Outcome Measures for Persons With Moderate to Severe Traumatic Brain Injury: Recommendations From the American Physical Therapy Association Academy of Neurologic Physical Therapy TBI EDGE Task Force

McCulloch, Karen L. PT, PhD, NCS; de Joya, Anna Lisa PT, DSc, NCS; Hays, Kaitlin PT, DPT; Donnelly, Erin PT, MS, NCS; Johnson, Tammie Keller PT, DPT, MS, ATP, CBIS; Nirider, Coby D. PT, DPT; Roth, Heidi PT, DHS, NCS; Saliga, Sue PT, MS, DHSc; Ward, Irene PT, DPT, NCS

Abstract:

Background and Purpose: The use of standardized outcome measures (OMs) is essential in assessing the effectiveness of physical therapy (PT) interventions. The purposes of this article are (1) to describe the process used by the TBI EDGE task force to assess the psychometrics and clinical utility of OMs used with individuals with moderate to severe traumatic brain injury (TBI); (2) to describe the consensus recommendations for OM use in clinical practice, research, and professional (entry-level) PT education; and (3) to make recommendations for future work.

Methods: An 8-member task force used a modified Delphi process to develop recommendations on the selection of OMs for individuals with TBI. A 4-point rating scale was used to make recommendations based on practice setting and level of ambulation. Recommendations for appropriateness for research use and inclusion in entry-level education were also provided.

Results: The TBI EDGE task force reviewed 88 OMs across the International Classification of Functioning, Disability, and Health (ICF) domains: 15 measured body functions/structure only, 21 measured activity only, 23 measured participation only, and 29 OMs covered more than 1 ICF domain.

Discussion and Conclusions: Recommendations made by the TBI EDGE task force provide clinicians, researchers, and educators with guidance for the selection of OMs. The use of these recommendations may facilitate identification of appropriate OMs in the population with moderate to severe TBI. TBI EDGE task force recommendations can be used by clinicians, researchers, and educators when selecting OMs for their respective needs. Future efforts to update the recommendations are warranted in order to ensure that recommendations remain current and applicable.

Keywords: measurement; human movement system; standardization

Introduction

The use of standardized outcome measures (OMs) in physical therapy (PT) practice is growing and becoming the standard of practice. Evidence of intervention effectiveness depends on, among other things, common use of valid and reliable tests and measures, which reflect clinically important outcomes and are responsive to change. An important initial step toward best practice is the identification and selection of the most appropriate OMs for patients whom therapists treat. However, clinicians may be uncertain in how to select the best OM based on an individual's specific limitations.[1,2] Common barriers to using OMs include the time required to learn or use them, perceptions that OMs are too difficult for patients to understand, and the time burden for clinicians to score and analyze test results.[3] The ability to track patient progress during recovery from a neurologic condition improves with the use of standardized OMs that are employed across settings. In addition, the use of common OMs may facilitate ongoing clinical research.

To address some of these issues, the Academy of Neurologic Physical Therapy of the American Physical Therapy Association (APTA) began a process to develop recommendations for the identification of core sets of OMs in 2009. A Research Section of APTA task force, the Evaluation Database to Guide Effectiveness (EDGE), was developed to make recommendations for OM utilization in PT practice. Building on recommendations from that group, members of the Academy of Neurologic Physical Therapy initiated what was described as an "EDGE group" focusing on the stroke population. This group established a yearlong process for rating and evaluating OMs, which culminated in the StrokEDGE report.[4] The following year, the process was followed by a group focused on OMs for patients with Multiple Sclerosis.[5] In the fall of 2011, the Academy of Neurologic Physical Therapy initiated task forces to evaluate OM use in traumatic brain injury (TBI) and spinal cord injury. Task forces looking at vestibular dysfunction and Parkinson disease measures were conducted the following year.

The choice of appropriate OMs for use with TBI can be a challenge. Traumatic brain injury is a chronic health condition that affects physical, cognitive, and behavioral function, often in heterogenous ways. Outcome measures must accommodate a large range of physical and cognitive strengths and limitations. Clinicians must be aware of the complexity of this diagnosis to determine which OMs are most appropriate.[6] After TBI, individuals are treated in a wide variety of settings, including intensive care units, acute care, in- and outpatient rehabilitation settings, long-term care facilities, and in the home. The environment, available space and equipment, as well as the individual's cognitive and physical limitations, all influence which OMs are feasible and appropriate.

The objectives of the TBI EDGE task force were:

1. to develop recommendations for clinicians, educators, and researchers for the use of standardized OMs to utilize throughout the continuum of care of the TBI population and span the domains of the International Classification of Functioning, Disability, and Health (ICF) and,
2. following the Academy of Neurologic Physical Therapy Board of Directors approval, to disseminate recommendations through available avenues such as the section Web site, conference presentations, and publications.

The work of each EDGE task force had traditionally been completed in a year period, requiring a scope sufficiently focused to be feasible with a limited volunteer workforce. It is the goal of this article to describe the yearlong processes that were used to create recommendations for OM utilization in the TBI patient population in clinical practice, as well as additional recommendations for inclusion into entry-level PT curricula and for use in research.

Methods

Task Force Recruitment

TBI EDGE task force members were invited to participate in November 2011 on the basis of review of applications from an open call for volunteers shared via the Academy of Neurologic Physical Therapy listserv and electronic newsletter. Interested individuals submitted their CVs and letters describing their interest. These applications were reviewed by the 2 co-chairs with the intent of inviting an 8-member task force that represented geographic and clinical practice diversity, incorporating educational and research perspectives. The members of the task force included all of the authors (K.L.M. and A.L.J. served as co-chairs; C.D.N. joined the task force after the initial meeting of the group to assist with secondary reviews in the participation realm.)

Development of Preliminary OM List

Two members (K.L.M. and A.D.) served as co-chairs of the group. Prior to an in-person meeting, the co-chairs reviewed documents that referenced or listed OMs for PT practice pertinent to TBI. These included APTA and Academy of Neurologic Physical Therapy documents (Commission on Accreditation Physical Therapy Education criteria),[7] The Guide to Physical Therapist Practice,[8] Neurologic Entry-level Education Recommendations,[9] and unpublished recommendations for OM use from the Academy of Neurologic Physical Therapy Brain Injury Special Interest Group, as well as resource documents from the Academy of Neurologic Physical Therapy Functional Toolbox Course. Web sites that focused on brain injury–specific resources including the Center for Outcome Measurement in Brain Injury site,[10]Acquired Brain Injury Evidence Based Review site,[11] and other consensus OM recommendations including papers on Common Data Elements were reviewed.[12–15] A master list of OMs for review by the task force was created that spanned the ICF continuum that addressed some aspect of body structure/function, activity, or participation, and could be specific or more global in nature. Measures that would reasonably be used by physical therapists as part of an examination or to track intervention progress were included on the list. On the basis of these varied sources, an initial list of 120 measures was created for the group to consider and discuss at the initial meeting.

Stage I: Defining the Scope and Processes for TBI EDGE

Prior to the APTA Combined Sections Meeting in February 2012, the TBI EDGE group met face to face for a 1-day intensive workshop to learn about the process used by prior EDGE groups, clarify the scope of the TBI review, modify the EDGE rating form to incorporate TBI-related impairments, streamline our list of measures for review, determine a process and timeline for the group's work, and assemble review teams. A partnership with the Rehabilitation Measures Database (RMD) team was planned as a way to disseminate the results of our work. The RMD was developed by a group of researchers at Northwestern University and Rehabilitation Institute of Chicago with the “Improving Measurementof Medical Rehabilitation Outcomes” grant from the Department of Education, NIDRR (National Institute on Disability and Rehabilitation

Research) grant number H133B090024 (PI: Allen Heinemann, PhD). The RMD is a repository for OM information that is housed on the Web site www.rehabmeasures.org. The site offers detailed information on more than 300 OMs used in rehabilitation, including links to instruments and instructions for test administration, psychometric information related to reliability and validity of measures, guidance for interpretation of measures, and an increasing number of recommendations for measure use in PT as a result of multiple EDGE group reviews. Task force members met with RMD project team in preparation to plan for efficient collaboration on this project, with anticipated sharing of TBI EDGE recommendations as part of the RMD Web site.

Consideration of ICF Components

Documents used by StrokEDGE and MSEDGE groups were reviewed by the TBI EDGE task force members and used as a starting point for developing the TBI EDGE addendum. This addendum was used to gather evidence about study of OM use in TBI, if it was available. Consistent with prior EDGE groups, we used the ICF to categorize OMs.[16] The ICF considers the interactions of an individual's health condition with body function/structure (ie, anatomical and physiologic status), activity (ie, task execution), and participation (ie, involvement in life situations), as well as environmental and personal factors.[17] Physical therapists commonly use the ICF to ensure a comprehensive examination.[18] Impairments specific to TBI were added including apathy, behavior, cognition, consciousness, dual-task activity, memory, orientation, and motivation. Activity and participation categories used by prior groups were retained, given the common challenges with mobility and community-level function that are encountered by many with neurologic dysfunction.

Refinement of Scope: Injury Severity

The TBI group refined the scope of our review to make it reasonable for a 1-year timeline, similar to the prior EDGE groups. We were aware of 2 groups addressing practice and OM guidance for mild TBI (Army Office of the Surgeon General requested mTBI toolkit[19] and Ontario Neurotrauma Foundation funded clinical practice guideline [CPG] revision for the treatment of persistent symptoms following mTBI)[20]; therefore, the group decided to focus its efforts on OMs for moderate to severe TBI. We also knew that an EDGE group was planned focusing on vestibular dysfunction, so OMs used to test and diagnose specific vestibular impairments were not included in our review list, even though vestibular function is an important component of a thorough PT examination for someone with TBI. Recommendations for OM were made for various levels of care throughout the continuum and level of function (physical and cognitive). These classifications are described later.

Refinement of Scope: Practice Settings

Individuals with TBI receive care in various treatment settings. The group arrived at a consensus the most common sites of care for PT, recognizing that the severity level of each patient and constraints of each setting varies and would influence the choice of OMs that would be useful. Settings were divided into groups: (1) acute care, (2) inpatient rehabilitation, (3) long-term acute care/skilled nursing facility, (4) home health, and (5) outpatient. The outpatient setting was defined to include a range of settings where post-acute care occurs such as day rehabilitation, community-based programs, as well as traditional outpatient clinics. These settings are similar to those categories used by previous EDGE task force groups. A therapist who is considering possible OM for use in a setting could review recommendations related to that setting, knowing that ratings were derived with the constraints of that environment in mind (eg, measures that require more time and space are not rated highly for an acute environment, or measures that

address participation issues are rated more highly for an outpatient setting, given a greater focus on participation concerns with that population).

Refinement of Scope: Consideration of Ambulatory Status

The group discussed other ways to classify individuals with TBI based on their physical or cognitive levels as an additional qualifier for OM recommendation. Other EDGE groups used diagnosis-specific classification systems (ie, Expanded Disability Status Scale for multiple sclerosis) or made recommendations based on acuity level (acute/subacute/chronic for stroke). Because of the wide range of disability in motor and cognitive function seen at all stages of TBI recovery, the task force felt a rating of physical and cognitive function would be useful; however, there is no standardized method to classify TBI in this way. Given our primary focus on physical function as physical therapists, we modified a method of ambulation classification developed for use in stroke, the Functional Ambulation Classification (FAC) as a guide to describe mobility level after TBI. The FAC is a scale of "0" (*nonfunctional ambulatory*) to "5" (*ambulator, independent*) and has been well validated for use with stroke.[21] We adapted the FAC for our purposes to include only 4 levels, eliminating the nonfunctional category and collapsing 4 and 5 into a single independent category, but taking into account the possibility that with TBI supervision might be required for physical and/or cognitive reasons (Table 1).

Table 1. TBI EDGE Ambulation Categories

Category	Ambulation
I—Independent	Independent ambulation on level and unlevel surfaces without assistive device
II—Mild dependence	Modified independent (requires assistive device) or requires supervisiona on level surfaces only and requires supervision for unlevel surfaces
III—Moderate dependence	Requires intermittent or continuous manual assistance of 1 person on level and unlevel surfaces
IV—Severe dependence	Unable to ambulate or requires more than 1 person to assist with ambulation

[a]Supervision may be required for physical or cognitive reasons.

Anticipated differences in OM needs based on patient mobility level necessitated this inclusion of ambulatory status as a rating criterion. For instance, measures that require running may have a floor effect for patients who are at a low level of physical function; likewise, some balance measures demonstrate a ceiling effect for patients who are focused on preinjury recreational activities.

Refinement of Scope: Cognitive and Behavioral Considerations

Given the significant challenges posed by cognitive and behavioral impairments following TBI, the group felt that it was important to evaluate and recommend OMs useful for physical therapists to document cognitive or behavioral abilities in a functional context. Measures typically administered by speech–language pathologists, psychologists, neuropsychologists, or occupational therapists were not targeted for inclusion in our reviews, but we did include feasible OMs that might be useful for PTs to screen or document impairments that influence physical function. In addition, if cognitive impairment might influence the administration or results of the OM (eg, a balance test that includes multiple step commands), task force members made notes about cognitive considerations in the comments section of our review forms (eg, a measure that requires following multiple step directions).

Recommendations for Education and Research

The TBI EDGE addendum included recommendations for use in entry-level PT education in 2 categories: exposure to an OM or training to administer and score the OM. Recommendations were also made for OMs that were deemed appropriate for research use. Practice settings were integrated into the addendum as discussed previously and also reflected ambulatory level as a

factor for consideration in OM selection using the modified FAC categories. The TBI EDGE addendum was finalized as our tool to gather and organize OM review details.

Outcome Measure Rating

The rating scale used by the stroke and MSEDGE groups was modified to better accommodate known gaps in the TBI literature. The previous rating scale ranged from 1 (*do not recommend*) to 4 (*highly recommend*), with the descriptor for a score of 2 being "unable to recommend." TBI EDGE members anticipated that there would be measures that are useful for TBI, with strong psychometric properties in similar patient populations (eg, stroke, MS, individuals with balance impairment), but have simply not been studied in the TBI population. Therefore, a score of 2 was reassigned the description "reasonable to use, but limited study in target group" (see Table 2).

Table 2. TBI Outcome Measure Rating Scale

4	Highly recommend	Excellent psychometrics in target population (eg, valid and reliable with available data to guide interpretation) AND excellent clinical utility (eg, administration is ≤ 20 min, requires equipment typically found in the clinic, no copyright payment required, easy to score)
3	Recommend	Good psychometrics in target population (eg, may lack information about reliability, validity, or available data to guide interpretation) AND good clinical utility (eg, administration/scoring > 20 min, may require additional equipment to purchase or construct)
2	Reasonable to use, but limited study in target group	Good or excellent psychometric data demonstrated in at least 1 population,[a] AND good or excellent clinical utility (refer to criteria given earlier) BUT insufficient study in target population to support a stronger recommendation
1	Do not recommend	Poor psychometrics (eg, inadequate reliability or validity) AND/OR limited clinical utility (eg, extensive testing time, unusual or expensive equipment, ongoing costs to administer)

[a]A neurologic population that has some impairment similarities to the target group would be most helpful, but other groups such as older adults with balance impairment could also meet this criterion.

Areas Considered in Ratings

Outcome measure ratings were based on strength of the psychometrics and the clinical utility of the measure with data gathered in a thorough literature search by the primary reviewer for each OM. We considered the population, meaning whether the measure was validated in the TBI population, and if not, whether it was validated in a population with impairments commonly seen in TBI. Clinical utility was also important. To have excellent clinical utility, the measure needed to have a short administration time (<20 minutes) require only equipment typically found in the clinic, be simple to score (clear directions, limited need for additional computation and interpretation), and not require payment for its use, consistent with EDGE recommendations from previous EDGE groups.[4,5] When determining the strength of the psychometric properties of each measure, group members used available data to guide interpretation, including information on responsiveness (minimal detectable change [MDC], minimum clinically important difference [MCID], standard error of measurement [SEM], standardized response mean, and/or effect size) as well as norms and cutoff points associated with functional level or risk for adverse outcome.

Our task force was composed of clinicians, academics, and researchers, so we leveraged these diverse perspectives in recommendations for the inclusion of measures in entry-level education. Faculty provided knowledge of time constraints in current curricula where clinicians provided insights into tools students must know how to administer in clinical practice. Measures commonly used in TBI research were often recommended as those students should be familiar with but not necessarily administer, to be able to interpret current literature. Recommendations

were made for TBI research use largely based on psychometric properties of tools, given that a research project may be designed using OMs that require more time or more expensive equipment for the purpose of capturing very precise data related to specific research questions. The data from the literature and OM ratings were documented on 2 forms, a template provided by the RMD group, and an addendum that included TBI EDGE specific information and recommendations.

Collaboration With Rehabilitation Measures Project Staff

In addition to the literature gathered by the TBI EDGE group members, the RMD staff contributed the literature that had been collected during the review process for their Web site.

R.M.D. then posted an "author kit" on a shared drive for each OM, which included OM title, link to the OM, reviewer(s), date of review, purpose, description, ICF domain, time to administer, the number of items, equipment required, training required, actual cost, populations tested, SEM, MDC, MCID, cutoff scores, normative data, test-retest reliability, interrater reliability, internal consistency, criterion validity (predictive/concurrent), construct validity (convergent, discriminant), content validity, face validity, floor/ceiling effects, responsiveness, professional association recommendations, considerations, and bibliography. The "author kit" also included links to literature used to populate the form if the measure was already posted on the RMD site (rehabmeasures.org). If the OM had been reviewed by another EDGE group or information collated by the RMD staff, the RMD template was populated with information in many of the categories, as was the case for 49 OMs in total, but typically did not include TBI-specific information. The TBI EDGE reviewer examined the template for accuracy, tracked changes including information specific to TBI for the measure, and incorporated new references.

Documentation of Recommendations

The TBI EDGE addendum documented TBI impairments, a link to the RMD online summary, OM ratings by practice setting and level of ambulation, entry-level education recommendations, and appropriateness for research use. The TBI EDGE addendum provides necessary information about recommendations, but more detail about locating measures, score sheets, and information on other populations is accessible via a link to the RMD site. This approach was chosen to be efficient and reduce redundancy and length in the summary TBI EDGE documentation (collated TBI EDGE addenda), given that online access is commonplace. References that were used to make recommendations were added to both forms, to make the RMD summary comprehensive, but allow sources specific to TBI to be easily identified (only TBI-specific references were included on the addendum). TBI EDGE forms were collated in a single document shared on the Academy of Neurologic Physical Therapy Web site (neuropt.org). As an example, see Supplemental Data File 1, a copy of the TBI EDGE form created for the High-level Mobility Assessment Test (available at: http://links.lww.com/JNPT/A145). Those seeking information about best measures to choose can access documents on the Academy of Neurologic Physical Therapy Web site and use the link on each addendum to obtain more details about a measure or its use in other populations.

Stage II: The Review Process

The task force was divided into 4 pairs of reviewers. Each pair included an individual who was primarily a clinician matched with someone who served in a research or academic role to balance perspectives on the value of measures. Within each pair, one person was assigned as the primary reviewer for specific OMs, and the other member of the pair served as the secondary reviewer

for any primary reviews done by his or her partner and vice versa. Reviews took place over an 8-month period. All reviewers completed at least one review to share with their secondary reviewer prior to a conference call with the entire task force soon after reviews had begun. We discussed the review process and addressed questions from the initial reviews so that all task force members proceeded in a similar way.

Primary reviewers completed their assigned primary and secondary OM reviews with their partners and arrived at a consensus rating before reviews were forwarded to the task force co-chairs. The primary reviewer performed a literature review on the use of that measure in the TBI population. If an OM had not been reviewed by the RMD group, a blank RMD template was completed on the basis of the available literature, as well as the TBI EDGE addendum. During this time, several new measures were found that were appropriate to add to our review list, but a number of measures were also removed from our review list for various reasons (see Table 3). The inclusion or deletion of OMs from the list was discussed with the co-chairs of the group so that reviews could be tracked and rationale agreed upon. In total, we considered 128 measures in our reviews, but deleted 40 from the list of active reviews, leaving 88 with completed recommendations.

Table 3. Outcome Measures Excluded From Review

ICF Area: Specific Categories	OMs Considered (TBI Specific)	OMs Added During Literature Review	OMs Reviewed on rehabmeasures.org	OM Measures Excluded	Reasons for OM Exclusion or Inclusion (Examples):
Body Structures/Functions: disorders of consciousness, impairments in cognition, behavior, awareness, motor control (upper extremity, trunk), fatigue, dizziness, as well as global outcome measures (eg, Glasgow Coma Scale)	44 (19)	Montreal Cognitive Assessment (MoCA), Cognitive-Log, Motivation for TBI Rehab Questionnaire	10	26	Exclusion: rarely administered by PT (eg, Galveston Orientation and Amnesia Test [GOAT]), proprietary OM, test more useful in stroke (eg, drawing tests for neglect) or were focused on concussion self-report
Activity: Activities of Daily Living, Wheelchair mobility, Balance (sitting, standing, reach, dynamic), gait (timed walking, gait analysis), dual-task walking, community mobility	33(3)	Four Functional Wheelchair Tasks test, Timed Up and Go (Cognitive), Walking & Remembering Test	18	8	Exclusion: Insufficiently standardized clinical test approaches (eg, timed sitting test, observational gait analysis, spatiotemporal gait characteristics), combined all reach measures
Participation: balance confidence, quality of life, life roles, environmental factors, life satisfaction, Computer-Assisted Test measures	34 (4)	Community Integration Measure	21	6	Rarely administered by PT (eg, Activity Card Sort), proprietary OM, generic health questionnaires with no TBI study
Totals	121 (26)	7	49	40	Total OMs reviewed: 88

Abbreviations: ICF, International Classification of Functioning, Disability, and Health; OMs, outcome measures; TBI, traumatic brain injury.

Following completion of the primary review, the secondary reviewer provided input on the TBI EDGE addendum and formulated their own OM rating for each area including clinical setting, ambulatory status, education, and research. Disagreements on ratings were discussed between each pair, with the aim of achieving a consensus rating. If a consensus could not be achieved, areas of disagreement were brought back to the larger group for discussion. To facilitate the work of the group, we added a member in the summer of 2012 (C.N.) who participated in secondary reviews of participation measures. Final reviews were completed on the basis of literature published until March–November of 2012 and recorded clearly on each TBI EDGE addendum.

Stage III: Group Consensus With Modified Delphi Process

The Delphi technique is a widely used and widely accepted method to reach a consensus among a group of respondents within their area of expertise.[22] A modified Delphi process was used in this case to reach agreement on the recommendations from each pair by the larger group, following processes used by the Stroke and MSEDGE groups.[4,5]To complete the rating process, a

group agreement of at least 80% was required. This meant that all but one reviewer must agree on the rating in the Delphi process in order for the rating to be put forward. This level of agreement is consistent with prior EDGE groups.

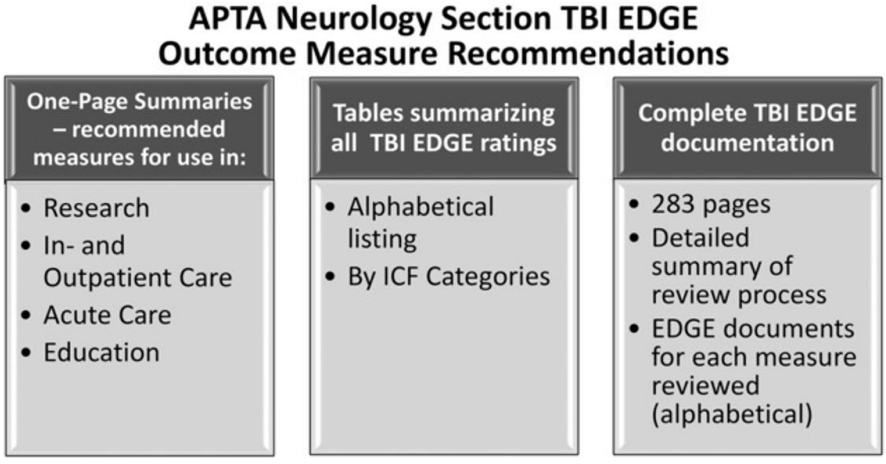
When all secondary reviews were completed, the RMD templates and TBI EDGE addenda were collated. An online survey was administered that allowed each group member to confirm or deny their agreement with each rating on each OM. The co-chairs of the task force reviewed all survey responses to identify ratings that did not achieve the 80% agreement level. A conference call was held with the entire group to discuss ratings that did not achieve consensus. Often these differences of opinion were resolved quickly, as the diverse perspectives of the task force members provided clear rationale regarding the rating choices. The expertise of the group members allowed these differences of opinion to be resolved in a single phone call.

Stage IV: Information Dissemination

Numerous methods of information dissemination were planned to share the recommendations of the TBI EDGE group. These methods are described here chronologically as they occurred. Following the Delphi process, the RMD team integrated TBI EDGE addendum information to existing OM summaries that included information from many patient diagnoses and created new summaries for those that the TBI EDGE group created unique to TBI. This information was made available in January 2013.

The task force presented a summary of the process and findings at APTA Combined Sections Meeting in February 2013. The complete TBI EDGE report was posted on the APTA Academy of Neurologic Physical Therapy Web site (neuropt.org) including a single document with a description of the EDGE process, a list of reviewed measures and TBI addendum forms. The figure illustrates the other resources available on the neuropt.org site that resulted from the review process, all of which may be downloaded. One-page summary sheets describe recommendations for acute care, IP or OP rehabilitation, research, and entry-level education. Two tables (Supplemental Digital Content Table Comprehensive TBI EDGE ratings, http://links.lww.com/JNPT/A144; and HiMAT EDGE form-–available as Supplemental Digital Content at: http://links.lww.com/JNPT/A145) describe the ratings for all measures reviewed, organized alphabetically and by ICF area. Task force members disseminated this information in regional and national conference presentations.

Figure 1



In conjunction with collaborators with RMD, we developed 2 “tear sheets” for the *Archives of Physical Medicine and Rehabilitation* journal. These 2-page sheets summarized the information from the TBI EDGE review as a quick reference page useful for clinicians. Tear sheets on the Coma Recovery Scale–Revised and High Level Mobility Assessment Tool were published in July 2014[23] and November 2014,[24] respectively.

Results

The TBI EDGE task force reviewed 88 OMs across all domains of the ICF (see the Supplemental Digital Content Table for a summary of TBI EDGE recommendations for all OMs reviewed, available at: http://links.lww.com/JNPT/A144). Of these, 15 measured body function/structure only (26 included some aspects of Body Structure/Function), 21 measured activity only (33 included some aspects of activity), and 23 measured participation only (29 addressed some aspects of participation). Outcome measures reviewed included 29 that covered more than 1 ICF level. Nineteen OMs were rated important for entry-level PT students to learn how to administer, and exposure to 32 additional OMs was recommended. Fifty-two of the OMs were recommended for use in research. A list of measures that were recommended (rating of 3) or highly recommended (rating of 4) in at least 2 settings was generated (see Table 4).

Table 4. Outcome Measures with Highest TBI EDGE Recommendationsa

	ICF Category			Practice Settings					Ambulatory Status [Level of (In)dependence]				Recommended In Entry-level Education		
Outcome Measures Reviewed	BS/F	ACT	PART	AC	IP	OP	LTAC-SNF	HH	Indep	Mild	Mod	Severe	Learn to Use	Exposed to	Useful for Research
10 Meter Walk Test[25]		•		2	3	3	2	2	3	2	2	1	•		•
6 Minute Walk Test[27]	•	•		2	3	3	2	1	4	3	2	1	•		•
Action Research Arm Test[28]		•		2	2	3	3	3	NA	NA	NA	NA	•		•
Agitated Behavior Scale[31]	•	•		3	3	2	3	2	NA	NA	NA	NA	•		•
Balance Error Scoring System[35]		•		2	2	3	1	2	3	2	1	1		•	
Berg Balance Scale[38]		•		2	3	3	2	2	2	2	2	1	•		•
Coma Recovery Scale–Revised[43]	•			3	4	4	4	4	NA	NA	NA	NA	•		•
Community Balance and Mobility Scale[44]	•	•		3	3	3	3	3	3	3	1	1	•		•
Community Integration Questionnaire[46]			•	1	1	3	1	3	NA	NA	NA	NA	•		•

Abbreviations: **ICF:** BS/F, body structure/function; ACT, activity; PART, participation; **Practice Settings:** AC, acute care; IP: inpatient rehabilitation; OP, outpatient rehabilitation; LTAC/SNF, long-term acute care/skilled nursing facility; HH, home health; **Ambulatory Status:** IND: independent; Mild, mild dependence for ambulation (cognitive or mobility based); Mod, moderate dependence for ambulation; Severe, severely dependent for ambulation; NA, not applicable.

[a]Measures that were rated 3 or 4 for at least two settings.

[b]Measures that have at least one “4” rating are given in italic.

Table 5. Rehabilitation Measures Database Page Views for TBI-Specific Measures Following TBI EDGE Recommendationsa

Page views	Measures	Page views	Measures
1300-2000	Disorders of Consciousness Scale Cog-Log O-Log	>8 000	Coma Recovery Scale–Revised Community Integration Questionnaire
>2500	Rancho Los Amigos Levels of Cognitive Functioning QOLIBRI	>9 700	Community Balance and Mobility Scale Functional Assessment Measure
>3500	Moss Attention Rating Scale Apathy Evaluation Scale	>13 600	High-level Mobility Assessment Tool
>5300	Agitated Behavior Scale Disability Rating Scale		

[a]Total page views from January 2013 to May 15, 2015.

Page views on the RMD Web site (from January 1, 2013, to May 14, 2015) for TBI EDGE measures that were designed specifically for TBI and were rated at least 3 (Recommend or Highly Recommend) are summarized in Table 5. Dissemination of TBI EDGE recommendations can be tracked most directly from page views from the APTA Academy of Neurologic Physical Therapy web site (www.neuropt.org), created in March 2013, following Combined Sections Meeting. From its creation in March 2013 until May 20, 2015, the page views numbered 14 562, with 8190 unique views.

Discussion

This project is an important initial step toward identifying priority measures for use in TBI intervention by physical therapists. Our group of 8 volunteers (eventually increased to 9) took on a significant workload in reviewing and recommending 88 measures. The process would not have been possible in the yearlong time frame without help from prior EDGE group leadership and the collaborative efforts of the RMD group.

We used ambulatory status (modified FAC categories) as a method to refine our OM selection; however, this factor was often "not applicable" for most impairment and participation measures, even though it proved reasonable for the activity measures that addressed standing, walking, and higher-level mobility (see Supplemental Digital Content Table, available at: http://links.lww.com/JNPT/A144). This is reflective of a challenge in TBI care, as there is no standard way to characterize the combination of cognitive and physical impairments that occurs following a brain injury.

Limitations and Developments on the Horizon for TBI OMs

Many of the OMs included in our review were developed by National Institute on Disability and Rehabilitation Research (NIDRR, now National Institute on Disability, Independent Living, and Rehabilitation Research) TBI Model Systems investigators for use in research projects. These measures are sometimes designed to characterize important issues such as injury severity (eg, Glasgow Coma Scale[67]), or to reflect global outcome (Glasgow Outcome Scale-Extended,[68]Disability Rating Scale[51]) but may not measure specific PT-related outcomes at a level that is useful clinically. This underscores the importance of recognizing measures that **do** capture clinically relevant abilities, such as the Coma Recovery Scale–Revised, an OM that received a high-level recommendation for inpatient rehabilitation.

In the TBI literature, there are measures that were developed long ago, sometimes called legacy measures, and many variations on prior measures. This was most evident in the participation category, where we identified many participation measures that could be used with TBI, but it was difficult to strongly advocate for a single choice. In this case, the Community Integration

Questionnaire (CIQ)[46] was rated the highest as a legacy measure that has been used in many studies, yet the CIQ has known ceiling effects postinjury.[114,115]

Participation measures developed to improve upon legacy measures such as the CIQ may lack published support to warrant a stronger recommendation. For instance, the PART-O,[85] based on TBI Model Systems researcher consensus, combined elements of 3 legacy participation measures (CIQ,[46] Participation Objective, Participation Subjective,[87] and the Craig Handicap Assessment and Reporting Technique[48,49]). Since information on the PART-O was first published in 2011, insufficient support was available during our review to rate it higher than a 2 on our rating scale, yet additional validation of the measure has been published since our review process was completed.[116–118] In the participation area, there were 22 measures that were rated at the "2" level, with the CIQ being the one of a few participation measures (also QOLIBRI and Sydney Psychosocial Rating Scale) to rise to the "3" level in more than 1 setting. This limited endorsement occurred despite efforts to improve the CIQ or create better alternatives that have been sufficiently validated to provide a stronger recommendation. Therapists working with TBI should monitor ongoing evidence emerging from the TBI Model Systems, as this collaborative research effort often leads the way in the validation of new measures. Future EDGE groups will need to consider this area carefully as newer measures become preferred tools.

Most of the OM-specific information reviewed in the EDGE process comes from classical test theory, using traditional measures of reliability and validity as a basis for recommendations. The use of item-response theory is increasingly a focus in the development of measures, not only to develop a hierarchy of item relationships but as a precursor to the use of computer-assisted test (CAT) methods. This approach allows testing of abilities across a wide continuum to occur rapidly by calibrating items tested based on individual responses to prior test items. Given the diversity of possible impairments and a range of abilities following TBI, CAT is an ideal target for TBI functional assessment. In our review, we examined literature related to PROMIS[119] and NeuroQOL,[83] measures that were not well studied in TBI at the time of the review; therefore, we included only NeuroQOL for TBI EDGE review. Since then studies on the TBI-related items for the NeuroQOL, referred to as TBIQOL, have been published.[120–122] The CAT approach is likely to be very useful for self-report instruments that cover a wide range of topics, such as quality-of-life and participation measures. These instruments are available to clinicians at no charge, although the clinical use of them requires the use of a computer for the patient to enter responses, which may challenge feasibility.

Call for PT-Focused TBI OM Research

There are many benefits to using the TBI EDGE and RMD summary forms in clinical practice. These recommendations include a wide variety of practice settings and levels of physical independence and allow for efficient identification of recommended and appropriate outcomes based on specific patient needs and practice settings. Many of the measures (n = 61) received no higher than "2" rating in multiple practice settings, including gait and balance measures that are in common use such as the Activities Specific Balance Confidence Scale, Balance Evaluation Systems Test, Clinical Test of Sensory Integration in Balance, Dynamic Gait Index, Fullerton Advanced Balance Scale, Functional Gait Assessment, Functional Reach, Sensory Organization Test, and Timed Up and Go (including cognitive version). These measures are reasonable to use, but there is not enough information on psychometric properties in the TBI population specifically to provide a higher-level recommendation. Measures rated at a "2" are ideal candidates for validation research for use in moderate to severe TBI.

There were 9 measures that were rated a "1" for all criteria, although only the Mini-Mental Status Exam was inadvisable to use with TBI *based on study of the measure*. For cognitive screening, the Montreal Cognitive Assessment appears better suited for TBI. Other measures that were rated "1" for all criteria had not been studied sufficiently in TBI to warrant a higher-level rating. Overall, the information from TBI EDGE provides an excellent starting point for a clinician or researcher looking for appropriate OMs for a specific patient or research study.

The effort summarized in this article is consistent with an ongoing Academy of Neurologic Physical Therapy priority on knowledge translation. The "knowledge to action framework" highlights steps in an inverse pyramid of knowledge creation that starts with knowledge inquiry—exemplified by the EDGE literature search process; knowledge synthesis—consistent with the process of rating each measure by setting type based on clinical perspectives and synthesized evidence; and knowledge tools that are created on the basis of the synthesis of information[123] described in the Figure. Basic knowledge tools that are disseminated via the Academy of Neurologic Physical Therapy and RMD Web sites are listed in Table 4 and in the 1-page summaries described in the Figure. It is not possible for an organization such as the Academy of Neurologic Physical Therapy to accomplish all of the steps of the knowledge to action process. Therapists and administrators in clinical practice have the greater challenge of implementing recommendations put forth in knowledge tools or products. End users of these OM tools must analyze their clinical context including possible barriers to OM use, choose the OM that are best for implementation, then monitor, evaluate, and sustain the use of recommendations based on "real-world" experience. Clinical research that documents the use of these knowledge tools will be valuable in providing updated information to revise future OM recommendations.

Integrating EDGE Recommendations Across Diagnostic Groups

The Academy of Neurologic Physical Therapy has sponsored the work of multiple EDGE groups across diagnostic groups, resulting in many tools that are recommended for use, but few that have the highest-level rating for multiple groups. The spread of ratings across hundreds of OMs may add to clinician difficulty in selecting the most appropriate OM for a patient. While EDGE documents are organized by condition, many clinicians work with multiple populations. Clinical practice guidelines are statements that include recommendations that synthesize the current literature. Since the EDGE groups have provided their recommendations, members of the Academy of Neurologic Physical Therapy of APTA are developing a CPG using EDGE recommendations to synthesize OM guidance across diagnostic groups. The leaders of this CPG group are former chairs of the Stroke and MSEDGE groups and the physical therapist liaison to the RMD, ideal players to facilitate a consensus. The process of continuing to integrate new literature into such recommendations also presents a challenge, but the likelihood of OM recommendations becoming more refined increases with collaborative processes such as the process used for TBI EDGE.

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