## Outcome Domain:

Physical Function

## Domain Description and Relevance in TBI:

“People with TBI (particularly severe TBI) may manifest difficulties in physical or neurological functioning including cranial or peripheral nerve damage, impairment in motor functioning, strength and/or coordination, or impairment in sensation. These impairments may contribute to difficulties in performing day-to-day activities safely and independently.” – Wilde et al. 2010

Table 1 CDE Classification by Type of TBI Study and Relevant Population for Recommended Physical Function Outcome Measures

| Outcome Measure Name | Relevant TBI Population | Acute Hospitalized | Moderate/ Severe Rehabilitation | Concussion/ Mild TBI | Epidemiology |
| --- | --- | --- | --- | --- | --- |
| Balance Error Scoring System (Modified) | Adult TBI and Pediatric TBI | Supplemental | Supplemental | Supplemental | Supplemental |
| Bruininks-Oseretsky Test of Motor Proficiency-2 (BOT-2) | Pediatric TBI | Supplemental | Supplemental | Supplemental | Supplemental |
| Functional Independence Measure (FIM) - Motor Subscale | Adult TBI | Basic | Basic | Supplemental | Supplemental |
| Functional Independence Measure for Children (WeeFIM) - Motor Subscale | Pediatric TBI | Basic | Basic | Supplemental | Supplemental |
| Gross Motor Function Measure (GMFM-88, GMFM-66) | Pediatric TBI | Supplemental | Supplemental | Supplemental | Supplemental |
| Neurophysical Outcome Scale (NOS) | Adult TBI | Supplemental | Supplemental | Supplemental | Supplemental |
| NeuroQOL mobility/ambulation domain | Pediatric TBI | Supplemental | Supplemental | Supplemental | Supplemental |
| NIH Toolbox Motor Battery | Adult TBI and Pediatric TBI | Supplemental | Supplemental | Supplemental | Supplemental |
| NIH Toolbox Sensory Battery | Adult TBI and Pediatric TBI | Supplemental | Supplemental | Supplemental | Supplemental |
| Patient-Reported outcomes Measurement Information System (PROMIS), Mobility and upper extremity domains | Pediatric TBI | Supplemental | Supplemental | Supplemental | Supplemental |
| Peabody Developmental Motor Scales, 2nd Edition | Pediatric TBI | Supplemental | Supplemental | Supplemental | Supplemental |
| Pediatric Evaluation of Disability Inventory (PEDI) - Mobility subscale | Pediatric TBI | Basic | Basic | Basic | Supplemental |

### References

McCauley SR, Wilde EA, Anderson VA, Bedell G, Beers SR, Campbell TF, Chapman SB, Ewing-Cobbs L, Gerring JP, Gioia GA, Levin HS, Michaud LJ, Prasad MR, Swaine BR, Turkstra LS, Wade SL, Yeates KO. Recommendations for the Use of Common Outcome Measures in Pediatric Traumatic Brain Injury Research. J Neurotrauma. 2012 March; 29: 678-705. PubMed PMID: 21644810.

Wilde EA, Whiteneck GG, Bogner J, Bushnik T, Cifu DX, Dikmen S, French L, Giacino JT, Hart T, Malec JF, Millis SR, Novack TA, Sherer M, Tulsky DS, Vanderploeg RD, von Steinbuechel N. Recommendations for the use of common outcome measures in traumatic brain injury research. Arch Phys Med Rehabil. 2010 Nov; 91(11):1650-1660.e17. [DOI: 10.1016/j.apmr.2010.06.033]

## Balance Error Scoring System Modified

### DESCRIPTION:

In the Balance Error Scoring System Modified, two stances—a single-leg stance using the non-dominant foot, and a heel-toe stance with the non-dominant foot in the rear—are held for 20 seconds each on a firm surface and then repeated on a piece of medium-density foam. The number of balance errors is recorded for each trial. Balance errors include moving the hands off of the iliac crests, opening the eyes, step stumble or fall, abduction or flexion of the hip beyond 30°, lifting the forefoot or heel off of the testing surface, and remaining out of the proper testing position for greater than 5 seconds. A maximum of 10 errors can be counted for any single condition. A total score is calculated from the four trials.

### PERMISSIBLE VALUES:

Number of errors from the four trials ranges from 0-40.

### PROCEDURE:

A standard testing protocol is administered and the test can be completed in under 10 minutes.

**COMMENTS:**

The test may be administered to children or adults and in military or civilian populations.

**RATIONALE:** The BESS- Modified is inexpensive and easy to administer, has been used extensively in athletes, and has proven validity and reliability.

### REFERENCES:

Guskiewicz KM. Postural stability assessment following concussion: one piece of the puzzle. Clin J Sport Med. 2001; 11:182–189.

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Riemann BL, Guskiewicz KM. Effects of mild head injury on postural stability as measured through clinical balance testing. J Athl Train. 2000:35(1):l9-25.

## Bruininks-Oseretsky Test of Motor Proficiency-2 (BOT-2)

### DESCRIPTION

The BOT-2 consists of 8 subtests of motor proficiency, including fine motor precision, fine motor integration, manual dexterity, bilateral coordination, balance, running speed and agility, upper-limb coordination. Normative data are available for four composite scores and an overall motor proficiency score.

### PERMISSIBLE VALUES

Standard scores have M=50, SD=10.

### PROCEDURE

The test is administered with game-like tasks that require 15-20 minutes (short form) or 45-60 minutes (complete battery) to complete.

### COMMENTS

It can be used with children through adults aged 4 to 21 years.

### RATIONALE

“The BOT-2 is psychometrically sound and has been used successfully in discriminating between populations, and is increasingly used with children with TBI. It provides normative interpretation of subtest and composite scores, provides a profile analysis for individuals, and is increasingly used with children with TBI. Both the original and second editions have been increasingly used.” – McCauley et al. 2012

### REFERENCES

Bruininks, R., and Bruininks, B. (2006). Bruininks-Oseretsky Test of Motor Proficiency (BOT- 2) Manual (Second Ed.). Pearson Assessments: San Antonio, TX.

Chaplin, D., Deitz, J., and Jaffe, K. (1993). Motor performance in children after traumatic brain injury. Arch Phys Med Rehabil 74(2), 161-164

Gagnon, I., Forget, R., Sullivan, S., and Friedman, D. (1998). Motor performance following a mild traumatic brain injury in children: an exploratory study. Brain Inj 12(10), 843-853.

Gagnon, I., Swaine, B., Friedman, D., and Forget, R. (2004a). Children show decreased dynamic balance after mild traumatic brain injury. Arch Phys Med Rehabil 85(3), 444-452.

Gagnon, I., Swaine, B., Friedman, D., and Forget, R. (2004b). Visuomotor response time in children with a mild traumatic brain injury. J Head Trauma Rehabil 19(5), 391-404.

Wallen, M., Mackay, S., Duff, S., McCartney, L., and O'Flaherty, S. (2001). Upper-limb function in Australian children with traumatic brain injury. Arch Phys Med Rehabil 82(5), 642-649.

## Functional Independence Measure (FIM) - Motor Subscale

### DESCRIPTION

The FIM(TM) is an 18-item ordinal scale, used with all diagnoses within a rehabilitation population. The FIM(TM) measures degree of independence in activities of self-care, sphincter control, transfers, locomotion, communication, and cognition. FIM(TM) scores range from 1 (total or >75% assistance) to 7 (complete independence).

### PERMISSIBLE VALUES

Total score range= 18-126. Thirteen item Motor subscore ranges from 13-91. Scores may be used raw or converted to interval scores.

### PROCEDURE

May be completed by rehabilitation clinicians as an observational scale, or by trained paraprofessionals or family members. May be administered by trained interviewers as a self-report or proxy report instrument, in person or by phone. FIM(TM) certification is available and required to officially utilize the tool. A detailed manual guides scoring, based on operationally-defined functional abilities. Administration time is 10-20 minutes.

### COMMENTS

Most appropriate for Severe and Moderate Disability levels of GOSE; ceiling effects limit utility in Good Recovery. Not sufficiently sensitive for mild TBI.

### RATIONALE

The most widely accepted functional assessment measure in use in the rehabilitation community, FIM(TM) is most useful for assessment of progress during inpatient rehabilitation. Its metric properties have been reported extensively and include high precision, convergent and discriminant validity, and good interrater agreement across flexible modes of administration.

### REFERENCES

Granger CV. The emerging science of functional assessment: our tool for outcomes analysis. Arch Phys Med Rehabil 1998; 79(3):235-240.

## Functional Independence Measure for Children (WeeFIM) - Motor Subscale

### DESCRIPTION

The WeeFIM builds on the format of the Functional Independence Measure for Adults of the Uniform Data System for Medical Rehabilitation, tracking disability outcomes in children. Specifically, this assessment measures independence in self-care, sphincter control, transfers, locomotion, communication, and social cognition. The WeeFIM consists of 18 items within the six domains.

### PERMISSIBLE VALUES

A 7-level Likert scale is used to score level of dependence. Scores for the WeeFIM range from 18 (complete dependence in all skills) to 126 (complete independence in all skills).

### PROCEDURES

Administered through an interview by a trained rater or a telephone interview of caregiver or subject by trained rater. The test takes between 20-30 minutes.

### COMMENTS

The measure is used with children aged 6 months to 7 years. It can be used by children above 7 years if their abilities are below that of 7-year-olds without disabilities.

### RATIONALE

“The motor scale (8 self-care, 5 mobility items) was primarily selected … to assess motor function in the acute recovery phase.” – McCauley et al. 2012

### REFERENCES

Chen, C., Bode, R., Granger, C., and Heinemann, A. (2005). Psychometric properties and developmental differences in children's activities of daily living item hierarchy: A study of the WeeFIM® instrument. Am J Phys Med Rehabil 84, 671-679.

Massagli, T., Michaud, L., and Rivara, F. (1996). Association between injury indices and outcome after severe traumatic brain injury in children. Arch Phys Med Rehabil 77, 125- 132.

Ottenbacher, K., Msall, M., Lyon, N., Duffy, L., Granger, C., and Braun, S. (1997). Interrater agreement and stability of the functional independence measure for children (WeeFIM): Use in children with developmental disabilities. Arch Phys Med Rehabil 78, 1309-1315.

Ottenbacher, K., Msall, M., Lyon, N., Duffy, L., Zivani, J., Granger, C., Braun, S., and Feidler, R. (2000). The WeeFIM Instrument: Its utility in detecting change in children with developmental disabilities. Arch Phys Med Rehabil 81, 1317-1326.

Ottenbacher, K., Taylor, E., Braun, S., Lane, K., Granger, C., Lyons, N., and Duffy, L. (1996). The stability and equivalence reliability of functional independence measure for children (WeeFIM). Devel Med Child Neurolog 38, 907-916.

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Swaine, B., Pless, I., Friedman, D., and Montes, J. (2000). Effectiveness of a head injury program for children. Am J Phys Med Rehabil 79(5), 412-420.

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Granger, C. (1998). The emerging science of functional assessment: our tool for outcomes analysis. Arch Phys Med Rehabil 79(3), 235-240.

Msall, M., DiGaudio, K., Rogers, BT, et al. (1994). The Functional Independence Measure for Children (WeeFIM): Conceptual Basis and Pilot Use in Children with Developmental Disabilities. Clinical Pediatrics 33(7), 421-430.

## Gross Motor Function Measure (GMFM-88, GMFM-66)

### DESCRIPTION

The GMFM requires the child to demonstrate various motor skills. The GMFM measures five areas of motor function: 1) lying and rolling; 2) sitting; 3) crawling and kneeling; 4) standing; and 5) walking, running, and jumping. The GMFM-66 is derived from the GMFM-88. Both tests are free to use with translations in Spanish and German.

### PERMISSIBLE VALUES

Each item is scored on a four-point system. These are added to obtain raw and percent scores for each of the five dimensions, selected goal areas and for total score.

### PROCEDURE

The GMFM-88 takes between 45-60 minutes to administer. The GMFM-66 takes slightly less time. It should be administered by pediatric therapists with experience assessing motor skills in children.

### COMMENTS

Ages 5 months to 16 years, for children with motor skills equivalent to a 5 year old without motor disability

### RATIONALE

“Responsiveness to change in motor function using the GMFM-88 after pediatric TBI has been demonstrated in multiple studies and the GMFM-66 as well as the GMFM-88 have recently demonstrated sensitivity and discriminant validity, with excellent test-retest reliability, for use in children and adolescents with TBI.” – McCauley et al. 2012

### REFERENCES

Russell, D., Rosenbaum, P., Cadman, D., Gowland, C., Hardy, S., and Jarvis, S. (1989). The Gross Motor Function Measure: a means to evaluate the effects of physical therapy. Dev Med Child Neurol 31, 341-352.

Russell, D., Avery, L., Rosenbaum, P., Raina, P., Walter, S., and Palisano, R. (2000). Improved scaling of the Gross Motor Function Measure for children with cerebral palsy: evidence of reliability and validity. Phys Ther 80, 873-885.

Kuhtz-Buschbeck, J., Hoppe, B., Golge, M., Dreesmann, M., Damm-Stunitz, U., and Ritz, A. (2003). Sensorimotor recovery in children after traumatic brain injury: analyses of gait, gross motor, and fine motor skills. Dev Med Child Neurol 45, 821-828.

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Linder-Lucht, M., Othmer, V., Walther, M., Vry, J., Michaelis, U., Stein, S., Weissenmayer, H., Korinthenberg, R., Mall, V., and Group, G. M. F. M.-T. B. I. S. (2007). Validation of the Gross Motor Function Measure for use in children and adolescents with traumatic brain injuries. Pediatrics 120(4), e880-e886

## Neurophysical Outcome Scale (NOS)

### DESCRIPTION

NOS-TBI is a 15-item scale modified after the National Institutes of Health Stroke Scale, but validated in a TBI population and containing items specific to TBI. Items include level of consciousness, vision, extraocular movements, facial paresis, limb strength, sensation, speech and language, olfaction, hearing, pupillary response, and gait (supplemental) and ataxia (supplemental).

### PERMISSIBLE VALUES

Minimum score is 0 (no deficits) and maximum score is 58 (without supplemental items). Each item is scored 0-2, 0-3, or 0-4 and scores for each item are summed for a total score. Two supplemental items can be given to patients that are ambulatory and weight-bearing (measuring gait and limb ataxia) for an additional supplemental score. Higher scores reflect greater impairment.

### PROCEDURE

Completed by clinician (physician, therapist, nurse, psychologist, social worker); some training required and videotape, online certification training of the NIHSS is recommended. Administration time is 10-15 minutes.

### COMMENTS

This measure includes scoring criteria even for patients that are comatose, non-responsive or extremely impaired (assigned highest score in most instances) and can therefore be used in acute severe injury as well as more chronic time intervals, though initial validation was on a rehabilitation population of moderate to severe TBI.

### RATIONALE

The NOS-TBI is a measure of neurologic functioning which has been validated in a TBI population. It is brief, easy to administer and score, and can be used in a wide range of post-injury intervals and levels of severity.

### REFERENCES

Wilde EA, McCauley SR, Levin HS, Kelly TM, Weyand AM, Boake C, Pedroza C, Clifton GL, Valadka AB, Robertson CS, Shah M Moretti PM. (Under Review). Feasibility of using the Neurophysical Outcome Scale in adults with traumatic brain injury.

McCauley SR, Wilde EA, Kelly TM, Weyand AM, Yallampalli R, Waldron E, Pedroza C, Boake C, Levin HS, Clifton GL, Valadka AB, Moretti PM. (Under Review). Reliability and convergent validity of the Neurophysical Outcome Scale in adults with traumatic brain injury.

Wilde EA, McCauley SR, Kelly TM, Weyand AM, Yallampalli R, Waldron E, Pedroza C, Boake C, Levin HS, Clifton GL, Valadka, AB, Moretti PM. (Under Review). Construct validity of the Neurophysical Outcome Scale in adults with traumatic brain injury.

## NeuroQOL mobility/ambulation domain

### DESCRIPTION

Contains 10 calibrated item banks with likert style items with several banks linked with PROMIS (e.g., anxiety, depression, stigma, positive psychological functioning, mobility, activities of daily living, satisfaction with social activities and roles, Social Roles, Applied and perceived cognitive functioning). Administered as short-forms to make keep assessments brief.

### PERMISSIBLE VALUES

T scores for all scales

### PROCEDURES

Patient reads Likert items on computer screen and responds. Computer scored. Administration time = < 5 minutes per subdomain (total time for short form across all domains is about 30 minutes).

### COMMENTS

General scale designed to be used in NINDS-sponsored clinical trials and other studies where cross-sample, cross-disease comparisons are desired. Has been tested in large samples of individuals from the general population and diverse neurologically impaired populations. However, has not been validated in TBI. Future plans are to develop a computer adaptive test (CAT).

### RATIONALE

Development funded by NINDS through a contract mechanism with the goal of utilizing in clinical trials research. Calibrated item banks offer advantages of obtaining reliable measurement across a wide spectrum of functioning with minimal items.

### REFERENCES

See [Neuro-QOL Instrument Link](http://www.neuroqol.org/Pages/default.aspx)

## NIH Toolbox Motor Battery

### DESCRIPTION

Validation version contains 11 diverse functional performance tasks, including:

* Dexterity – (25 hole Grooved Pegboard)
* Endurance (2 Minute Walk)
* Locomotion (40 Meter Walk)
* Strength – Upper Extremity (Grip Strength Dynamometry)
* Vestibular Balance (Balance Accelerometry Measure)

### PERMISSIBLE VALUES

Under development. Technician will provide instructions and participant will be required to perform on functional tasks. Tasks include walking tasks of varying lengths, putting pegs in a board, squeezing a device with one's hand, and balance. Administration time should be 30 minutes or shorter

### PROCEDURE

The battery is designed to be used in large epidemiological studies and in clinical trials for ages 3 to 85.Should be able to examine broad range of normal functions.

### COMMENTS

Will be tested in large samples of individuals from the general population. However, has not been yet validated in TBI.

### RATIONALE

Designed as part of the NIH Blueprint initiative for use in NIH research involving large epidemiological studies and clinical trials. The battery will examine various motor skills, will be at nominal cost and will take no more than 30 minutes to complete. Large standardization is being planned.

### REFERENCES

[NIH PROMIS Instruments Link](http://www.nihtoolbox.org) Principal Investigator: Richard Gershon PhD e-mail -mail: gershon@northwestern.edu

## NIH Toolbox Sensory Battery

### DESCRIPTION

Validation version includes 8 tasks including:

* Audition (Hearing Thresholds)
* Olfaction – Identification (Odor Identification Test)
* Somatosensation – Texture Discrimination (Tactile Discrimination Test)
* Taste – Perception (Regional Taste Test)
* Taste – Sweet Preference (Sucrose Preference Test)
* Vestibular Ocular Reflex (Dynamic Visual Acuity)
* Vision – (Visual Acuity)

### PERMISSIBLE VALUES

Under development

### PROCEDURE

Technician will provide instructions and participant will be required to perform on functional tasks. Administration time should be 30 minutes or shorter.

### COMMENTS

The battery is designed to be used in large epidemiological studies and in clinical trials for ages 3 to 85.Should be able to examine broad range of normal functions. Will be tested in large samples of individuals from the general population. However, has not been yet validated in TBI.

### RATIONALE

Designed as part of the NIH Blueprint initiative for use in NIH research involving large epidemiological studies and clinical trials. The battery will examine various sensory skills, will be at nominal cost and will take no more than 30 minutes to complete. Large standardization is being planned.

### REFERENCES

[NIH Toolbox Instruments Link](http://www.nihtoolbox.org/) Principal Investigator: Richard Gershon PhD e-mail -mail: gershon@northwestern.edu

## Patient-Reported outcomes Measurement Information System (PROMIS), Mobility and upper extremity domains

### DESCRIPTION

Version 1.0 contains 12 calibrated item banks with likert style items (e.g., anger, anxiety, depression, Fatigue, pain, physical function, satisfaction with social activities and roles, sleep/wake disturbance, and global health). Can be administered as a computer adaptive test or short-forms make assessment brief, yet reliable

### PERMISSIBLE VALUES

T scores for all scales

### PROCEDURES

Patient reads Likert items on computer screen and responds. Computer adapted version will select items with maximum discriminability and tailored to individual. Computer scored. Administration time is < 5 minutes per subdomain (total time for short form or CAT across all domains is about 30 minutes).

### COMMENTS

General scale designed to be used across multiple general medical populations for cross-sample comparisons. Has been tested in large samples of individuals from the general population and diverse medical populations. However, has not been validated in TBI.

### RATIONALE

Designed as part of the NIH Roadmap initiative for use in NIH sponsored clinical trials research. Calibrated item banks and CAT administration offer advantages of obtaining reliable measurement across a wide spectrum of functioning with minimal items.

### REFERENCES

See [NIH PROMIS Instruments Link](http://www.nihpromis.org/default.aspx)

## Peabody Developmental Motor Scales, 2nd Edition

### DESCRIPTION

The PDMS-2 assesses gross and fine motor skills in children under the age of 5. It includes six subtests in Reflexes, Stationary, Locomotion, Object Manipulation, Grasping, and Visual-Motor Integration. Quotients for gross motor, fine motor, and total motor scores are calculated. For suboptimal results, a suggested remediation program is provided.

### PERMISSIBLE VALUES

Each item is scored on a 3-point scale. Subtest scores are the sum of item raw scores and can be converted to standard scores (M=10, SD=3). Gross motor quotient, fine motor quotient, and total motor quotient all M=100, SD=15. Percentiles, age equivalents, and T-scores are also available.

### PROCEDURE

The PDMS-2 is individually administered and takes 45 to 60 minutes to complete. Each subtest is 20-30 minutes in length.

### COMMENTS

The test is appropriate from birth to 5 years of age.

### RATIONALE

“The PDMS-2 can be used by occupational therapists, physical therapists, diagnosticians, early intervention specialists, adapted physical education teachers, psychologists, and others who are interested in examining the motor abilities of young children.” – McCauley et al. 2012

### REFERENCES

Folio, M., and Fewell, R. (2000). Peabody Developmental Motor Scales (PDMS-2) (Second ed.). Western Psychological Services: Los Angeles, CA.

## Pediatric Evaluation of Disability Inventory (PEDI) - Mobility subscale

### DESCRIPTION

The PEDI is a descriptive measure of a child’s current functional capabilities performance and also tracks changes over time. The measure has three content areas: Self-care, Mobility and Social Function. The self-care sub-domain includes activities such as eating, grooming, dressing, bathing, etc.

### PERMISSIBLE VALUES

Scores for the PEDI range between 0-100, with higher scores indicating a lesser degree of disability.

### PROCEDURES

The PEDI takes between 45 and 60 minutes to administer. Skills commensurate with at least a Master’s degree level in psychology, education, or related field are recommended for interpretation. The PEDI is a paper based instrument. The computerized PEDI-MCAT provides individual patient reports that summarize a patient’s functional status and provide a comparison of scores to the norm.

### COMMENTS

The PEDI™ is recommended for children in acute and rehabilitation settings and for post-discharge follow-up. The measure is appropriate for ages 6 months to 7 years.

### RATIONALE

“The mobility subdomain of this measure was selected as an alternative to the WeeFIM as a core measure of physical functioning in the acute recovery phase.” – McCauley et al. 2012

### REFERENCES

Haley, S., Coster, W., Ludlow, L. H., JT, and Andrellos, P. (1992). Pediatric evaluation of disability inventory: development, standardization, and administration manual, version 1.0. Trustees of Boston University, Health and Disability Research Institute: Boston, MA.

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Tokcan, G., Haley, S., Gill-Body, K., and Dumas, H. (2003). Item-specific recovery for children and youth with acquired brain injury. Pediatr Phys Ther 15, 16-22.

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