**Activities-Specific Balance Confidence Scale**

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| ICF Category | Activity |
| Description | Used to assess balance confidence in ambulatory community-dwelling older adults, individuals with vestibular disorder and persons with stroke. Activities include changing positions and walking in progressively more difficult situations without falling or experience a feeling of unsteadiness. |
| Measurement Method | Patient report measure consisting of 16 questions related to balance confidence while performing activities. |
| Nature of variable | Ratio |
| Units of measure | Patient reported confidence on a scale of 0-100% |
| Diagnostic Accuracy | Reliability  Internal Consistency (Chronbach’s alpha = 0.95)1  Excellent test-retest in community dwelling elderly adults (r=0.92)1  Inter-rater – not applicable  Intra-rater – not applicable  Responsiveness  Not established  Minimal Clinically Important Difference  MDIC—Not established for individuals with concussion/mTBI  Minimal Detectable Change  MDC – Not established for individuals with concussion/mTBI; 13 for Parkinsonism2  Cut-off Scores  Not established for individuals with concussion/mTBI  Standard Error of Measure  Not established for individuals with concussion/mTBI |

1. Weightman M, Radomski M, Mashima P, Roth C. *Mild Traumatic Brain Injury Rehabilitation Toolkit.* Chapter 3: Balance and Functional Abilities Assessment and Intervention, pg. 46. Borden Institute. Fort Sam Houston, TX. 2014.
2. Steffen T, Seney M. Test-retest reliability and minimal detectable change on balance and ambulation tests, the 36-item short-form health survey, and the unified Parkinson disease rating scale in people with parkinsonism. Phys Ther. 2008;88(6):733-46.

**Balance Error Scoring System**

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| ICF Category | Activity |
| Description | Designed to objectively measure static postural stability in individuals with mTBI/concussion and to assist in return to sport decisions. |
| Measurement Method | 6 conditions are measured with patient barefoot and eyes closed. Each condition is tested for 20 seconds. Conditions include double leg stance with feet together on firm and foam surfaces, single leg stance on non-dominant foot on firm and foam surfaces, and tandem stance with non-dominant foot back on firm and foam surfaces. Each condition is scored by summing the total number of deviations from proper stance (max=10). |
| Nature of variable | Nominal |
| Units of measure | Total number of errors is summed from 6 conditions for a maximum total score of 60. |
| Diagnostic Accuracy | Reliability  Internal Consistency – Not established  Adequate test-retest (Youth athletes) - (ICC=0.70)1  Adequate to excellent intra-rater (Healthy Athletes) (ICC=0.60-0.82)2  Excellent inter-rater- (Athletes) (ICC=0.78-0.96)1  Responsiveness  Not Established  Minimal Detectible Change (Athletes)3  Mean intra-rater MDC = 7.3 points Mean inter-rater MDC = 9.3 points  Minimal Clinically Important Difference (Young Athletes)4  Reliable Change Index at 70% confidence interval = 3 points  Cut-off Score  Not established  Standard Error of Measure  SEM (Healthy Young Adults age = 20.42 ± 2.08)=3.3  SEM (Healthy Young Athletes age 9-14)=1.016 |
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1. Bell DR, Guskiewicz KM, Clark MA, Padua DA. Systematic review of the balance error scoring system. Sports Health. 2011;3(3):287-95.

2. Susco TM, Valovich mcleod TC, Gansneder BM, Shultz SJ. Balance Recovers Within 20 Minutes After Exertion as Measured by the Balance Error Scoring System. J Athl Train. 2004;39(3):241-246.

3. Finnoff JT, Peterson VJ, Hollman JH, Smith J. Intrarater and interrater reliability of the Balance Error Scoring System (BESS). PM R. 2009;1(1):50-4.

4. Valovich mcleod TC, Barr WB, Mccrea M, Guskiewicz KM. Psychometric and measurement properties of concussion assessment tools in youth sports. J Athl Train. 2006;41(4):399-408.

5. Broglio SP, Zhu W, Sopiarz K, Park Y. Generalizability theory analysis of balance error scoring system reliability in healthy young adults. J Athl Train. 2009;44(5):497-502.

6. Valovich mcleod TC, Perrin DH, Guskiewicz KM, Shultz SJ, Diamond R, Gansneder BM. Serial administration of clinical concussion assessments and learning effects in healthy young athletes. Clin J Sport Med. 2004;14(5):287-95. Buffalo Concussion Treadmill Test

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| ICF Category | Activity |
| Description | Developed from a modified Balke protocol with intention to monitor symptoms and physiologic response to graded exercise demands in individuals with concussion. |
| Measurement Method | Treadmill speed is set at constant speed for the duration of the test. Treadmil inclination begins at 0% and is raised 1% each minute for the duration of the test (20 minutes). Heart rate, rate of perceived exertion and patient reported concussion symptoms (0-10) are recorded at baseline and every 2 minutes for the duration of the test. Testing is terminated if patient reported symptoms increase 3 or more points from baseline, RPE exceeds 19 or if maximum heart rate is reached. If maximum treadmill inclination is reached prior to test termination or completion speed is increased 0.4 mph for each subsequent minute. |
| Nature of variable | Multiple |
| Units of measure | Heart rate: Beats per minute  Rate of perceived exertion: Borg scale  Symptom report: 0-10 |
| Diagnostic Accuracy | Reliability  Excellent inter-rater reliability for symptom exacerbation – (ICC = 0.90)1  Good test-retest reliability for maximum HR - (ICC=0.79)1  Responsiveness Not established  Minimal Detectible Change  Not Established  Minimal Clinically Important Difference  Not Established | |

Buffalo Concussion Treadmill Test

1. Leddy JJ, Baker JG, Kozlowski K, Bisson L, Willer B. Reliability of a graded exercise test for assessing recovery from concussion. Clin J Sport Med. 2011;21(2):89-94.

Dizziness Handicap Index

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| ICF Category | Body Structure, Body Function, Participation |
| Description | Designed to measure self-perception of disability from vestibular system dysfunction. This is a standard disease-specific tool used to assess health status and quality of life in individuals with vestibular disorders |
| Measurement Method | 25-item self-assessment inventory used to evaluate self-perceived handicapping effects imposed by dizziness. The emotional scale has 9 items, the physical scale has 7 items and the functional scale has 9 items. |
| Nature of variable | Ordinal |
| Units of measure | Each item provides 3 possible answers: 4 (always), 2 (sometimes) or 0 (never). The maximum total is 100 points. |
| Diagnostic Accuracy | Reliability (vestibular)  Excellent test-retest (total score) (r=0.97, df=12, p<0.001)1  Excellent test-retest (sub-scales scores) (r=0.92-0.97, p<0.001)1  Excellent internal consistency (total score) (Chronbach’s alpha=0.89)1  Inter-rater Reliability – Not applicable  Intra-rater Reliability – Not applicable  Responsiveness (vestibular) An average decrease in DHI score of 12 points (P <0.01) following physical therapy intervention (average 4.9 visits over 4 month period)2  Minimal Clinically Important Difference (vestibular)  MCID: 18 points (95% confidence interval)1  Minimal Detectable Change (vestibular)  MDC – 17.181  Standard Error of Measure (peripheral and central vestibular)  SEM=6.231  Cut-Off Score (vestibular dysfunction)  Mild: 0-30, Moderate 31-60, Severe 61-1003 |

1. Jacobson GP, Newman CW. The development of the Dizziness Handicap Inventory. Arch Otolaryngol Head Neck Surg. 1990;116(4):424-7.

2. Whitney SL, Wrisley DM, Brown KE, Furman JM. Physical therapy for migraine-related vestibulopathy and vestibular dysfunction with history of migraine. Laryngoscope. 2000;110(9):1528-34. Weightman M, Radomski M, Mashima P, Roth C.

3. Whitney SL, Wrisley DM, Brown KE, Furman JM. Is perception of handicap related to functional performance in persons with vestibular dysfunction?. Otol Neurotol. 2004;25(2):139-43.

4. Weightman M, Radomski M, Mashima P, Roth C. *Mild Traumatic Brain Injury Rehabilitation Toolkit.* Chapter 2: Vestibular Assessment and Intervention, pg. 25. Borden Institute. Fort Sam Houston, TX. 2014.

Dynamic Gait Index

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| ICF Category | Activity |
| Description | Assesses an individuals functional mobility and ability to adjust to external demands |
| Measurement Method | 8 walking tasks performed in a 20-foot gait lane. Tasks include steady state gait, ambulation with changing speeds, ambulation with horizontal and vertical head turns, manage obstacles, navigating stairs and pivoting. |
| Nature of variable | Ordinal |
| Units of measure | Each task is scored individually on a 4-point scale for a maximum total score of 24. |
| Diagnostic Accuracy | Reliability (Vestibular)  Excellent test-retest reliability (total score)(ICC=0.86)1  Adequate inter-rater reliability (k=0.64)2 Internal Consistency not established  Responsiveness  Not established for mTBI/concussion population  Minimal Detectable Change (Vestibular Disorders)  MDC = 3.2 points1  Cut-Off Scores (Vestibular Disorders)  Subjects scoring 19 or less are 2.58 times more likely to have fallen within the past 6 months3  Standard Error of Measure (Peripheral Vestibular Disorders)  SEM=2.8 points1 |

1. Hall CD, Herdman SJ. Reliability of clinical measures used to assess patients with peripheral vestibular disorders. J Neurol Phys Ther. 2006;30(2):74-81.

2. Wrisley DM, Walker ML, Echternach JL, Strasnick B. Reliability of the dynamic gait index in people with vestibular disorders. Arch Phys Med Rehabil. 2003;84(10):1528-33.

3. Whitney SL, Hudak MT, Marchetti GF. The dynamic gait index relates to self-reported fall history in individuals with vestibular dysfunction. J Vestib Res. 2000;10(2):99-105.

Functional Gait Assessment

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| ICF Category | Activity |
| Description | Used to assess postural stability during various walking tasks. Developed for use in patients who reach the ceiling effect in the Dynamic Gait Index in individuals with vestibular disorder. |
| Measurement Method | Ten-item measure with all 10 activities completed in a 20-foot gait lane. Tasks include steady state gait, ambulation with changing speeds, ambulation with horizontal and vertical head turns, navigating stairs, pivoting, ambulating with narrowed base of support, ambulating backward and ambulating with eyes closed |
| Nature of variable | Ordinal |
| Units of measure | Each item measured on a 0-3 scale with a maximum total score of 30 |
| Diagnostic Accuracy | Reliability (Vestibular Disorders)  Excellent internal consistency (Chronbach’s alpha = 0.79)2  Excellent inter-rater reliability (ICC = 0.84)3  Excellent intra-rater reliability (ICC = 0.83)3  Responsiveness  Not established for concussion/mTBI population  Minimal Clinically Important Difference (vestibular)  MCID=8 points1  Minimal Detectable Change  Not established for mTBI/concussion population |

1. Marchetti GF, Lin CC, Alghadir A, Whitney SL. Responsiveness and minimal detectable change of the dynamic gait index and functional gait index in persons with balance and vestibular disorders. J Neurol Phys Ther. 2014;38(2):119-24.

2. Wrisley DM, Walker ML, Echternach JL, Strasnick B. Reliability of the dynamic gait index in people with vestibular disorders. Arch Phys Med Rehabil. 2003;84(10):1528-33.

3. Wrisley DM, Marchetti GF, Kuharsky DK, Whitney SL. Reliability, internal consistency, and validity of data obtained with the functional gait assessment. Phys Ther. 2004;84(10):906-18.

4. Weightman M, Radomski M, Mashima P, Roth C. *Mild Traumatic Brain Injury Rehabilitation Toolkit.* Chapter 3: Balance and Functional Abilities Assessment and Intervention, pg. 79. Borden Institute. Fort Sam Houston, TX. 2014.

HiMAT

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| ICF Category | Body Function; Activity |
| Description | Physical performance test used to assess high-level motor performance and mobility deficits in patients with TBI |
| Measurement Method | The test contains 13 items measured with either a stopwatch or tape measure. Each item scored on a 0-5 scale based on results and summed for total HiMAT score (maximum score 54). Testing is estimated to take 5 to 15 minutes to administer. |
| Nature of variable | Continuous |
| Units of measure | Seconds, centimeters |
| Diagnostic Accuracy | Reliability  Excellent internal consistency (Cronbach alpha = 0.97)1  Excellent test-retest reliability (ICC = 0.99)1  Excellent inter-rater reliability (ICC = 0.99)1  Responsiveness (Chronic TBI)2   * The HiMAT was found to be more responsive to change in high-level mobility than the Motor FIM or the Gross Function Rivermead Motor Assessment * Mean improvement of 12.1 points (range: 3 to 25 points; max score = 54 points). 13/14 subjects exhibited change greater than MCD95 within 3 months * Large Effect Size in subjects <12 months post-TBI who were retested after 3 months (Responsiveness Indices 1.08-10.34)   Minimal Detectable Change (Chronic TBI)  MDC95 = Total HiMAT score increase of 4 points or decrease of 2 points2  Minimally Clinical Important Difference Not established  Cut-Off Scores  Not applicable  Standard Error of Measure (Chronic TBI)  SEM=1.36 |

1. Williams GP, Greenwood KM, Robertson VJ, Goldie PA, Morris ME. High-Level Mobility Assessment Tool (HiMAT): interrater reliability, retest reliability, and internal consistency. Phys Ther. 2006;86(3):395-400.

2. Williams G, Robertson V, Greenwood K, Goldie P, Morris ME. The concurrent validity and responsiveness of the high-level mobility assessment tool for measuring the mobility limitations of people with traumatic brain injury. Arch Phys Med Rehabil. 2006;87(3):437-42.

3. Kleffelgaard I, Roe C, Sandvik L, Hellstrom T, Soberg HL. Measurement properties of the high-level mobility assessment tool for mild traumatic brain injury. Phys Ther. 2013;93(7):900-10.Sensory Organization Test

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| ICF Category | Activity |
| Description | A form of posturography used to assess quantitative ability to use visual, proprioceptive and vestibular cues to maintain postural stability in bilateral stance in individuals with vestibular disorder. Computed averages identify impairments of individual sensory systems. |
| Measurement Method | 6 independent sensory conditions are tested including: eyes open on fixed surface, eyes closed on fixed surface, eyes open with sway referenced visual input, eyes open on sway referenced support surface, eyes closed on sway referenced support surface, and eyes open on sway referenced support surface with sway referenced visual input. Average center of gravity measured via force plate for each condition. |
| Nature of variable | Continuous |
| Units of measure | Composite equilibrium score is a weighted average of six conditions. Sensory analysis ratios are computed averages of individual sensory systems. Center of gravity alignment reports center of gravity in relation to the base of support at the start of each trial. Strategy analysis reports relative amounts of hip and ankle strategy used to maintain balance. |
| Diagnostic Accuracy | Reliability Internal consistency – Not established  Inter-rater reliability – Not established Test-retest Reliability (Healthy young adults)1  Adequate composite score reliability ICC =0.67  Poor to adequate individual equilibrium scores ICC-0.35-0.79  Responsiveness  Not established  Minimal Detectible Change (Healthy young adults)  MDC – Composite change greater than 8 points indicates change due to rehabililitation.1  Minimally Clinical Important Difference Not established  Cut-off Scores (Vestibular)2  Composite score less than 38 indicates increased likelihood ration (4.13) for repeated fallers in past 6 months (sensitivity 53%, specificity 87%)  Standard Error of Measurement (Healthy young adults)1  Composite Score SEM = 2.81 |

1. Wrisley DM, Stephens MJ, Mosley S, Wojnowski A, Duffy J, Burkard R. Learning effects of repetitive administrations of the sensory organization test in healthy young adults. Arch Phys Med Rehabil. 2007;88(8):1049-54.

2. Whitney SL, Marchetti GF, Schade AI. The relationship between falls history and computerized dynamic posturography in persons with balance and vestibular disorders. Arch Phys Med Rehabil. 2006;87(3):402-7.

Vestibular/Ocular-Motor Screen

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| ICF Category | Body Structure, Body Function |
| Description | Developed to assess vestibular and ocular motor impairment via patient-reported symptom provocation.1 |
| Measurement Method | Brief assessments of smooth pursuit, horizontal and vertical saccades, convergence, horizontal vestibular ocular reflex, and visual motion sensitivity. Patient reported changes in headache, dizziness, nausea, and fogginess used to rate symptom provocation following each assessment and compared to preassessment state.1 |
| Nature of variable | Ordinal |
| Units of measure | Patient report of change in headache, dizziness, nausea, and fogginess on a scale of 0 (none) to 10 (severe) |
| Diagnostic Accuracy | Reliability (Sport-related Concussion)  Excellent Internal Consistency – Chronbach’s alpha = 0.92  Inter-rater – not applicable  Intra-rater – not applicable  Responsiveness  Not established |

1.Mucha A, Collins MW, Elbin RJ, et al. A Brief Vestibular/Ocular Motor Screening (VOMS) assessment to evaluate concussions: preliminary findings. Am J Sports Med. 2014;42(10):2479-86.

2. Weightman M, Radomski M, Mashima P, Roth C. *Mild Traumatic Brain Injury Rehabilitation Toolkit.* Chapter 3: Balance and Functional Abilities Assessment and Intervention, pg. 79. Borden Institute. Fort Sam Houston, TX. 2014.