Physical Therapy Evaluation and Treatment for Concussion/Mild Traumatic Brain Injury: Clinical Practice Guidelines

INTRODUCTION

Aim and Purpose of the Guideline

The American Physical Therapy Association (APTA) and the various academies associated with the APTA encourage the creation of clinical practice guidelines (CPG) for physical therapy management of patients with physical impairments and functional limitations described in the World Health Organization's International Classification of Functioning, Disability and Health (ICF).[1]

The purpose of this endeavor by the APTA and its associated academies is to produce clinical guidelines that include:

- Describe evidence-based physical therapy practice, including diagnosis, prognosis, intervention and assessment of outcome approaches for disorders commonly managed by physical therapists
- Classify these conditions using World Health Organization terminology related to impairments of body structure and function, activity limitations, participation restrictions
- Identify interventions supported by current best evidence to address impairments of body function and structure, activity limitations, and participation restrictions associated with common musculoskeletal conditions
- Identify appropriate outcome measures to assess changes resulting from physical therapy interventions in body function and structure as well as in activity and participation of the individual
- Provide a description to policy makers, using internationally accepted terminology, of the practice of physical therapists
- Provide information for payers and claims reviewers regarding the practice of physical therapy for common neurologic and musculoskeletal conditions
- Create a reference publication for physical therapy clinicians, academic instructors, clinical instructors, students, interns, residents, and fellows regarding the best current practice of physical therapy

Statement of Intent

These guidelines are not intended to be construed or to serve as a standard of medical care. Standards of care are determined on the basis of all clinical data available for an individual patient and are subject to change as scientific knowledge and technology advance and

patterns of care evolve. These parameters of practice should be considered as guidelines only. Adherence to them will not ensure a successful outcome in every patient, nor should they be construed as including all proper methods of care or excluding other acceptable methods of care aimed at the same results. The ultimate judgment regarding a particular clinical procedure or treatment plan must be made based on clinician experience and expertise in light of the clinical presentation of the patient; the available evidence; the available diagnostic and treatment options; and the patient's values, expectations, and preferences. However, we suggest that significant departures from accepted guidelines should be documented in the patient's medical records at the time the relevant clinical decision is made.

Scope

Within this CPG, the word "concussion" is used as an umbrella term that broadly encompasses other commonly used terms in the clinical and research literature including, "mild traumatic brain injury" and "mild closed head injury." For the purposes of this guideline, a ***concussion*** is defined as a traumatic injury that affects the brain, induced by biomechanical forces transmitted to the head by a direct blow to or forces exerted on the body.[2-4] Concussions occur via many different mechanisms and in a variety of contexts including but not limited to: falls, motor vehicle crashes, blast exposures, and sporting and recreational injuries, or physical conflict. The nature of such mechanisms and contexts constitute a ***concussive event***. Considering an injury of this nature as a concussive event is useful because the forces that induce concussion may result in damage to brain function (justifying the classification of the injury as a "mild traumatic brain injury") but also concomitant injury to other body structures and functions, especially areas in close proximity to the head such as the cervical spine and vestibular system. The Gudieline Development Group (GDG) embraced the perspective that all concussions stem from a concussive event to ensure a broader consideration of the other structures, tissues, and body systems that may be involved when a physically traumatic incident occurs.

The intended scope of this CPG is to guide physical therapist clinical decision-making for individuals who have experienced a concussive event resulting in movement-related symptoms, impairments, and functional limitations. It is important to acknowledge that there is potential for an individual to have experienced a concussive event but to have *never* been evaluated for a medical diagnosis of concussion prior to a physical therapy encounter. Therefore, the starting criterion for implementation of this guideline is a physical therapy encounter with a patient who has sustained a potential concussive event, regardless of whether the patient has a medical diagnosis of concussion or not. The CPG may be implemented whether the potential injury occurred recently or in the more distant past.

Recommendations in this CPG are focused on the evaluation and treatment of individuals age 8 years and older and with no more than mild cognitive impairment. Theoretically, the recommendation statements provided in this document could be applied to children under the age of 8 years and individuals with more severe cognitive impairments. However, current management strategies for concussion rely heavily on reliable patient reports of their symptom responses to provocation tests and interventions. There is limited data

available on symptom assessment in children under the age of 8 years,[4-6] which may limit the applicaibility of these recommendations for clinical decision-making with young children.

It is not the intent of this CPG to address acute concussion screening or diagnosis (eg sideline assessment), neurocognitive/neuropsychological management, or pharmacological management. These issues are well covered in consensus statements and CPGs that are published by various professional groups and associations (eg, the Ontario Neurotrauma Foundation,[3] Centers for Disease Control and Prevention,[4] U.S. Department of Veterans Affairs and Department of Defense[7]). We encourage physical therapists to become familiar with other guidelines to enrich their understanding of postconcussion assessments and interventions that are often used but may fall outside the scope of physical therapy care.

CPG Framework

The complexity of concussion-related symptoms and impairments often necessitates the involvement of multi-disciplinary teams that include a variety of medical and rehabilitation professionals.[2,8-11] The conventional approach to managing individuals with concussion was to encourage rest until symptom resolution.[8,12] One rationale supporting rest, especially acutely after concussion, is that it may help alleviate symptoms and ease the discomfort individuals with concussion often experience.[13-15] It has also been hypothesized that rest can facilitate the brain's recovery by reducing energy demands and attenuating the acute neurometabolic and inflammatory responses to a concussive injury.[12,16] Moreover, concerns over potential risk for catastrophic injury if another head injury occurs prior to recovery from the first concussion has led to cultural and policy shifts designed to prevent individuals from returning to high-risk activities too soon.[2]

Recently, authors have questioned the value of rest until symptom resolution and suggest that an earlier gradual return to activity may be beneficial.[8,12] Observational and experimental studies have demonstrated that both strict rest and intense bouts of cognitive or physical activity acutely after injury may be associated with delayed recovery trajectories.[12,14,17-42] Prolonged rest, specifically, may lead to development of secondary effects that are similar to common postconcussion symptoms (eg, deconditioning with exertional intolerance, anxiety or depression due to social isolation and/or reduced participation), making it difficult to discern if the source of ongoing symptoms is the prescribed rest for the concussion or from the injury itself.[12,21]

Most recent CPGs and guidance documents focus on recommendations that embrace the encouragement of 24-48 hours of complete rest or "relative rest" (steady re-integration of usual activity with recommendation to "rest as needed") followed by phased activity progressions based on symptom response to increasing activity.[2-4] While randomized controlled clinical trial studies in this area are sparse, current clinical recommendations typically advocate for the resumption of low levels of activity in the presence of mild symptoms as long as symptom exacerbation does not occur.[2-4,43]

Another emerging paradigm that contrasts with the rest-focused "wait-and-see" approach leverages active intervention approaches to attempt to facilitate recovery for individuals with concussion, often referred to as "active rehabilitation." Many of these active intervention strategies incorporate skilled rehabilitation techniques within the physical therapist's scope of practice.[8,12,16,28-30,32,34,36,44-61] Consequently, physical therapists are increasingly involved as key members in an interdisciplinary approach to caring for individuals with concussion.[2,12,54]

The recommendations for this CPG are situated within an overarching framework for strategies physical therapists can implement to support an active rehabilitation approach for management of patients who have experienced a concussive event. The framework is comprised of 3 components: 1) Determine Appropriateness of Physical Therapy Concussive Event Examination, 2) Physical Therapy Concussive Event Examination and Evaluation Process, and 3) Development and Implementation of a Physical Therapy Plan of Care for a Concussive Event. Recommendations are broken down into sections that directly align with each component and visual decision trees are provided to support implementation of the recommendations within the components.

Within components 2 and 3, examination and treatment strategies are further broken down into primary impairment domains. Based on a synthesis of the literature, the GDG identified four overarching impairment domains that align with physical therapists' scope of practice: 1) cervical musculoskeletal impairments, 2) vestibulo-oculomotor impairments, 3) exertional tolerance impairments, and 4) motor function impairments. These impairment domains are described below in the *Classification* section and serve as focal points for the examination and intervention recommendations provided in this CPG.

Examination and intervention strategies for movement-related impairments often require procedures that are intended to proke symptoms to determine if an impairment is present, and in some cases, to help directly treat the impairment. ***Irritability*** is a term used by rehabilitation practitioners to reflect the tissue or body system's ability to handle physical or physiological stress,[62] and is presumably related to physical status and the extent of injury and inflammatory activity that is present. The GDG concluded that information gleaned during the intake interview can be used to help determine probable levels of irritability for the various systems, which in turn, can be used to help strategically identify priorities and sequencing for examination procedures to allow for a greater number of assessments and greater accuracy of the tests that are performed. Determining probable levels of irritability may also help clinicians plan for modifications to examination procedures to address safety concerns, patient comfort, and/or patient and family goals and preferences. Likwise, irritability levels for specific impairment areas can help guide prioritization and selection of type of physical therapy interventions. Therefore, the concept of irritability is applied throughout this CPG to guide sequence of screening, examination and management of individuals who have experienced a concussive event.

Rationale

Over the last decade, numerous concussion evidence-based CPGs, consensus statements, and clinical guidance documents have been published.[2-4,7,8,43,63,64] These documents have

typically focused on the diagnosis of concussion and medical management of individuals postconcussion but provide little specific guidance for physical therapy management of concussion and its associated impairments. Further, many of these guidance documents have targeted specific populations (eg, athletes and military personnel) in specific care contexts (eg, sideline assessments and return-to-activity decision-making.[2,8] The lack of guidance for management of a wider scope of patients is particularly problematic for physical therapists, as they may encounter patients with concussions from a variety of injury mechanisms and contexts (eg, children injured in recreational activities, military personnel in active duty service, older adults after falls, or passengers in motor vehicle collisions). Practice settings also vary across the continuum of care, from acute inpatient settings to ambulatory outpatient clinics.

The rise of the evidence and encouragement for active rehabilitation strategies for postconcussion impairments[12] prompts the need for recommendations regarding how physical therapists should approach the management of individuals who have experienced a potential concussive event. Furthermore, a CPG for physical therapists may be useful in informing other health professionals and stakeholders about the expertise and services physical therapists can provide for patients diagnosed with a concussion. The primary purpose of this CPG is to provide a set of evidence-based recommendations for physical therapist management of the wide spectrum of patients who have experienced a concussive event.

Specific objectives for this CPG are to:

- Systematically review the available scientific evidence pertaining to physical therapist management of patients who have experienced a concussive event,
- Provide evidence-based recommendations to guide physical therapist treatment, and
- Educate all stakeholders regarding physical therapy strategies for management of patients who have experienced a concussive event.

Secondary objectives are to:

- Identify current gaps in knowledge related to physical therapist management of concussion,
- Provide consensus-based recommendations for physical therapist management where evidence is lacking.

Special Considerations for Physical Therapy Management of a Concussive Event

This CPG is the first to provide a comprehensive set of evidence-based recommendations for examination, evaluation, treatment, and outcome measurement strategies for physical therapist management of patients who have suffered a potential concussive event. Many of the symptoms, impairments, and functional limitations often reported after concussion correspond with conditions and functional limitations that physical therapists are specifically trained to evaluate and treat (eg, vestibular impairments causing dizziness and imbalance, cervical impairments resulting in neck pain, headache, cardiorespiratory deconditioning). However, the treatment for these conditions is supported in large part by

evidence and CPGs derived from evidence that is not specific to concussion. *The complex and multi-factorial nature of concussion requires that physical therapists use clinical reasoning to apply CPGs and evidence that is not directly focused on patients with concussion to optimally evaluate and treat patients who present with these conditions after a concussive event*. More research is needed to specifically evaluate the appropriateness and feasibility of using guidelines developed for impairments common after a concussive event but have yet to be specifically tested for use with people who have experienced a concussive event.

Barriers and Facilitators to Implementation

A potential barrier for implementation of this CPG is that physical therapist management of patients who have experienced a concussive event may require evaluation and treatment strategies that are typically provided by physical therapy specialists. *Effective physical therapist management of concussion may necessitate referral to providers with necessary expertise appropriate across the continuum of management*. For example, an individual with complex neck pain or cervical spine dysfunction may normally be treated by a physical therapist with expertise in orthopaedic manual therapy techniques, while an individual with dizziness may typically be managed by physical therapists who specialize in vestibular rehabilitation. After a concussive event, however, a patient may need both types of interventions. These challenges are compounded by the practice of having patients with brain injuries managed by physical therapists who specialize in more severe neurologic conditions that may not commonly progress to a level where advancement in high physical performance contexts is needed (eg, sports, military, tactical professions such as police, fire, or other emergency medical personnel). Therapists in outpatient orthopaedic and sports settingsmay be more familiar with progressing people to high performance levels but have less expertise in managing patients with brain injuries. Therefore, it is important for physical therapists to be mindful of their clinical strengths and limitations and refer to and/or consult with other physical therapist colleagues as needed to help ensure their patients receive the care that they need. *We urge physical therapists who plan to treat patients with concussion regularly are strongly encouraged to seek out specialized training and coursework that prepares them to manage the myriad of possible presenting signs and symptoms from the various systems affected*.

Facilitators for implementing this CPG may include a local practice culture that embraces evidence-based practice, and physical therapists that are trained to specifically manage patients who have experienced a concussive event. Another facilitator for implementation may be access to a multi-disciplinary concussion clinic or network of health care providers that can work together to help manage patients who have experienced a concussive event. Lastly, the complexity of concussive injuries may lead to highly variable care delivery processes. Clinical pathways that support optimal patient referral and treatment flows that align with the recommendations proposed in this CPG are encouraged to facilitate direct integration into local practice settings.

METHODS

Guideline Development Overview

The composition of the GDG was strategically designed to ensure representation of diverse perspectives and experience within the profession of physical therapy. Representatives

from the American Physical Therapy Association, Academy of Orthopaedic Physical Therapy, American Academy of Sports Physical Therapy, Academy of Neurologic Physical Therapy, and Academy of Pediatric Physical Therapy were recruited to ensure a GDG comprised of sufficient and complementary clinical and research expertise to address the wide range of neurologic, orthopaedic, age-related, and functional impairments that are commonly present among individuals who have experienced a concussive event. The CPG development process was guided by a trained methodologist who was an integral part of the team using standards consistent with the Institute of Medicine, Guidelines International Network[65] and subsequently outlined in the 2018 Edition of the American Physical Therapy Association's Clinical Practice Guideline Process Manual.[66] In addition, the authors received methodological guidance and support from leading methodologists in the field. See Affiliations and Contacts section at end of the CPG for full list of acknowledgments.

The authors declared relevant relationships and conflict of interests and submitted a conflict-of-interest form to the Academy of Orthopaedic Physical Therapy. Articles identified for review that were authored by GDG members or volunteer reviewers were assigned to alternate reviewers. Throughout the CPG development process, the GDG received support through an APTA grant and sponsorship from the Academy of Orthopedic Physical Therapy, American Academy of Sports Physical Therapy, and the Academy of Neurologic Physical Therapy for training, travel, software, and librarian assistance. The funding bodies did not have any influence over the recommendations proposed.

Background Information Resources

Due to the large volume of background literature on concussion, the heterogeneity of the available literature, and the lack of specific relevance to physical therapy techniques and strategies, the GDG judged systematic review and critical appraisal for the topics included in the background section to be outside the intended scope of this CPG. Citations provided in this sections were not critically appraised relative to a specific clinical questions related to incidence, risk factors, or clinical course. When possible, the highest level and most recent references were chosen as key informational sources.

Systematic Literature Searches

The recommendations provided in this CPG are based on the scientific literature published in print or as an electronic publication ahead of print prior to December 31, 2018. Appendices A-F provide details about the search strategies, database search results, inclusion/exclusion criteria, critical appraisal tools, and flow chart of included articles, respectively . The review of the evidence for this CPG encompassed a range of physical impairments that may be relevant when making a differential diagnosis after a concussive event, with the goal of determining the underlying cause(s) of presenting signs and symptoms and matching them with intervention priorities. The GDG worked with a librarian from the University of North Carolina at Chapel Hill to engage in the two phases of the literature search process (Preliminary Searches and Systematic Searches) as recommended by the APTA Clinical Practice Guideline Process Manual.[66] EndNote X8 (Clarivate Analytics; Boston, Massachusetts) and DistillerSR software (Evidence Partners; Ottawa, Ontario, Canada) were used to manage the literature searches, coordinate evidence

selection, carry out critical appraisals, and store notes and information about the evidence sources.

Evidence Selection

Title and Abstract Screening

Potential original research studies were initially screened independently by 2 GDG members by title and abstract. Screening criteria for this phase was that the document appeared to have potential relevance to: inform prognosis, diagnosis, examination, or intervention of concussion relative to physical therapist practice patterns. In cases where the screeners disagreed or the abstract was not clear enough to make a determination, the article was carried forward to the full text review stage.

Full Text Review

Each article carried forward from the title and abstract screen was independently reviewed by 2 GDG members using previously established inclusion and exclusion criteria (See Appendix C). Reviewers were given the option to identify an article that was not in direct alignment with the inclusion/exclusion criteria if it might prove relevant for background information. The articles identified in this category could then be reviewed and considered Level V (expert opinion) evidence to help inform the GDG's drafting of action statements and research recommendations if higher level evidence was lacking. In cases of disagreement on inclusion, the reviewers were asked to resolve the conflict through discussion. If needed, a third reviewer was consulted to help make a final determination.

Critical Appraisals of Evidence

Each article was critically appraised by 2 independent reviewers using a designated critical appraisal tool based on study type. All reviewers were trained in use of the critical appraisal tools they would use by evaluating test articles to establish interrater reliability. When a study arose that was authored by a member of the GDG, the article was appraised by other GDG members. Each dyad compared scores for agreement and resolved conflicts through discussion, and submitted a single critical appraisal form for determination of the Level of Evidence. In cases where the appraisers were unable to come to agree, the GDG discussed the article as a group to achieve consensus. The final step entailed the GDG's assessment of the identified risks of bias and relative importance of those risks to the procedures or specific outcome of interest to designate the article into 1of 4 quality ratings: 1) high quality, 2) acceptable quality, 3) low quality, and 4) unacceptable quality. If a study was deemed as unacceptable quality, it was removed from consideration for inclusion relative to the recommendations related to that area.

Conceptual, Theoretical, and Expert Consensus Documents:

Given the rapidly evolving practice standards and relatively new treatment paradigm of active concussion rehabilitation, a number of conceptual models, theory-focused commentaries, and expert consensus documents have emerged in the literature. Systematic critical appraisal for such types of documents is challenging and largely subjective in nature. However, several manuscripts and documents identified through the search process provided valuable strategies for framing how to approach physical therapy examination and intervention processes, for which evidence is currently lacking. Two

independent reviewers from the GDG reviewed conceptual, theoretical, and expert consensus documents identified during the systematic searches and determined the appropriateness for inclusion in the CPG based on the criteria provided in Appendix C.

Strength of Evidence
Using the submitted critical appraisal ratings, each article was assigned a level of evidence in accordance with the designations and procedures described in Appendix E. An abbreviated version of the level of evidence rating system is provided below. It is important to note that an individual article or recommendation statement from a previously published CPG could be assigned multiple levels of evidence if it was linked to more than 1 outcome of interest.

Level	Studies and Expert Opinion Documents
I	High quality systematic review, diagnostic studies, prospective studies, or randomized controlled trials
II	Moderate or lesser quality but acceptable systematic review, diagnostic study prospective study, or randomized controlled trials (eg, weaker diagnostic criteria and reference standards, improper randomization, no blinding, less than 80% follow-up)
III	Case-control studies, retrospective comparative studies, correlational studies
IV	Case series, descriptive reports, or expert opinion/expert consensus documents with adequately reported methods sections (eg, Delphi study or other consensus generating process)
V	Expert opinion, qualitative literature reviews, conceptual or theoretical documents with no systematic evaluation of evidence or consensus generation processes

Development of Recommendations.
The GDG developed recommendations based on the strength and limitations of the body of evidence, including how directly the studies addressed the clinical questions posed. Additionally, the authors considered potential health benefits, side effects, and risks of tests and interventions. The GDG used BRIDGE-Wiz Version 3.0 to write implementable and transparent recommendations that meet the Institute of Medicine CPG standards.[65] The GDG worked with the editors and staff of the target journal for publication and APTA CPG leaders to refine the recommendations and supporting documentation structure into a publishable format.

Selection and Adaptation of Recommendations from Previously Published CPGs
Numerous evidence-based CPGs and expert consensus guidance documents on concussion have been published. Likewise, several CPGs applicable to physical therapy examination and intervention strategies relevant to impairments and functional limitations common with concussive events have been developed and endorsed by the APTA and its associated academies. The GDG determined it was important to minimize redundancy in the literature and avoid replication of general practice recommendations by using a process of critical appraisal to adapt recommendations from previously published high quality CPGs relevant

to general management of patients who have experienced a concussive event physical therapy management practices. As CPGs are often reviewed and updated, the group continued to monitor publication of updates and release of new CPGs through December 31st, 2018 for potential inclusion in this document. This ensured the inclusion of existing guidelines appropriate for endorsement and integration in this CPG.

Recommendations from previously published CPGs were eligible for inclusion if they met the following criteria: 1) published January 1, 2015 or later, 2) included a multi-disciplinary team for authorship, 3) recommendations were based on a systematic review and appraisal of the literature, 4) included recommendations that pertained to movement-related impairments, and 5) determined to be acceptable based on critical appraisal by two trained independent reviewers using criteria on the AGREE II tool. The AGREE II instrument consists of 23 items categorized under 6 domains rated using a 7-point scale. A rating of 7 represents the highest possible score. Three CPGs were identified that met these criteria: 1) guidelines produced by a working group for the Ontario Neurotrauma Foundation (ONF) in 2015),[3] 2) guidelines produced by a working group for the U.S Department of Veterans Affairs and Department of Defense (VA/DoD) in 2016,[7] and 3) guidelines for pediatric patients produced by a working group for the Centers for Disease Control and Prevention (CDC) in 2018.[4] Recommendations in this CPG that were developed based on an adaptation of previously published CPGs were assigned a level of evidence in accordance with the table below.

Level	Evidence Level Rating for Recommendations Adapted from Previously Published CPGs on Concussion Management
I	Recommendation being adapted was generated from Level I evidence
II	Recommendation being adapted was generated from from Level II evidence
III	Recommendation being adapted was generated from Level III evidence
IV	Recommendation being adapted was generated based on expert consensus of the authors of the published CPG

Grades of Recommendations

Grades for each recommendation were assigned through a consensus generation process in accordance with the recommended grades and definitions provided below. The wording of the clinician level of obligation used in the recommendations was designed to align with the recommended language for linking evidence, grades of recommendation, and strength of obligation (Level of Obligation column). The grade assigned for recommendations formulated based on an adaptation from previously published CPGs was based on a synthesis of the recommendations across relevant CPGs that met the inclusion and exclusion criteria. The adapted version of the relevant recommendations for this guideline had to reach a level of unanimous agreement from the GDG to be included.

GRADES OF RECOMMENDATION	STRENGTH OF EVIDENCE	Level of Obligation

A	Strong evidence	A preponderance of level I and/or level II studies support the recommendation. This must include at least 1 level I study	Must: benefits substantially outweigh harms Should: benefits moderately outweigh harms May: Benefits minimally outweigh harms or benefit/harm ratio is value dependent Should not: harms minimally or moderately outweigh benefits or evidence of no effect Must not: harms largely outweigh benefits
B	Moderate evidence	A single high-quality randomized controlled trial or a preponderance of level II studies support the recommendation	Should: benefits substantially outweigh harms May: benefits moderately or minimally outweigh harms or benefit/harm ratio is value dependent Should not: evidence that harms outweigh benefits or evidence of no effect
C	Weak evidence	A single level II study or a preponderance of level III and IV studies, including statements of consensus by content experts, support the recommendation	Should: benefits substantially outweigh harms May: Benefits moderately or minimally outweigh harms or benefit/harm ratio is value dependent Should not: harms minimally or moderately outweigh benefits
D	Conflicting evidence	Higher-quality studies conducted on this topic disagree with respect to their conclusions. The recommendation is based on these conflicting studies	May: conflicting evidence, the benefit/harm ratio is value dependent

E	Theoretical/ foundational evidence	A preponderance of evidence from animal or cadaver studies, from conceptual models/principles, or from basic sciences/bench research support this conclusion	May: in the absence of evidence from clinical studies, theoretical and or foundational evidence supports benefit. Should not: in the absence of evidence from clinical studies, theoretical and or foundational evidence suggests risk of harms.
F	Expert opinion	Best practice based on the clinical experience of the guideline development group	Must: Strongly supported by consensus-based best practice/standard of care Should: Moderately supported by best practice/standard of care May: supported by expert opinion in the absence of consensus Should not: best practice/standard of care indicates potential harms Must not: Potential harms are strongly supported by consensus-based best practice/standard of care

AGREE II Review

To ensure the CPG was of high-quality and implementable, the complete draft of the CPG was reviewed by members of the Academy of Neurologic Physical Therapy Evidence Based Practice Committee, using AGREE II, a tool to assess the quality and reporting of CPGs. As previously mentioned, the AGREE II instrument consists of 23 items categorized under 6 domains rated using a 7-point scale, with a rating of 7 being the highest possible score. Scores and comments provided by the AGREE II reviewers were discussed by the GDG. Domain scores for the CPG ranged from xx to xx When deemed feasible and appropriate, the GDG edited the CPG to address reviewer concerns and suggestions.

External Stakeholder Review Processes

This CPG underwent multiple formal reviews. The first complete draft was reviewed by invited representative stakeholders for a variety of domains and perspectives, including: physical therapists, physicians, athletic trainers, neuropsychologists, occupational therapists and optometrists. The second draft was posted for public comment on xxxx on

websites for the components of the APTA that supported the development process (the Academy of Orthopedic Physical Therapy, American Academy of Sports Physical Therapy, and the Academy of Neurologic Physical Therapy). Notices encouraging contributions to the public commentary were sent via email and electronic newsletters to members of APTA components for orthopaedics, sports, neurology, pediatrics, and geriatrics as well as to individuals who inquired about the CPG during its development. Comments, concerns, and suggestions from each round of reviews were considered with each successive draft of the document. Appendix A provides acknowledgements for specific reviewers.

Organization of the Guideline

The guideline covers topics related to concussion incidence, risk factors for prolonged recovery, physical therapist examination strategies, and physical therapist intervention strategies. At the end of the document, high-level decision trees that provide a general triaging system for decision-making and sequencing of activities are provided. These decision trees are designed to directly align with the recommendations to guide physical therapists' decision-making processes.

Classification

The primary ICD-10 code associated with **concussion** is S06.0: Concussion. Additional codes that may be directly associated with the brain injury aspect of concussive events include *S06.9X: Unspecified intracranial injury*, *S06.2X: Diffuse traumatic brain injury*, and *F07.81: Postconcussional syndrome*. Due to the complex nature, ICD-10 codes related to physical impairments that may result from a concussive event and may be addressed by physical therapists are summarized in Table 1 and Primary body Function Codes in Table 2. These codes were identified from studies that have defined core sets of ICF indicators following concussion, spine trauma, or vestibular complaints.[63,67,68] Issues that would reasonably be addressed by physical therapy were identified from these sources, and consensus of the CPG development group confirmed their inclusion.

Table 1 ICD-10 Codes Related to Physical Impairments Associated with Concussive Events

G43	Migraines
G43.909	Headache, migraine
G44.209	Headache, tension type
G44.309	Headache, post-traumatic
G44.319	Headache, posttraumatic, acute
G44.329	Headache, posttraumatic, chronic
G44.84	Headache, exertional
G89.11	Pain, due to trauma
G89.21	Pain, chronic duty trauma
G89.29	Pain, chronic
G89.4	Pain, chronic pain syndrome
G96.9	central nervous system disorder
H51.1	Convergence insufficiency and excess

H74.8	fistula middle ear
H81.1	Benign Positional vertigo
H81.3	Other peripheral vertigo
H81.39	Vertigo, peripheral
H81.4	Vertigo of central origin
H81.8	Unspecified disorder of vestibular function
H81.9	vestibular function disorder
H82	Vertiginous syndromes
H83.1	fistula inner ear
H83.2	Imbalance, labyrinth
M24.28	vertebral ligament disorder
M25.60	Joint stiffness
M26.62	Pain, temporomandibular joint
M26.69	derangement, temporomandibular joint
M46.01	Enesthopathy, spinal, occiput-atlas-axis
M46.02	Enesthopathy, spinal, cervical region
M50.90	cervical disc disoder
M53.1	Pain, cervicobrachial; Cervical root syndrome
M53.2	Instability, joint, post-traumatic, spine
M53.82	Dorsopathy, cervical region
M54.2	Cervicalgia
M79.1	Pain, myofascial
M84.48	fracture neck
M84.68	fracture vertebra
R26.8	Other abnormalities of gait and mobility
R29.3	Imbalance, postural
R42	Dizziness and Giddiness
R51	Headaches
R52	Pain, acute
R53.83	fatigue
S04.6	Injury, acoustic nerve
S06.06	Concussion
S06.2X	Diffuse traumatic brain injury
S06.9X	Unspecified intracranial injury
S09.31	Injury, blast, ear
S10	Superficial injury of neck
S10.9	Injury, superficial neck
S12.9	fracture cervical
S13.4	Sprain of ligaments of cervical spine

S13.4	Whiplash injury
S16	Injury of muscle, fascia and tendon at neck level
S16.9	Injury, neck muscle
S19.9	Injury, neck

Table 2 ICF Codes Related to Physical Impairments Associated with Concussive Events

b Body Functions	**s Body Structures**	**d Activities & Participation**
b130 -Energy & drive functions b134 -Sleep functions b140 -Attention functions b147 -Psychomotor functions b156 -Perceptual functions b210 -Seeing functions b215 Functions of structures adjoining the eye/oculomotor function b235 -Vestibular functions b240 -Sensations associated with hearing & vestibular function b260 -Proprioceptive functions b280 -Sensation of pain, headache, neck pain/other pain. b455 -Exercise tolerance functions b710 -Mobility of joint functions b730 -Muscle power functions b735 -Muscle tone functions b740 Mucle endurance b760 -Control of voluntary movement functions b770 -Gait pattern functions	s110 -Structure of the brain s260 -Structure of inner ear s410 -Structure of cardiovascular system s710 -Structure of head and neck region	D220-Undertaking multiple tasks d410 -Changing basic body positions d415 -Maintaining a body position d430 -Lift and carry objects d450 -Walking d455 -Moving around (includes running, jumping) d460 -Moving around in different locations d469 -Walking & moving, other specified and unspecified d475 -Driving d640 -Doing housework d660 -Assisting others d810-839: -Education d840-859: -Work and employment d810-839: -Education d910 -Community life d920 -Recreation and leisure

The GDG identified four domains that are relevant to physical therapist examination intervention processes and may be useful to help identify specific patient needs and develop treatment plans. These domains should not be treated as mutually exclusive classifications, as patients may exhibit impairments that fall into more than one category. The four domains are presented below with specific rationale about the associations between that impairment and concussive events.

Cervical Musculoskeletal Impairments. Cervical musculoskeletal impairments can lead to a variety of symptoms that are also commonly reported by individuals with a diagnosis of concussion (eg, neck pain, headache with or withiout neck pain, dizziness, and diminished

balance/postural control).[32,55,69-72] Currently, the incidence of cervical musculoskeletal impairment associated with concussive events is not comprehensively studied or well-reported. However, given the biomechanical mechanism of many concussive event injuries, it is hypothesized that cervical musculoskeletal impairments may be present.[53,73,74] In patients with neck pain in the absence of concussion, there is strong evidence that impairments such as diminished range of motion, poor strength, and insufficient muscle endurance and control exist.[75] There is also evidence indicating the potential for impaired sensorimotor control deficits that may originate from alterations in cervical afferent input.[76-83] These may included impaired cervical reflex responses and cervical proprioception that can affect the visual and vestibular systems and lead to dizziness, visual dysfunction, balance problems, and difficulties with head and eye movement control.[78,84] Therefore, even when neck pain is not present, cervical musculoskeletal impairments may serve as an underlying source driving other symptoms, particularly dizziness, imbalance and headache.

Vestibulo-oculomotor Impairments. Numerous studies indicate that vestibular and oculomotor deficits are common after concussion.[69] Such deficits can contribute to many postconcussion symptoms, impairments, and functional limitations, including dizziness, balance problems, blurred vision, headaches, nausea, sensitivity to light, sensitivity to sound, mental fogginess, difficulty reading, difficulty concentrating, anxiety and fatigue.[76,85] Precise incidence rates for these impairments remain unclear, and they may be driven by different factors and/or multiple factors.[69,85-88] Physical therapy examination and intervention strategies for both of these systems are inextricably linked. Therefore, it is practical to view these as a single impairment domain for examination and treatment purposes. Regardles, it is important for physical therapists to consider the interplay and overlap between cervical and vestibular causes of dizziness, oculomotor dysfunction, and imbalance.

Autonomic Dysfunction and Exertional Intolerance. Mounting evidence indicates that reduced tolerance to physical exertion is common after concussion, with many individuals reporting an increase in a variety of concussion-related symptoms with physical exertion.[2,9,12,13,16,52-54,89-94] Poor tolerance to physical exertion may also be associated with higher reports of fatigue as the effects of physical exertion may not occur during actual exercise but may emerge later.[52,95] The extent to which physical exertion intolerance is present among individuals with concussion has not been systematically studied nor are the specific mechanisms that may drive physical exertion intolerance fully understood. Emerging evidence indicates that autonomic dysfunction resulting from the brain injury itself may be a contributing factor for exertional intolerance.[16,38,56,91,96] It has been hypothesized that concussions can lead to an uncoupling of the central autonomic nervous system and the heart leading to a reduced ability to maintain and adjust: cerebral blood flow, blood pressure, and/or heart rate in response to increases and decreases in physical exertion.[13,16,89,92,96] While confirmatory studies for these hypotheses are needed, preliminary work in this area suggests that concussions may be associated with altered autonomic regulation.[13,89,97,98] This autonomic dysregulation has been linked to higher perceived rates of exertion compared to individuals who have not recently sustained a concussion[89] and may also be captured by assessments for orthostatic hypotension.[99]

Another potential source of poor tolerance to physical exertion is general deconditioning or secondary physical inactivity/lifestyle changes that may be recommended or occur as a result of the concussive injury.[12,20,59]

Motor Function Impairments. A variety of studies have reported that individuals who have experienced a concussive event may present with altered motor function abilities, including static and dynamic balance/postural control impairments, changes in dual/multi-tasking impairments, delayed motor reaction time, and increased difficulty with motor coordination (especially with more complex environments or tasks).[77,100-102] A growing body of evidence suggests that these motor function impairments may be relatively subtle and difficult to capture clinically.[103-108] Studies also suggest that these underlying impairments may persist for months to years and may be present even when symptoms have seemingly resolved.[100,109]The extent to which such subtle motor function impairments may interfere with daily function and activity participation is unclear and the prevalence of these impairments remains unknown. However, emerging studies indicate that these types of impairments may lead to increased risk for future concussions and other injuries among athletes and those in high-activity/high-risk jobs (eg, active-duty military, firefighters, and police officers).[110-112 113]

Dissemination and Implementation Plans and Tools

In addition to the publication of this document in *xxx*, these guidelines will be posted on CPG areas of xxx, xxx, xxx, and APTA websites for free access. The initial presentation of the recommendation draft were presented January 24, 2019 at the APTA Combined Sections Meeting in Washington, DC. Additional plans are in place for ongoing presentation of the guidelines at educational conferences and webinars for clinicians. Planned implementation tools include, a patient-oriented guideline summary, read-for-credit continuing education units, and suggestions for common data elements and minimal datasets for contribution to the Physical Therapy National Outcomes Data Registry.

Plan for Updating the Guideline

Typically, the updated/revisions to CPGs are planned to occur every five years. Evidence related to this guideline continues to evolve quickly. The plans for updating this guideline include to continue to monitor the evidence on a monthly basis and publish a revision in approximately five years. If evidence of sufficient quality becomes available that directly contradicts or would result in substantial changes to the recommendations provided in this CPG prior to the planned five years, a revised CPG may be completed sooner.

IMPAIRMENT/FUNCION-BASED DIAGNOSIS

Incidence

Evidence Summary

Concussion is increasingly recognized as a major public health concern due to high incidence rates and the potential for long-term effects.[2,4,10,11,44] Overall incidence rates for concussion have varied greatly across studies. The Centers for Disease Control and Prevention estimates that 1.6 to 3.8 million concussion occur during sports and recreational activities annually.[114] In 2008, the Agency for Healthcare Research and Quality

reported 43,802 emergency department (ED) visits for sports-related concussion, and more than 12 times as many reported non-sports related concussions during the same period.[115] Thus, while media reports have often focused on the high incidence and dangers of concussion in sports, and particularly American football, it is important to recognize that the mechanisms and contexts of concussive events vary greatly, and frequently occur outside of sports contexts (i.e., falls, motor vehicle crashes, military injuries).[115-117] Furthermore, recent epidemiological reports indicate that incidence rates for concussions have been on the rise, likely as a direct result of the increases in research and media coverage indicating the potential dangers associated with concussive events and mild brain injuries.[116,118]

A commonly acknowledged limitation of incidence estimates is that not all individuals who experience a concussive event seek medical care.[10,114,118-122] Additionally, many concussive events go unrecognized or unreported,[118] and the symptoms, impairments, and functional limitations associated with concussion can be subtle, vary in presentation, and be easily confused with other common illnesses or injuries.[8,10,118] For example, headaches, fatigue, and dizziness commonly occur after a concussive event; however, they are also associated with other injuries and illnesses.[3,4,6,7] Collectively, these factors are significant challenges for providing clear estimates for the incidence and prevalence of concussion.[2,6,8,10]

Gaps in Knowledge

Future research should investigate the prevalence of patients participating in physical therapy who do not have a medical diagnosis of concussion yet experienced a concussive event and exhibit signs and symptoms indicative of a concussion. Research in this regard would help provide estimates for undiagnosed concussion among individuals referred to physical therapy.

Risk Factors

Evidence Summary

There is growing recognition that concussion recovery trajectories are complex, highly variable, and influenced by a range of factors (eg, age, sex, prior history of concussion, pre-morbid diagnoses).[8,10,11,123] A recent systematic review highlighted *pre-injury factors*, *injury-related factors*, and *post-injury factors* associated with prolonged recovery after a concussion.[123] It has been suggested that *pre-injury factors* such as history of concussion, female sex, younger age, attention deficit hyperactivity disorder (ADHD), history of migraine, and genetics may all be associated with prolonged recovery from concussion.[123] *Injury-related factors* associated with prolonged recovery include: loss of consciousness, anterograde amnesia, retrograde amnesia, and delayed removal from sports participation.[123] *Post-injury factors* associated with prolonged recovery include symptoms of dizziness, headache, migraine, or depressive symptoms.[123] However, studies have also documented a lack of association between prolonged recovery and many of the aforementioned factors.[123] Consequently, definitive characterization of risk factors associated with poor concussion recovery remains unclear.[10,11,123]

Two emerging areas of research highlight additional factors that may influence recovery outcomes: 1) psycho-social factors (e.g., perceived competence, tenacity, tolerance of

negative affect, and pstitive acceptance of change)[10,124-128] and 2) early concussion management factors (e.g., strict rest versus relative rest versus active rehabilitation.[8,10,61] Identification of risk factors and implementation of management approaches have continued to evolve quickly as new knowledge is gained and alternative factors and strategies are proposed. This fast-paced evolution of evidence likely contributes to variation in care, which in turn, adds to the difficulty in defining natural concussion recovery trajectories and the extent to which various strategies directly affect outcomes.[10,11]

Gaps in Knowledge

More research is needed to determine risk factors related to poor recovery from concussion and how how timing and utilization of physical therapy services may affect recovery.

Clinical Course

Evidence Summary

Concussions are associated with a wide array of complaints including headache, dizziness, balance problems, neck pain, sensitivity to light and sound, fatigue, disorientation, mental fogginess, sleep disturbances, and difficulty regulating emotions, among others.[6,10,118] Many studies report that most individuals who sustain concussions "recover" within a relatively short period of time (~7-14 days post injury).[8,118,123] However, definitions for concussion and the strategies to measure recovery have been inconsistent.[10,123] In recent years, the notion that most individuals recover fully from concussions within a few days or weeks has been increasingly challenged.[2,8,123] Studies have demonstrated that as many as 5-58%[10,129] of individuals who sustain a concussion have persistent symptoms, impairments, and/or limitations that affect daily function. The timing of these complaints range from a few days to a few weeks or longer.[129-132]

Although it is often reported that symptoms, impairments, and functional limitations follow a gradual pattern of improvement, the trajectory may not be linear.[19] Rather, many patients experience symptom exacerbations, during their recovery period.[19] In some cases, these exacerbations may be an immediate reaction to a specific mechanism (eg, change of position or intense bout of physical or cognitive exertion),[52] or delayed reaction associated with activities over the preceding 24-hour period.[19] Some studies indicate that subtle, underlying impairments may continue to be present after concussion [100,101,131] and put individuals at risk for additional injuries[110,133] or long-term sequelae (e.g, chronic pain, persistent motor control deficits).[100,101,132,134]

Since approximately 2007, clinical commentaries and studies have supported postconcussion assessment, management, and skilled rehabilitation techniques that fall within physical therapists' scope of practice (eg, progressive aerobic exercise, vestibular and oculomotor interventions, manual therapy and exercises targeting the cervical spine).[8,12,16,28,30,32,34,36,44-59] Systematic reviews support active rehabilitation strategies for concussions under the direction of a physical therapist as a promising management approach for facilitating recovery.[12,58] Consequently, physical therapists have become key members in an interdisciplinary approach to caring for individuals with concussion.[2,54]

Gaps in Knowledge
Despite a growing body of evidence on the safety and primarily positive outcomes for physical therapy interventions, additional research is needed to provide more specific insight into factors that affect patient responsiveness to physical therapy for concussion-related symptoms, impairments, functional limitations, and participation restrictions. Additionally, studies evaluating the prevalence of the different types of movement-related impairments would be informative.

SCREENING AND DIAGNOSIS

Diagnosis

I

Two high-quality CPGs (ONF and VA/DoD) strongly emphasize the need to recognize and diagnose a concussion as soon as possible to promote positive health outcomes and mitigate poor health outcomes and secondary effects of concussion. [3,7]

Evidence Synthesis
High-quality concussion CPGs and consensus-based guidance documents consistently acknowledge: 1) the importance of identifying and diagnosing a potential concussion as early as possible, 2) the importance for the involvement of a trained medical professional for determining the concussion diagnosis, and 3) common signs and symptoms that should be used to diagnose a concussion. Given the known problem of underreporting and underrecognition of concussions, physical therapists may encounter undiagnosed patients who have experienced a concussive event and exhibit concussion-related symptoms, impairments, and functional limitations. The benefits of identifying an unidentified concussion and associated impairments outweigh the potential costs of time, resources, and potential over-identification that may occur with more expansive screening efforts.

Recommendation

A

Physical therapists *should* screen all individuals who have experienced a potential concussive event for the presence of concussion-related symptoms, impairments, and functional limitations.

Screening for Indicators of Emergency Conditions

I

Two high-quality CPGs (ONF and CDC) included recommendations emphasizing the importance of screening for more serious neurological or musculoskeletal conditions that may require emergency evaluation and treatment.[3,4]

Evidence Synthesis
Although incidence is relatively low, there is potential for an individual with an initial presentation of mild brain injury to develop signs of decline that may be indicative of more

moderate to severe brain pathology. The following are all examples of indicators for a need for immediate emergency evaluation: 1) declining level or loss of consciousness, cognition, or orientation, 2) new onset of pupillary asymmetry, seizures, repeated vomiting or other focal neurologic signs, 3) severe or rapidly worsening headache or other neurological deficits, and 4) possible undiagnosed skull or spine fracture. Any of these signs warrant referral for emergency evaluation. Additionally, given the mechanisms of a concussive event, a screen for potential cervical spine pathology regardless of complaints of neck pain. Signs indicative of infection, cancer, cardiac involvement, arterial insufficiency (i.e., dizziness in combination with neurologic signs), upper cervical ligamentous insufficiency (i.e., positive transverse or alar ligament testing), unexplained cranial nerve dysfunction, signs of central cord compression (i.e., positive upper motor neuron tests) or fracture (i.e., findings suggesting imaging is required based on the Canadian C-spine rules and/or the National Emergency X-Radiography Utilization Study—NEXUS—criteria) warrant further assessment and referral for consultation with physicians or other members of the health care team (Figure 1, Sidebar 1).[75,135-137]

Recommendation

A

Physical therapists *must* screen patients who have experienced a potential concussive event for signs of medical emergency or severe pathology (eg, more serious brain injury, medical conditions, or cervical spine injury) that warrant further evaluation by other health care providers. Referral for further evaluation should be made as indicated (See Figure 1, Sidebar 1).

Differential Diagnosis

I

Evidence and recommendations from high-quality CPGs (ONF, VA/DoD, CDC) did not support the use of imaging for immediate diagnosis in the absence of more severe brain injury concerns.[3,4,7] The use of biomarkers, and the consideration of helmet-based measurement devices for diagnosing concussion are not recommended outside the context of research studies.[2-4,6,7]

I

Evidence and recommendation from two high-quality CPGs (ONF and CDC) support using a symptom checklist or symptom rating scale to help diagnose a concussion and multi-system evaluations.[3,4] However, there are no clear evidence-based endorsements to support specific symptom scales or system measures.

I

Evidence indicates that computerized neurocognitive assessments are an option to complement diagnostic evaluation for concussion, but the reliability, validity, and utility across patient populations remains unclear.[7,9,138,139]

II

Evidence from the CDC CPG proving recommendations specific to children indicates that age-appropriateness may be an important consideration for selection of concussion symptom scales as there are different scales developed specific age ranges.[4]

II

Evidence and recommendations from 1 high-quality CPG (ONF) support evaluation for cognitive difficulties through focused clinical interviews and symptom checklists.[3] Evidence and recommendations from one high-quality CPG (VA/DoD) recommended against the use of comprehensive and focused neurocognitive assessments in the first 30 days, instead encouraging general screening until symptoms appear to be persistent.[7]

Evidence Synthesis

Available guidance documents collectively indicate the multi-dimensional factors that should be considered and the triangulation of information sources to make a determination for the appropriateness of concussion as a diagnosis (Figure 1, Sidebar 2). As recognized by high-quality CPGs and numerous epidemiological studies, memory problems and confusion are common symptoms associated with concussion. Reports from individuals who know a patient well can be used to help verify and expand upon information the patient provides. The use of a symptom scale or checklist is a common standard of practice. However, there is no clear gold standard for the most appropriate diagnostic tools based on previously published guidelines, and comparative studies between tools are limited. Appendix C in a report published developed by the Committeee on sports-Related Concussions in Youth; Board on Children, Youth, and Families; Institute of Medicine; and National Research Council provides a good summary of many of the most commonly cited and used concussion assessment tools.[140]

Gaps in Knowledge

Many of the symptoms and impairments that are often present with concussion are not specific to concussion and were not specifically developed for physical therapist purposes. Patients may have diagnoses that pertain to entirely different pathoanatomical or pathophysiological mechanisms that may be distinct from concussion. Future research should identify best tools or develop an optimal diagnostic approach and battery of assessments for identifying patients with a concussion within physical therapy settings and contexts.

Recommendations

A

Physical therapists ***should*** determine and document the appropriateness of a diagnosis of concussion for a patient based on patient/family/witness reports, the patient's past medical history, the use of an age-appropriate symptom scale/checklist, and physical observation/examination (See Figure 1, Sidebar 2 for diagnostic criteria).

F

If diagnostic criteria for a concussion is not met, physical therapists ***should*** evaluate for other potential diagnoses and follow standard of care procedures in accordance with their findings.

Comprehensive Intake Interview

I

Evidence and recommendations from a high-quality CPG (ONF) emphasized a need to conduct a comprehensive intake on various aspects of the patient's past medical history, review of mental health history, injury-related mechanisms, injury-related symptoms, and early management strategies.[3]

II

Evidence from one high-quality CPG further supports that multiple tools should be used to assess children with concussion but does not provide specific endorsement of any tools.[4]

IV

Evidence from expert consensus documents and case studies provide further support for a comprehensive intake for factors that may affect or be affected by recovery from concussion.[2,43,63]

Evidence Synthesis

Guidance documents propose a variety of domains that are important to consider for diagnostic and prognostic purposes for individuals who experience a concussive event. Specific topics recommended for the intake process include: 1) the type, severity, and level of irritability of concussion-related symptoms; 2) pre-injury medical history that could result in symptoms similar to concussion-related symptoms (eg, learning challenges or disabilities, mood or emotional disorders, depression, frequent headaches); 3) any conditions or diseases that limit or serve as a contraindication or necessitate alternative testing options for comprehensive physical therapy evaluations and interventions (eg, cardiovascular concerns, concomitant musculoskeletal injury or pain); 4) details regarding the injury (eg, chronicity, mechanism and early symptoms); 5) medical management strategies used since the injury and reflection on factors/activities that seem to result in worsening or improvement of symptoms; 6) physical function goals, priorities, and perceived limitations; and 7) mental health screen for referral needs. No tools have been specifically designed to help determine the appropriateness of physical therapy evaluation and treatment after a concussive event.

Gaps in Knowledge

There may be benefit in the development of a symptom checklist and/or screening tool specific to help determine appropriateness for physical therapy examination.

Recommendations

A

Physical therapists *should* perform a screen for mental health, cognitive impairments, and coinciding diagnoses for patients who have experienced a concussive event (See Figure 1, Sidebar 3).

F

If the patient is not deemed appropriate for a comprehensive physical therapy examination (i.e., severe mental health concerns or health conditions that require medical clearance for comprehensive physical examination), education regarding concussion symptoms, prognosis, and self-management strategies should be provided and the patient should be referred for consultation with other health care providers as indicated.

EXAMINATION

Systems to be Examined

II

Evidence and recommendations from a high-quality CPG (ONF)[3] and a moderate quality systematic review[9] consistently emphasize the importance of multi-system physical examination to help discern specific impairments that may need to be monitored or targeted with rehabilitation strategies. Systems to be evaluated included: neurological (including specific screens for impairments with vision, auditory, sensory processing, cognition, motor control and coordination), musculoskeletal, and vestibular systems.

IV

Four recent expert consensus statements provide robust evaluation of potential physical examination techniques and domains with varying strengths of recommendation based on clinical expertise.[2,43,63,64] Recommendations for examination approaches most relevant to this CPG included assessments for musculoskeletal function (especially in the cervical spine), vestibular and oculomotor function, exertional tolerance, gait, balance, and dual/multi-tasking.

Evidence Synthesis

There is strong evidence to support that there is high potential for concussive events to result in multiple system impairments that both affect and are affected by movement. There are no well-validated or clear gold standard, evidence-based approaches or tools to specifically guide how the multiple systems should be evaluated. Recent expert consensus studies provide insight into what may be considered best practice strategies at this time.[63,64] However, it should be acknowledged these recommendations were meant for more global management of concussion and not specific to physical therapy management of concussion. Recent evidence offers some potential screening tools that include screens for movement-related impairments (eg, Buffalo Concussion Physical Examination[141,142]). There is also insufficient evidence to support the validity, reliability, or utility of these screening tools for physical therapy purposes. Therefore, while there is moderate to strong evidence to suggest that it is important to assess for the domains identified, the recommendations in this CPG are intentionally vague with regard to specific assessments that should be used. As previously mentioned in the Clinical Course Section, the GDG identified 4 overarching system domains that align with movement-related impairments that align with physical therapists' scope of practice: 1) cervical musculoskeletal impairments, 2) vestibulo-oculomotor impairments, 3) autonomic dysfunction/exertional tolerance impairments, and 4) motor function impairments. Identifying when impairments

in each of these domains are present may be useful to help develop targeted treatment plans that are personalized to the needs of each patient.

Gaps in Knowledge
Future research to develop, test, and optimize a specific battery of physical therapy examination strategies most appropriate for individuals who have suffered a concussive event would be valuable.

Recommendation
B
For patients identified as safe and appropriate for a comprehensive examination, physical therapists *should* determine and document a need for physical therapy to facilitate recovery from a concussive event based on findings from a comprehensive multi-system physical therapy examination and evaluation. Examination procedures should include examination for impairments in the following domains: cervical musculoskeletal function, vestibulo-oculomotor function, autonomic dysfunction/exertional tolerance, and motor function through foundational standard of care screening strategies (See Figure 2).

Sequencing of Examination Based on Levels of Irritability
Evidence Synthesis
The systematic search did not return any evidence to constitute specific sequencing for physical therapy examination and evaluation for patients who have experienced a concussive event. However, screening and examination for movement-related impairments often require procedures that are intended to provoke symptoms to determine if an impairment is present. The consensus of the GDG was that symptom emergence and exacerbation is expected as a natural part of physical therapy examination processes and because of the multi-system effects, it is possible that examination procedures for one system may flare up symptoms to a level that may make it difficult to proceed or could compromise the validity of additional tests for other systems.

Gaps in Knowledge
Figure 2 provides a triage system (process to help determine priorities) to guide sequencing of the examination that is based solely on the GDG's consensus of expert opinion with a focus on using anticipated levels of irritability to strategically sequence exam procedures. Recommended irritability considerations with regard to symptom reports and examination procedures include: 1) frequency of symptom provocation, 2) vigor of movement required to reproduce symptom(s), 3) severity of symptoms once provoked, 4) how easily symptoms are provoked, 5) what factors ease the symptoms, and 6) how much, how quickly, and how easily the symptoms resolve (See Figure 2, Sidebar 2). Future research is needed to test the utility and value of this triage strategy.

Recommendations
F
Prior to initiating a comprehensive physical examination for patients who have experienced a concussive event, physical therapists *should* first determine probable levels

of irritability for movement-related symptoms and impairments and plan to strategically sequence and/or delay examination procedures based on patients' symptom types and probable level of irritability. Physical therapists are encouraged to first triage for neck pain and then for reports of dizziness and/or headache (See Figure 2).

F
For patients who have experienced a concussive event and have high neck pain irritability but exhibit no signs of serious neck or systemic pathology, physical therapists *should* first examine the cervical and thoracic spine for sources of musculoskeletal dysfunction and address appropriately to promote symptom relief (eg, stretching, soft tissue mobilization, modalities) and support tolerability and accuracy of examination of other body systems (See Recommendation 2.4).

F
For patients who have experienced a concussive event and report dizziness and/or headache, physical therapists *should* thoroughly examine for sources of cervical and thoracic spine dysfunction, vestibular and oculomotor dysfunction, and orthostatic hypotension/autonomic dysfunction that may contribute to the emergence or exacerbation of these symptoms (See Figure 2 and Recommendations 2.4-2.8). The recommended sequence of these assessments is to start with the tests that are anticipated to be the least irritable and proceed with the tests anticipated to be the most irritable based on patient tolerance.

F
After triaging for neck pain, dizziness, and headache, physical therapists *should* proceed with multi-system comprehensive examination of any untested domains of cervical musculoskeletal function, vestibulo-oculomotor function, autonomic dysfunction/exertional tolerance, and motor function using and sequencing tests and measures based on clinical judgement as indicated (See Figure 2).

Cervical Musculoskeletal Impairments
III
A systematic review of lower level studies and an additional cohort study indicate cervical spine dysfunction may be present postconcussion including poorer performance in cervical flexor endurance, cervical flexor strength, anterolateral neck strength, and joint position error tests.[69,72]

IV
Multiple consensus documents and lower level studies emphasize that cervical musculoskeletal dysfunction is complex and may contribute to variable types of symptoms.[55,74,88,93,143,144] However, when possible, evidence and consensus statements encourage attempts to differentiate between the sources that may be causing the symptoms.[74,88,143] The report of neck pain with concussion and the potential for cervical spine musculoskeletal dysfunction in high, however the potential for dizziness to be caused by cervical dysfunction postconcussion is less clear.[143] Low level evidence indicates that

examination of both the cervical musculoskeletal function and vestibulo-oculomotor function may be able to help clinicians differentiate between dizziness caused by cervical spine dysfunction and dizziness caused by other sources.[143]

IV

Several level IV studies, including one Delphi study provide examples of cervical musculoskeletal assessments that may be useful to help identify impairments that may contribute to neck dysfunction and cervicogenic dizziness.[71,99,143] Proposed examination techniques included: active range of motion of the neck, the presence of pain during active range of motion, manual passive joint mobility assessment, active trigger point assessment and tenderness to palpation, Cranial Cervical Flexion Test, Cervical Flexion-Rotation Test, Smooth Pursuit Neck Torsion Test, Head-Neck Differentiation Test, vibration tests, and motor control assessment of deep cervical flexors and extensors. Results of a Delphi study indicated consensus of clinical utility for the following tests with regard to identifying potential cervicogenic dizziness in patients with sports-related concussion: Dix-Hallpike Test, Orthostatic Hypotension Testing, Spontaneous Nystagmus, head impulse test, roll test, gaze-hold nystagmus, saccade testing, vestibulo-ocular reflex cancellation, head shake Test, and Smooth pursuit testing.[143] There was no clear consensus on the clinical utility of static and dynamic balance tests, converegence assessment, dynamic visual acuity test, reproduction of dizziness through manual passive joint mobility, joint position error test, neck pain and relatetd dizziness, reproduction of dizziness through palpation of cervical musculature. A consensus denoting weak clinical utility for Cervical Flexion-Rotation Test, Smooth Pursuit Neck Torsion Test, vibration tests, Head-Neck Differentiation Test, and motor control assessments of deep cervical flexors and extensors.

V

A number of expert opinion, narrative reviews, and theoretical/conceptual papers have provided rationale and theoretical support for the potential role and relatively high prevalence of cervical musculoskeletal impairments that may coincide with symptom reports of dizziness and headache with proposed assessment strategies.[53,69,93,145]

<u>Evidence Synthesis</u>

There is limited evidence on examination procedures for cervical musculoskeletal dysfunction derived from patients who have experienced a concussive event. The evidence that is available is mostly lower level sources of evidence. The GDG consensus was that examination to detect impairments is useful for patients who have experienced a concussive event includes examination of: passive and active range of motion of the neck, muscle strength and endurance for cervical and scapulothoracic muscles, tenderness to palpation of cervical and scapulothoracic muscles, passive cervical and thoracic spine joint mobility, and joint position error. When dizziness is reported, the cervical spine should be examined to determine the potential for musculoskeletal dysfunction as a source of the dizziness. The GDG also agreed that the most recent Academy of Orthopaedic Physical Therapy Neck Pain CPG[75] can be used as a resource for guiding physical therapist examination procedures.

<u>Gaps in Knowledge</u>

Future research is needed to test the direct utility and implementability of the Neck Pain CPG for patients who have experienced a potential concussive event. Although the scope of the systematic search process did not specifically cover the role of neck strength in mitigating subsequent concussion risk, numerous studies and expert opinion reports have hypothesized and demonstrated a potential link between concussion risk and neck strength and control.[55] Given the theoretical and hypothesized linkages between concussion risk, the potential dangers of subsequent concussions, and the expertise of physical therapists to address cervical spine dysfunction, the benefit of identifying potential cervical spine musculoskeletal impairments outweighs the potential costs and burden of examining for the spine, even among those patients who do not report neck pain, headache, or dizziness. Future research to evaluate the value of examining neck strength and control among individuals in physical therapy when headache, neck pain, and dizziness are not reported would be beneficial.

Recommendations

C

Physical therapists *should* examine the cervical and thoracic spine for potential sources of musculoskeletal dysfunction for patients who have experienced a concussive event with reports of any of the following symptoms: neck pain, headache, dizziness, fatigue, balance problems, or difficulty with focusing on a target. Recommended cervical musculoskeletal examination strategies include: range of motion, muscle strength and endurance, tenderness to palpation of cervical and scapulothoracic muscles, passive cervical and thoracic spine joint mobility, and joint position error testing.

F

Physical therapists *may* examine the cervical spine for potential sources of musculoskeletal dysfunction for patients who do not report the symptoms listed to determine if sub-clinical impairments are present.

Vestibulo-oculomotor Impairments

I

One CPG specific to concussion and CPGs not directly addressing individuals who have experienced a concussive event indicate benign paroxysmal positional vertigo (BPPV) may be present and support the use of the Dix-Hallpike Test/positional tests to assess for BPPV.[3,146]

II

Evidence from a CPG specific to concussion provides strong support for examination to detect vestibular and oculomotor dysfunction that may contribute to postconcussive symptoms.[3] A moderate quality systematic review reported the following as examination techniques that have been used in research to detect postconcussive oculomotor impairments: saccadic eye movement, smooth pursuit, vergence, and accommodation.[147]

II

A prospective cohort study comparing pre-injury baseline data and post-injury scores for 63 athletes indicates that both total and change scores on the Vestibular/Ocular Motor Screening (VOMS) may help identify vestibular and oculomotor impairments in athletes who have experienced a concussive event.[148]

II
A cross-sectional study comparing 64 athletes with concussion and 78 healthy controls provided preliminary support for adequate internal consistency, sensitivity, and utility of the VOMS assessment.[149]

III
Evidence from CPGs and SRs using level III studies and additional level III studies further support the use of vestibular and oculomotor evaluations to identify potential sources of postconcussive symptoms.[4,7,9,85-87,150-153]

IV
A retrospective chart review of 167 youth patient records indicated that poorer scores on the VOMS in any of the domains except for near point convergence may be predictive of delayed recovery after sports-related concussion.[154]

IV
Expert consensus from 2 Delphi studies and preliminary evidence from other studies indicate that the following tests may have clinical utility for helping to investigate various sources for dizziness, including dizziness of vestibular or oculomotor origin, after a concussive event: ocular alignment, Dix-Hallpike Test, orthostatic hypotension testing, spontaneous nystagmus, head impulse test, roll test, gaze-hold nystagmus, saccade testing, vestibulo-ocular reflex testing, vestibulo-ocular cancellation testing, head shake test, smooth pursuit testing, motion sensitivity, optokinetic stimulation, and dynamic visual acuity.[99,143,155-158]

IV
A retrospective chart review indicated that pediatric patients who showed signs of vestibular abnormality on initial clinical examination at a sports medicine clinic, took a significantly longer time to return to school or be fully cleared for return to sport.[51]

IV
Multiple descriptive cohort studies indicate that dizziness, which is often tied to vestibulo-oculomotor dysfunction, is likely multifactorial and that it may be difficult to differentiate the specific impairments leading to the reports of dizziness.[85,88,93,99,143]

V
A number of expert opinion, narrative reviews, and theoretical/conceptual papers have provided rationale and theoretical support for the potential role and relatively high prevalence of vestibular and oculomotor impairments that may coincide with symptom reports of dizziness and headache and proposed assessment strategies.[53,69,93,145,159-161]

Evidence Synthesis

Although evidence is available regarding evaluation for vestibular and oculomotor dysfunction, there is limited evidence specifically derived from patients who have experienced a concussive event. Various strategies to assess for impairments in vestibular and oculomotor dysfunction have been proposed. The VOMS is a vestibular and oculomotor functional screening tool that is commonly cited in the literature and was developed and has been tested for use specifically for patients with concussion. Preliminary study of the VOMS supports its use for diagnosing a sport-related concussions and predicting prolonged recovery. The VOMS captures self-reported symptom provocation with assessment of 5 areas: smooth pursuit, horizontal and vertical saccades, convergence, horizontal and vertical vestibular-oculomotor reflex, and visual motion sensitivity. The VOMS has demonstrated strong internal consistency and significant correlation with the Post-Concussion Symptom Scale and has potential to help differentiate between individuals with concussion and healthy control comparators. However, the tool was not designed as a comprehensive tool for vestibular and oculomotor function and may not encompass all of the screening strategies necessary to examine all aspects of vestibular and oculomotor dysfunction. Therefore, it may be useful as a screening tool, but is not appropriate as a replacement for a comprehensive vestibular and oculomotor assessment.

The GDG determined that the following examination strategies may be useful for patients who have experienced a concussion: ocular alignment, head impulse testing, smooth pursuit, saccades, vergence and accommodation, gaze stability, dynamic visual acuity, and visual motion sensitivity. If symptoms, indicate, the use of positional tests (eg, Dix-Hallpike Test) may help to identify Benign Paroxysmal Positional Vertigo (BPPV). Additionally, the CPGs for Vestibular Hypofunction[162] and BPPV[146] and their associated implementation tools may be useful to help guide examination and evaluation procedures.

Gaps in Knowledge

Various strategies to examine vestibular and oculomotor function have been proposed. At this time, there is limited evidence to support one strategy over others for examining patients who have experienced a concussive event. More research is needed to determine the utility and implementability of the CPGs for Vestibular Hypofunction and BPPV and other oculomotor-vestibular assessment protocols for use with individuals who have experienced a concussive event.

Recommendations

B

Physical therapists ***should*** examine vestibular and oculomotor function for patients who have experienced a concussive event with reports of any of the following symptoms: headache, dizziness, nausea, fatigue, balance problems, visual motion sensitivity, blurred vision, or difficulty with focusing on stable or moving targets.

C

Physical therapists ***should*** examine vestibular and oculomotor function related to the following: ocular alignment, smooth pursuit, saccades, vergence and accommodation, gaze

stability, dynamic visual acuity, visual motion sensitivity, lightheadedness caused by orthostatic hypotension, and vertigo caused by BPPV.

A
If BPPV is suspected, physical therapists should assess the patient using a Dix-Hallpike Test.

F
Physical therapists *may* examine patients who have experienced a concussive event for vestibulo-oculomotor function even if vestibulo-oculomotor symptoms are not reported to identify potential sub-clinical impairments.

Exertional Tolerance
I
A high quality systematic review appraised the evidence on strategies for evaluating responses to physical exertion after mild traumatic brain injury/concussion for clinical and research purposes.[163] Findings indicate testing may identify impairments that would not otherwise be detected based on symptom reports or physiologic measures taken with the patient at rest. Additionally, patient responses to exertional tests may result in a slight, short-term exacerbation of symptoms.

I
Evidence from a randomized controlled trial indicate that systematic evaluation of exercise tolerance testing for adolescents within 1 week of sports-related concussion did not affect recovery and degree of early exercise intolerance may be strongly associated with prolonged recovery time.[164]

II
Evidence from 2 scoping reviews of the literature for postconcussion assessment strategies indicate that graded exercise tests are becoming more prominent in research and clinical practice, and they may provide valuable insight into concussion recovery trajectories and potential impairments.[9,165]

II
Two high-quality studies indicate that treadmill and stationary bicycling graded exercise testing could be useful tools for capturing impairment after concussion and monitoring recovery.[52,166]

III
A mildly blunted heart rate response, altered heart rate variability, and higher ratings of perceived exertion have been shown to be captured among individuals who have experienced a concussive event during graded exercise testing, suggesting potential autonomic dysfunction.[13,89,98,166] Findings indicated exertional testing may identify impairments that would not otherwise be detected based on symptom reports or

physiologic measures taken with the patient at rest[89,98] and that results may be predictive of recovery trajectory.[166,167]

IV
A variety of case series and other lower level study designs indicate that graded exertional tests are safe, tolerable, and can be clinically valuable for assessing individuals who have experienced a concussive event.[39,168,169] Additionally, graded exertional tests have become an recognized as an option for assessment via expert consensus documents and workgroups.[2,64]

V
The use of graded exertional tests is further supported by numerous theoretical papers, clinical commentaries, and narrative review papers describing the potential value of postconcussive exertional tests.[16,46,53,54,91,92,94,159,170,171]

Evidence Synthesis
Collectively, the evidence suggests that evaluating symptoms and physiological metrics at rest (eg, heart rate, respiration rate, blood pressure) are not sufficient to effectively detect lingering postconcussion exertional intolerance. There is strong evidence that indicates that: 1) exertional assessments using symptom thresholds as a guide can provide important insights into recovery and 2) exertional tolerance tests are a key assessment strategy for individuals with concussion with persistent symptoms and who desire to return to high exertion activities (eg, sports, active military duty). Common outcome measures used with exertional tests include: self-reported symptom exacerbation, heart rate, and blood pressure. Potential risks and harms related to exertional intolerance examination include: 1) the patient may experience an exacerbation of concussion-related symptoms, 2) patients may vary in their comfort level and preferences for exercise in general or certain exercise modalities,[163,172,173] 3) a general lack of fitness may limit utility of an exertional assessment for identifying specific injury-related impairment, and 4) some patients with cardiovascular, orthopaedic, or vestibular conditions or impairments may not tolerate certain types of exertional modalities or protocols. Emerging evidence suggests that exertional tests are safe and may be beneficial for athletes to help make return-to-play decisions and may be administered within the first week of injury. Additionally, given the growing body of evidence supporting aerobic exercise training for promoting brain healing and health, the GDG group consensus was that exertional tests may be useful for providing a initial post-concussion measures and setting target exertion levels for promoting brain healing and health, regardless if exertional intolerance is suspected.

Gaps in Knowledge
Additional studies are needed to help clarify optimal testing modes, protocols, and interpretation for exertional tests with individuals who have experienced a concussive event.

Recommendations
B

Physical therapists *should* test for orthostatic hypotension/autonomic dysfunction and conduct a symptom-guided graded exertional tolerance test for patients who have experienced a concussive event, report exertional intolerance, dizziness, headache, and/or desire to return to high-level exertional activities (i.e., sports, active military duty, jobs that entail manual labor). Prior to testing, safety and appropriateness of exertional testing in general, testing modality, and testing protocol should be considered. Testing modality (eg, treadmill versus stationary bicycle) and protocol selection should be based on clinical judgement, patient comfort, and the availability of necessary equipment.

C
If vestibulo-oculomotor or cervical spine impairments or symptoms are present, physical therapists *should* use a stationary bicycle for testing to reduce risk for exacerbating impairments or compromising the validity of the test results.

B
Physical therapists *may* use assessments for orthostatic hypotension/autonomic dysfunction and symptom-guided graded exertional tolerance tests for patients who do not report exertional intolerance to help determine the role autonomic dysfunction, deconditioning, or general fitness may play in symptoms (eg, headache, fatigue, fogginess).

F
Physical therapists *may* conduct exertional tests for patients who have experienced a concussive event and do not directly report symptoms indicative of exertional intolerance in order to establish a initial postconcussion performance level and identify exertional targets for aerobic exercise training to promote brain health and healing.

Motor Function Impairments
I
A high-quality cohort study demonstrated that concussion may affect body posture control impairments during gait as far post-injury as 2 months and that a dual-task assessment may help capture these deficits.[174]

II
A moderate quality systematic review provided foundational evidence that response times are greater, gait strategies are less efficient, and postural control deficits are greater among individuals who have experienced a concussion under divided attention tasks.[175]

III
Multiple case-control studies and systematic reviews of moderate quality evidence found potential motor function impairments that may be present after a concussive event, including impairments in static and dynamic balance, dual-task/multi-tasking gait tasks, and motor coordination with complex movement tasks, which may or may not correlate with symptom reports.[72,84,100,108,109,131,175-189]

III

Studies indicate that the measurement properties for evaluation of motor tasks are uncertain with numerous potential limitations related to the reliability, validity, utility, interpretability of the various measures currently in the literature, especially with regard to age and complexity of task used for assessments.[175,176,190-194] Several studies indicate that examination techniques most sensitive for detecting concussion-related motor function impairments may necessitate special equipment (e.g., force plates or accelerometers) and/or advanced analyses (e.g., entropy analyses or complexity metric analyses), thus limiting clinical implementability and practicality at this time.[152,194-197]

IV
Additional case series and case-control studies indicate that age/developmental factors and the presence of headache versus no headache may influence motor function assessment scores for individuals with concussion.[198-200]

IV
Multiple case series and retrospective analyses indicate that subtle, sub-clinical motor function impairments (e.g., postural control/sway metrics or sensory integration ability) may persist beyond the presence of easily observable and detectable impairments (e.g., balance tests).[105,182,196,201,202]

IV
Multiple evidence-based expert consensus documents based on lower level study designs encourage the use of motor function assessments for motor function abilities such as dual-task/multi-tasking, balance, and motor coordination for individuals who have experienced a concussive event.[2,4,43,64,184,203-205]

<u>Evidence Synthesis</u>
A variety of tools and assessment strategies for motor function impairments related to concussion are available, some of which are touted and cited more often than others. However, most of these have been designed for sideline and clinical evaluation for symptoms and impairments that may indicate a concussion is probable. Many studies pertaining to this topic did not meet the relevancy or inclusion/exclusion criteria set forth by the GDG. Consequently, at this time, there is insufficient evidence to support a clear set of motor function measures for individuals who have experienced a concussive event. There are inherent challenges in determining how useful, valid, and reliable a given test is when used by a physical therapist to inform plan of care, monitor progress, and determine episode of care endpoints for discharge from physical therapy. These challenges are compounded by an ever-growing body of new technologies or approaches that infiltrate the literature but have only been tested in laboratory conditions and/or with healthy participants. In fact, the Food and Drug Administration recently released a Safety Communication in April of 2019 warning that products marketed for the assessment, diagnosis, or management of head injuries often lack validity and are not appropriately validated or vetted for accuracy and safety.[206] Current research suggests that more advanced and sophisticated assessment and analyses techniques (eg, complexity analyses of postural sway, accelerometer or other technologically-advanced instrumentation) may improve capacity to detect subtle motor function impairments in the future.

Gaps in Knowledge

Due to insufficient evidence to inform selection of motor function assessments specific for physical therapy needs and purposes for individuals who have suffered a concussive event, GDG consensus for motor function assessments is to use standard of care practices for testing these hypothesized motor function impairments. More research is needed to identify specific tests and measures that would inform clinical decision-making and physical therapy intervention selection for individuals who have experienced a concussive event.

Recommendation

B

Physical therapists *should* examine patients who have experienced a concussive event for motor function impairments including: static balance, dynamic balance, motor coordination and control, and dual/multi-tasking. Selection and timing of motor performance assessments should be based on clinical judgement about which evaluation strategies are most appropriate for the patient's age and ability and will provide the most insight into current functional levels relative to goal levels.

Classification of Examination Findings into Impairment Profiles

III

Recommendations from two high-quality CPGs (ONF and VA/DoD) note that patients who have experienced a concussion report headache, the severity of headache related disability should be assessed and aligned with a headache phenotype based on the International Classification of Headache Disorders.[3,7]

IV

A cross-sectional study of athletes between the ages of 10-23 years with a diagnosis of concussion found that many of the patients with a complaint of dizziness post-concussion demonstrated deficits in a variety of tests that indicate that dizziness was not attributable to one main type of dysfunction but rather multifactorial in nature.[99]

IV

An expert consensus study indicate that there is a strong agreement among participating experts that "matching targeted and active treatments to clinical profiles may improve recovery trajectories after concussion" and that "There is growing empirical support for the heterogeneity of this injury and clinical profiles, but additional research in these areas is warranted.[8]

IV

A case series demonstrated that symptoms alone do not clear differentiate patients into sub-groups.[93]

V

Several conceptual schemas promote the idea that although patients who experience concussions have variable clinical presentations and recovery trajectories, it may be possible to identify specific clinical profiles of diagnoses associated with concussion that can be targeted with specific rehabilitation techniques.[53,54,73,207]

Evidence Synthesis

Historically, individuals who experienced a concussion were conceptualized as a homogeneous patient population with similar responses to the trauma and relatively parallel recovery experiences and trajectories. The current proposed schemas vary in the specific profile groups they suggest and the methods for determining which profile or profiles a patient fits best. However, current classification models have also not been thoroughly validated and tested. Additionally, there is growing expert consensus denoting that patients may not directly fit any one classification but rather exhibit more of a profile that may entail patterns consistent with multiple classifications.

Gaps in Knowledge

Although clinically important and conceptually compelling, current classification models have not been thoroughly validated and tested. At this time, there is insufficient evidence to guide the endorsement of one classification system over others. The GDG consensus was to encourage physical therapists to identify all potential impairments that could be addressed with physical therapy interventions as well as their levels of irritability to formulate an impairment profile that is individualized to each patient. Future research is needed to identify an optimal classification or profiling system for patients who have experienced a concussive event and are experiencing movement-related impairments and symptoms.

Recommendation

E

Physical therapists ***should*** establish and document an impairment profile consisting of one or multiple impairment domains and the levels of irritability for each domain to help determine treatment priorities and strategies for patients who have experienced a concussive event.

B

For patients who have experienced a concussive event and report headache as a symptom, physical therapists ***should*** determine and document the potential headache type in accordance with the International Classification of Headache Disorders.

Psychological and Sociological Factors

Evidence Synthesis

No studies directly related to physical therapy and psychological and sociological implications were identified. However, there was theoretical and foundational epidemiological studies evidence indicating that psychological and sociological resilience (personal qualities and social factors that enable one to thrive in the face of adversity) and psychological and social vulnerabilities (psychological and social factors that may put them at risk for poor recovery) may play important roles in recovery processes.[10,124-127,208] These

theoretical and foundational studies also suggest that psychological and sociological variables may contribute to who recovers naturally and may respond well or not to specific interventions. For example strong coping skills and a good social support system may facilitate recovery, while an absence of these factors may be detrimental for recovery. These studies are further supported by a number of theoretical and conceptual expert opinion documents highlighting the likelihood of psychological and sociological factors as important considerations for prognosis and intervention selection.[10,128] Specific assessments and evaluative decisions based on these factors have not been thoroughly tested. These studies are further supported by a number of theoretical and conceptual expert opinion documents highlighting the likelihood of psychological and sociological factors as important considerations for prognosis and intervention selection.[10,128]

Gaps in Knowledge. More research is needed to help develop specific evaluation measures for identifying potential psychological and sociological factors that may influence optimal physical therapy intervention and dosing selection.

Recommendation

E

Physical therapists *should* elicit, document, and evaluate factors related to self-management abilities and potential psychological and sociological factors that may significantly influence recovery processes and outcomes for physical therapy interventions.

Outcome Measure Selection

II

Evidence from high-quality CPGs informed by moderate level evidence indicate that postconcussion symptom assessments/checklists should be used to monitor recovery, with perhaps more comprehensive outcome measures to specifically evaluate certain symptoms (eg dizziness, headache, fatigue, and neck pain).[3,4,6,7]

III

Evidence from a moderate quality cohort study indicates that the Dizziness Handicap Index (DHI) and Dynamic Visual Acuity Testing (DVAT) may be useful as outcome measures for individuals who have experienced a concussion and exhibited vestibular impairments.[209]

III

A moderate quality diagnostic study provided preliminary reliability, validity, and responsiveness of the High-Level Mobility Assessment Tool (HiMAT) for individuals who have experienced a concussive event and were reporting balance problems 3 months post-injury.[210]

IV

Two recent expert consensus documents provide recommendations for a variety of outcome measures that may be useful for monitoring postconcussion recovery.[63,64]

Evidence Synthesis

Typically, outcome measures include assessments of the patient's symptoms, impairments, activity limitations, and participation restrictions. These measures are important for helping to identify initial states, determine treatment priorities, and monitor changes in status and progress. Systematic and repeated outcome assessments provide a mechanism to evaluate the end results of care at the patient and population levels. Many outcome measures have been proposed for use with patients who have experienced a concussive event. However, the utility and appropriateness of these measures for physical therapy purposes are unclear. The GDG found insufficient quality and uncertain relevancy of comparative studies for use for physical therapy purposes for many studies related to postconcussion outcome measure assessment. Moderate level evidence was available to support the ongoing use of symptom checklists or scales, however, there was no consensus on the most appropriate symptom assessment method for outcome tracking purposes. There was weak evidence to support the use of the HiMAT. However, there is a large ceiling effect, and it may not be useful for detecting outcomes related to more subtle movement-related impairments. Expert consensus recommendations have proposed a variety of data elements that would be worth collecting, but the clinical utility and implementability for physical therapy purposes have not been tested. There was also weak evidence to support the DHI and DVAT, however, additional research is needed to evaluate the validity and reliability of these measures for patients diagnosed with concussion.

The GDG did not find sufficient evidence to endorse any specific outcome measures for use with patients with concussions. CPGs for the Academy of Neurologic Physical Therapy's Core Set of Outcome Measures for Adults with Neurologic Conditions,[211] measures recommended for Neck Pain[75] and Peripheral Vestibular Hypofunction[162] may be useful for some patients. However, the utility and implementability for patients who have experienced a concussive event also remain untested. The GDG consensus at this time is that selection of specific outcome measures to use should be based on clinician judgement of best fit for patient functional status, age, goals, needs, and prognosis.

Gaps in Knowledge. Future studies are strongly encouraged to develop, test, and optimize a battery of outcome measures that may include self-report, observation/performance based, and the use of clinically useful technology for patients who have experienced a concussive event. Decision tools for selection of appropriate outcome measures given various impairment profiles may also be investigated.

Recommendation
F
Physical therapists *should* determine and document a plan for follow-up testing and outcome measurement for patients who have experienced a concussive event for any impairment domains that will be targeted with physical therapy interventions and/or were previously untested due to poor tolerance.

INTERVENTIONS

Communication and Education

I
Evidence from high-quality CPGs (ONF and CDC) and evidence from a high-quality systematic review highlights the importance of educating and providing assurance to patients who have experienced a concussion that most people recover well and typically do not have significant difficulties that last more than 1-3 months post-injury.[3,4,6]

III
High-quality CPGs based on moderate level evidence and other studies indicate that after an initial period of rest for the first 24-48 hours, patients with concussion should be encouraged to avoid activities that have a high risk for another concussion but gradually resume normal activity based on their tolerance.[2-4,6,12]

IV
Consensus-based recommendations from a panel of experts indicate that patients with concussion can benefit from education on lifestyle and self-management of symptoms to decrease the impact of symptoms on quality of life and to facilitate recovery.[43]

Evidence Synthesis
Several guidance documents stressed the importance of how the diagnosis of concussion is communicated to patients and their families. The rationale for clear communication and education around concussion diagnosis and prognosis is to establish an expectation for recovery and avoid unintentional reinforcement of insecurities, fears, or a trajectory of catastrophizing about the injury. Published guidelines for concussion management also consistently emphasize the importance of patient education regarding the risks for subsequent injury, management strategies, and return-to-activity progressions.

Recommendations
B
Physical therapists *should* educate patients who have experienced a concussive event about self-management of symptoms, the importance of relative rest (rest as needed) instead of strict rest, the benefits of progressive re-engagement in activities, safe return-to-activity pacing strategies, and potential signs and symptoms for the need for follow-up care.

A
Physical therapists *should* educate patients who have experienced a concussive event and their families/caregiveres about the various symptoms, impairments, and functional limitations that are associated with concussion and that most patients with concussion recover relatively quickly. Providing this information can help avoid inadvertent reinforcement of a poor recovery expectations.

Interventions for Movement-Related Impairments

II
Two systematic reviews synthesizing results from moderate level study designs indicate that personalized physical therapy interventions targeting movement-related impairments (e.g., therapeutic exercises for cervical spine impairments, vestibulo-

oculomotor impairments, and aerobic exercise training) are safe and result in clinical improvement (i.e., reduced symptoms, improved ability to return to pre-injury activities) after an initial period of relative rest, and potentially biological and physiological improvement.[12,58]

II
Recommendations from high-quality CPGs based on moderate level evidence indicates that in addition to movement-related impairments, patients may also experience a range of other persistent postconcussion symptoms and impairments that may require treatment from other healthcare professionals.[3,4,6,7]

IV
Numerous retrospective cohort studies and case series provide further support for the potential for multi-modal physical therapy approaches to safely facilitate recovery after concussion.[32-35,61,212,213] Further, several of these studies indicate that these interventions can be safely introduced within a few days to weeks post-injury, with earlier initiation potentially resulting in better outcomes for patients.[61,212-214]

Evidence Synthesis
The most recent concussion-related consensus statements and guidelines encourage physical therapy evaluation and treatment for individuals who continue to report or demonstrate symptoms, physical impairments, or functional limitations that last 3-4 weeks or more. However, studies published since the evidence was reviewed for those CPGs are prompting a deeper consideration for the initiation of physical therapy interventions as early as the first week of injury. No studies have identified physical therapy related as a factor contributing to safety concerns or poor outcomes. This is not surprising, however, as study designs and clinical practice patterns are often guided by theoretical and clinical judgements that are based on minimizing the potential for adverse events to occur. Collectively, these studies suggest that time since injury should not independently drive decisions about the appropriateness and potential benefit of physical therapy for individuals who have experienced a concussive event. Additionally, patients may experience additional symptoms and impairments that may affect movement-related impairments, may be affected by movement-related activities. Some of these impairments may require specialized treatment that is not within physical therapists' scope of practice including: auditory impairments, vision impairments (including impairments with ocular alignment), cognitive impairments, sleep problems, migraine and other chronic headache symptoms.

Gaps in Knowledge
Despite a growing body of evidence reporting on the safety and primarily positive outcomes for physical therapy interventions targeting postconcussion symptoms, impairments, functional limitations, and participation restrictions, data regarding specific patient and injury characteristics and responsiveness to physical therapy interventions are limited. Given the large volume of patients who recover naturally or with general education about activity-progressions, there are presumably some who may be able to self-manage mild movement-related impairments with education and a home exercise program. We

propose a triaging plan in Figure 3 to help with identification of patient's who may be able to self-manage their symptoms and impairments versus those who would benefit from ongoing skilled physical therapy care. Future research testing the proposed triaging system would be beneficial. Additionally, more research is needed to help develop a system for identifying which patients can optimally benefit from physical therapy interventions to facilitate recovery after experiencing a concussive event.

Recommendations

F

Physical therapists *should* use findings from the examination to triage patients who have experienced a concussive event into 1 of 3 categories: 1) patients with movement-related impairments and dysfunction who are good candidates for independent self-management, 2) patients with movement-related impairments and dysfunction who are not good candidates for independent self-management, or 3) patients with no identified movement-related impairments or dysfunction (See Figure 3 and Figure 3, Sidebar 1). *Time since injury may influence level of irritability, but should not be the sole determinant for how to triage patients into self-management versus physical therapy follow-up pathways. Evidence indicates physical therapy after concussion is safe, regardless of timing, and that earlier initiation of physical therapy interventions may facilitate a faster recovery*.

B

Physical therapists *should* design a personalized intervention plan for patients who have experienced a concussive event that aligns planned interventions with the patient's identified impairments, functional limitations, and levels of irritability.

B

Physical therapists *should* refer patients who have experienced a concussive event for further consultation and follow-up with other health care providers as indicated. Of specific note, high-quality CPGs recommend referral for speciality evaluation and treatment in cases of persistent migraine-type and other chronic headaches, vision impairments (including ocular alignment), auditory impairments, sleep disturbances, mental health symptoms, and cognitive problems.

Cervical Musculoskeletal Interventions

II

Evidence from a randomized control trial and recommendations from CPGs with Level II evidence indicate that physical therapy interventions that address the cervical spine can independently and in combination with other therapies (e.g., vestibular interventions) lead to improvement in symptoms, function, and return-to-activity after concussion.[28,213,215] For the randomized control trial, individuals in the treatment group were 3.91 times more likely to be medically cleared by 8 weeks.[28]

IV

Retrospective chart reviews and case series provide further support for cervical musculoskeletal interventions to experience improvements in symptoms and function for individuals who have experienced a concussive event.[32,33,55,71]

V
A narrative systematic review of studies related to the cervical spine and concussion highlighted several low quality studies and theoretical papers emphasizing the potential for stronger neck muscles and anticipatory cervical muscle activation to reduce risk for future concussions.[69]

Evidence Synthesis
Few studies have been dedicated specifically to the study of physical therapy interventions for cervical musculoskeletal impairments in patients who have suffered a concussive event or been diagnosed with a concussion. The treatment studies identified typically incorporated interventions to address cervical musculoskeletal impairments in combination with other types of interventions (eg, aerobic exercise training and/or oculomotor-vestibular interventions). Regardless of the underlying mechanisms leading to these symptoms, several studies indicate that patients with concussion who exhibit signs of cervical musculoskeletal impairment may respond well to physical therapy interventions for cervical spine dysfunction alone and in combination with other active rehabilitation strategies. Additionally, neck strength and muscle strength imbalances have been shown to be associated with concussion risk. Therefore, even if cervical spine impairments are not present as a result of concussion, it may be valuable for physical therapists to provide cervical spine musculoskeletal interventions with the goal of decreasing a patient's risk for subsequent concussive injuries. Evidence guiding specific postconcussion cervical spine interventions for patients who have experienced a concussive event is limited at this time. The consensus of the GDG is to use best practice standards for selecting and implementing cervical musculoskeletal interventions at this time. The Neck Pain CPG[75] studies guiding general management of cervical spine dysfunction may be useful to inform intervention strategies.

Gaps in Knowledge. Future research is needed to determine, test, and optimize cervical musculoskeletal interventions for individuals who have experienced a concussive event and exhibit cervical musculoskeletal impairments.

Recommendations
B
Physical therapists *should* implement interventions aimed at addressing cervical and thoracic spine dysfunction for strength, range of motion, postural position, and/or sensorimotor function (eg, cervicocephalic kinesthesia, head position control, cervical muscle dysfunction), and manual therapy to the cervical and thoracic spine as indicated when patients with cervical or thoracic musculoskeletal dysfunction.

Vestibulo-oculomotor Interventions
I

High-quality CPGs supported by Level I evidence recommend that if BPPV is identified as a potential source of dizziness, canalith repositioning maneuvers should be used.[3,146]

II
Evidence from a high-quality randomized control trial indicates that rehabilitation strategies targeting vestibulo-oculomotor independently and in combination with other physical therapy interventions may be feasible even within the first 10 days after a concussive injury and can be effective in reducing symptoms, reducing time to recovery, and improving function.[28,213,215] For the randomized control trial, individuals in the treatment group were 3.91 times more likely to be medically cleared by 8 weeks.[28]

IV
Multiple clinician survey studies, case series, and retrospective chart reviews without comparators indicate that vestibular rehabilitation, including canalith repositioning maneuvers for BPPV, are commonly used by physical therapists to treat individuals who have experienced a concussive event[48] and may help reduce dizziness and improve gait and balance dysfunction for patients who have experienced a concussive event.[44,87,173,216]

<u>Evidence Synthesis</u>
Studies suggest that physical therapists commonly integrate vestibular and oculomotor rehabilitation strategies when working with patients who have experienced a concussive event. Vestibulo-oculomotor rehabilitation, when prescribed in isolation or in conjunction with other rehabilitation interventions, is associated with reduced dizziness and improved balance, and faster return to sport times. Based on current evidence, it is expected and desired that vestibulo-oculomotor rehabilitation exercises cause a mild transient increase in symptoms. This transient increase in symptoms is desirable to habituate the symptoms of concussion. The American Academy of Otolaryngology, Head and Neck Surgery recommends patients with posterior and lateral canal BPPV should be treated with canalith repositioning procedures.[146] Although repositioning maneuvers can be effective in treating BPPV, a patient may require additional interventions in the presence of concomitant vestibular hypofunction.[146]

Evidence guiding specific vestibulo-oculomotor intervention protocols for patients who have experienced a concussive event is limited at this time. However, the Amerian Academy of Neurologic Physical Therapy's Vestibular Hypofunction CPG[162] may provide some guidance for treatment strategies. Additionally, the American Academy of Otolaryngology, Head and Neck Surgery's CPG for BPPV may also be a useful resource for physical therapists.[146]

<u>Gaps in Knowledge</u>
More research is needed to evaluate the direct implementation of these guidelines with patients who have experienced a concussive event.

Recommendations
B

Physical therapists with appropriate expertise in vestibular and oculomotor rehabilitation *should* implement an individualized vestibular and oculomotor rehabilitation plan for patients who have experienced a concussive event and exhibit vestibular and/or oculomotor dysfunction. Physical therapists who lack appropriate training in vestibular and oculomotor rehabilitation *should* refer patients who exhibit vestibular and/or oculomotor impairments to a clinician with appropriate expertise. If visual vertigo/visual motion sensitivity (dizziness provoked by repetitive or moving visual environments) is identified, an individualized visual-motion habituation program may also be beneficial. Patients with neck pain or other cervical impairments may exhibit worsening of cervical impairments due to repetitive head movement as part of vestibular rehabilitation. Therefore, the implications of head rotation interventions on the possible concomitant cervical impairments should be considered and addressed.

A. If BPPV is identified as a potential impairment, physical therapists *should* use canalith repositioning interventions.

Exertional Tolerance and Aerobic Exercise Interventions

I

A high-quality systematic review that included 5 randomized controlled trial provides strong evidence that monitored, progressive, symptom-guided aerobic exercise training is feasible, safe, and may accelerate symptom resolution and neurologic recovery after a concussive event.[95] The exertion training protocols varied by exercise mode, exertion protocols, and dosage of training. Despite these discrepancies in the studies, the meta-analysis results indicated that exercise resulted in significant decreases in symptom scores as measured by PCSS score (mean difference of -13.06 with confidence interval of -16.57 to -9.55 and p = <.0001), reaction time score among RCTs that used the Immediate Post Concussion and Cognitive Test (mean difference of -0.43 with confidence interval of (-0.90 to –0.06 and p = 0.02), number of days off work (17.7 days versus 32.2 days, p < 0.05), and perent of patients with full function at end of study period (72 versus 17, p = 0.02).

II

A quasi-experimental study provided evidence indicating that aerobic exercise training among males with sport-related concussion initiated within the first few days after injury may reduce total time to recovery compared to relative rest.[217] A second quasi-experimental study provided evidence of improved quality of life and less anger among youth who are slow to recover after concussion and follow and exercise-based active rehabilitation intervention.[218]

IV

Numerous case series and small pilot studies provide further support for the safety, feasibility, and potential benefits of aerobic training among individuals who have experienced a concussive event.[32,33,36,61,169,212] Additionally, a recent retrospective case series with a propensity scoring analysis indicated that earlier time to aerobic exercise training may facilitate faster recovery for athletes and help mitigate delayed prolonged recovery from concussion for athletes and non-athletes.[61]

Evidence Summary

Both alone and coupled with other impairment-specific active rehabilitation interventions, aerobic exercise training has been linked to faster symptom resolution and rate of return to sport, enhanced structural connectivity, and improved brain activation after concussion. Many of the efficacy studies have been performed with patients who were 4-6 weeks post-injury. However, preliminary evidence in the form of case series, and propensity scoring analysis provide some initial support that introducing physical exertion activities earlier after injury may be safe, feasible, and potentially advantageous.

There is limited evidence for the best mode, protocol, progression parameters, dosing, and timing of initiation for aerobic exercise training after concussion. Currently available studies have utilized multiple modes including treadmill training, bicycling, elliptical trainers, and multimodal training (eg, resistance training coupled with cardiovascular training and/or sport-specific training). However, there are no studies directly comparing modes or protocols. Additionally, protocols across studies have varied in terms of progression parameters. Some studies used systematic progressions guided by heart rate or ratings of perceived exertion. Others were time-based with more generic specifications about intensity. A common assertion from experts in consensus statements and commentaries has been that aerobic training interventions should be guided by symptoms, in that significant exacerbation of symptoms beyond a mild degree should result in exercise termination for the session, and an absence of symptom exacerbation can provide support for progressing exercise intensity and duration.[2,12] Symptom exacerbations may occur with aerobic activity, but they should be mild and temporary in nature.[52,56]

Gaps in Knowledge

More research is needed to determine optimal protocols for timing, progressing, and dosing strategies for exertion and aerobic exercise interventions for individuals who have experienced a concussive event.

Recommendations

A

Physical therapists ***should*** implement a symptom-guided, progressive aerobic exercise training program for patients who have experienced a concussive event and exhibit exertional intolerance and/or are planning to return to vigorous physical activity levels. Selection of modality and protocol for training with a specific focus on the patient's goals, comfort level, lifestyle, and access to equipment is encouraged.

E

Physical therapists ***may*** implement progressive aerobic training for all patients who have experienced a concussive event, including those who do not exhibit exertional intolerance and those who do not intend to engage in vigorous physical activity to reduce risk for de-conditioning and promote functional brain healing and health.

Motor Function

IV
Expert consensus from high-quality CPGs based on weak evidence from case series studies and expert opinion consensus documents suggest that interventions that target motor function impairments after concussion may be beneficial.[3,7,8,32,43]

V
An expert opinion article provides guidance for physical therapy interventions for service members with mild traumatic brain injury that includes suggestions for balance and dual-task activities.[219]

Evidence Synthesis
At this time, there is limited evidence investigating the efficacy and effectiveness of interventions to target motor function impairments. Given the volume of evidence indicating the potential for motor function impairments, the GDG consensus was that motor function interventions are likely to beneficial, even if the impairments are sub-clinical and difficult to identify as part of the clinical examination process. Expert consensus and low-level studies indicate that gradual, progressive return to higher level motor function tasks and challenges, including return-to-work and return-to-physical activity/sport could be supported through physical therapy interventions and progressions directly targeting motor function.

Gaps in Knowledge
More research is needed to evaluate the outcomes and value of interventions that target motor function.

Recommendation
C
Physical therapists *should* implement motor function interventions that address identified or suspected motor function impairments and help progress the patient toward higher-level functional performance goals. Motor function interventions that target the following impairments are strongly encouraged: static balance, dynamic balance, motor coordination and control, dual/multi-tasking. Additionally, interventions that directly help improve motor function for work/recreation/activity-specific tasks are strongly encouraged.

Monitoring and Progressing Patients
Evidence Summary
The systematic search did not yield any evidence to specifically inform recommendations for how to make decisions regarding monitoring and progressing physical therapy interventions for patients who have experienced a concussive event. Studies that informed the clinical course section of this CPG indicate that it is important for clinicians to understand that patients' symptoms, impairments, and functional limitations may change and/or become more apparent during an episode of care. Thus continual monitoring and re-evaluation of the patient's response to treatment and emerging clinical presentation is critical for providing an optimal match of interventions throughout a patient's episode of care. It is important to appreciate that the patient may present differently at various points in the recovery process and may experience exacerbations and setbacks as they re-

integrate and introduce new activities into their daily routines. Follow-up with physical therapy and referrals for follow-up with other health care providers should be encouraged as needed or indicated.

Gaps in Knowledge
Studies specifically designed to help inform intervention dosing parameters, monitoring and re-assessment strategies, and criteria for progressions and discharge would be beneficial.

Recommendation
F. Physical therapists *should* regularly monitor symptoms, provide re-assessments of movement-related impairments, and administer selected outcome measures as needed or indicated for patients they are treating for movement-related impairments postconcussion. The following data elements and monitoring frequencies are recommended:

Symptoms
-Age-appropriate symptom scale/checklist at least weekly until discharge

Cervical spine musculoskeletal impairments
-Active neck range of motion and pain with active neck range of motion and other cervical spine measures as determined by physical therapist at initial visit and at least every 2 weeks until discharge
-Cervical flexor and extensor strength and endurance at initial visit and approximately every four weeks until impairments are resolved
-Self-report outcome scales/measures (e.g., Neck Disability Index, Head Disability Index) as indicated at initial and at least every 2 weeks until discharge

Vestibulo-oculomotor impairments
-If BPPV is present, the Dix Hall Pike test should be performed at the initial and at least weekly until BPPV is resolved
-Vestibular and oculomotor tests and measures as indicated at initial visit and at least every 2 weeks until impairments are resolved
-Self-report outcome scales/measures (e.g., Dizziness Handicap Index) as indicated at initial and at least every 2 weeks until discharge

Exertional Test
-Graded exertion test completed during at least one visit for individuals reporting symptoms related to exertional intolerance
-Graded exertion test completed during at least one visit and as needed to determine readiness to return-to-play or work for athletes and/or individuals with high-exertion activity needs

Motor Function
-Age and functional level tests and measures as indicated at initial visit and at least every 2 weeks until impairments are resolved

PHYSICAL THERAPY MANAGEMENT DECISION TREES

Visual decision tree models can provide valuable guidance for how physical therapists plan and make decisions during a patient's episode of care after a concussive event. The proposed decision tree model is depicted in Figures 1-3 and broken down into the following components: 1) Determine Appropriateness of Physical Therapy Concussive Event Examination, 2) Physical Therapy Concussive Event Examination and Evaluation Process, and 3) Development and Implementation of a Physical Therapy Plan of Care for a Concussive Event. Recommendations are broken down into sections that directly align with each component such that a clinician can use the component narrative overviews below, the figures, and the recommendations together to inform their decision-making processes. The ovals in the decision trees indicate start and end points in that component. Rectangular boxes indicate a process or procedure to be implemented. Diamonds indicate a decision point that will lead to one pathway versus another pathway.

Component 1 (Determine Appropriateness of Concussive Event Examination)

A triaging process may help determine if a patient who has experienced a concussive event is appropriate for a more comprehensive examination to identify potential movement-related symptoms and impairments related to that event (See Figure 1). The starting point for Component 1 is a physical therapy encounter with a patient who has experienced a potential concussive event. Physical therapists should screen all patients who have experienced a potential concussive event for the possibility of a concussion, regardless of previous screening for a diagnosis of concussion related to that event. The first step in this component is observation and interview to evaluate for indicators of potential medical emergency and need for referral (Figure 1, Sidebar 1). Next, the physical therapist will determine if diagnostic criteria for a concussion is met (Figure 1, Sidebar 2). This screening may be useful even if the concussive event was not recent, as residual symptoms could be the result of an undiagnosed concussion injury. If the patient's history and presenting criteria are consistent with a diagnosis of concussion, the physical therapist will then decide if the patient is appropriate for a comprehensive physical therapy examination based on a multi-faceted interview (Figure 1, Sidebar 3).

Component 2 (Concussive Event Examination and Evaluation Process)

Differential evaluation of clinical findings from patient interviews and physical examination can help determine the most relevant and key physical impairments associated with the diagnosis of concussion and also identify existing functional limitations. Determining probable movement-related impairments and levels of irritability (Figure 2, Sidebars 1 and 2) may help clinicians plan for test sequencing and modifications to address safety concerns, patient comfort, and/or patient and family goals and preferences. Neck pain is the first priority for sequencing as neck pain irritated by movement limits the feasibility and accuracy of other tests, particularly vestibulo-oculomotor tests. If neck pain is present, pain relief interventions could be provided to potentially support tolerability and accuracy for additional tests. Dizziness and headache are symptoms that require more complex assessments and clinical reasoning to identify potential sources of impairment that may contribute to symptom complaints. When dizziness and/or headache are reported, physical

therapists are encouraged to perform tests that are expected to be the least irritable for the patient first, progressing to the tests anticipated as most irritable per patient tolerance. Sequencing in this way should help increase the likelihood of patient tolerance for testing of all domains. If no specific reports of neck pain, dizziness, or headache are identified, clinical judgement should be used to determine optimal sequencing based on reported levels of irritability and disability, patient needs and preferences, and patient ability to tolerate tests. Therapists are encouraged to develop an impairment profile that specifically reflects the various movement-related impairments identified during the physical examination processes. Identification and consideration of psychological and sociological facilitators and vulnerabilities and potential needs for follow-up testing are also encouraged. As part of the examination process, the physical therapist should determine and document a plan for follow-up testing and outcome measure administration.

Component 3 (Development and Implementation of a Physical Therapy Plan of Care)
Development and implementation of a plan of care should be based on findings from the physical therapy clinical examination in combination with patient and family needs and preferences (See Figure 3). Education regarding the risks and prognosis for patients, self-management, and activity-related recommendations, and potential signs of need for follow-up care are important for patients who have experienced a concussive event. Movement-related impairments may not be identified for patients who have experienced a concussive event. In these cases, education about potential signs and symptoms that may emerge and benefit from physical therapy interventions can be provided with encouragement to follow-up for further physical therapy evaluation and treatment if indicated. Other patients may exhibit movement-related impairments, but also be well-suited to manage their symptoms and treatments at home by following a home exercise program (See Figure 3, Sidebar 2). For patients with movement-related impairments who are not good candidates for self-management, in-person physical therapy sessions are encouraged. Intervention strategies for patients may vary depending on their impairment diagnosis profiles and level of irritability. Dosing parameters (frequency, intensity, timing, and type of intervention) for each impairment domain should be adjusted in accordance with the patient's level of irritability. Additionally, it is important for clinicians to understand that patients' symptoms, impairments, and functional limitations often change and/or become more apparent during an episode of care. Thus continual monitoring and re-evaluation of the patient's response to treatment and emerging clinical presentation is critical for providing optimal matching of interventions throughout a patient's episode of care.

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