 206-218. doi:10.1097/HTR.0b013e3181dc82d3

Weuve, J., Kang, J. H., Manson, J. E., Breteler, M. M., Ware, J. H., & Grodstein, F. (2004). Physical activity, including walking, and cognitive function in older women. *Jama, 292*(12), 1454-1461. doi:10.1001/jama.292.12.1454

Wickwire, E. M., Williams, S. G., Roth, T., Capaldi, V. F., Jaffe, M., Moline, M., . . . Lettieri, C. J. (2016). Sleep, Sleep Disorders, and Mild Traumatic Brain Injury. What We Know and What We Need to Know: Findings from a National Working Group. *Neurotherapeutics, 13*(2), 403-417. doi:10.1007/s13311-016-0429-3

Wintermark, M., Sanelli, P. C., Anzai, Y., Tsiouris, A. J., Whitlow, C. T., & American College of Radiology Head Injury, I. (2015). Imaging evidence and recommendations for traumatic brain injury: advanced neuro- and neurovascular imaging techniques. *AJNR Am J Neuroradiol, 36*(2), E1-E11. doi:10.3174/ajnr.A4181

Yeo, S. S., Kim, S. H., Kim, O. L., Kim, M. S., & Jang, S. H. (2012). Optic radiation injury in a patient with traumatic brain injury. *Brain Inj, 26*(6), 891-895. doi:10.3109/02699052.2012.661119

Yue, J. K., Winkler, E. A., Sharma, S., Vassar, M. J., Ratcliff, J. J., Korley, F. K., . . . the, T.-T. B. I. I. (2017). Temporal profile of care following mild traumatic brain injury: predictors of hospital admission, follow-up referral and six-month outcome. *Brain Inj, 31*(13-14), 1820-1829. doi:10.1080/02699052.2017.1351000

Zachariae, R., Lyby, M. S., Ritterband, L. M., & O'Toole, M. S. (2016). Efficacy of internet-delivered cognitive-behavioral therapy for insomnia - A systematic review and meta-analysis of randomized controlled trials. *Sleep Med Rev, 30*, 1-10. doi:10.1016/j.smrv.2015.10.004

Zafonte, R. D. (2006). Update on biotechnology for TBI rehabilitation: a look at the future. *J Head Trauma Rehabil*, *21*(5), 403-407.