

Recommended Vestibular Outcome Measures for Use in the Military Population

Vestibular injuries in military personnel can differ from those in the civilian population and can occur as a result of a combat situation and/or blast injury.¹ Vestibular symptoms that arise as the result of a traumatic brain injury (TBI) or concussion can have more complex etiologies than vestibular deficits resulting outside of combat situations.¹ Typical treatment strategies for dizziness might not be appropriate for a patient who also has experienced a TBI. Clinicians could benefit from information about how to best treat patients with these two simultaneous and complex conditions.

Current best evidence suggests that in individuals with concurrent concussion and symptoms of dizziness (whose symptoms aren't resolved with rest) vestibular rehabilitation could be beneficial in resolving these symptoms.² Although the evidence is varied in terms of which specific interventions are best practice, some that have been shown to be beneficial include: static and dynamic balance activities, canalith repositioning maneuvers, gaze stabilization exercises, and adaptation exercises.²⁻⁴

Unfortunately the current evidence for evaluating and treating individuals with concurrent TBI and vestibular symptoms is extremely limited. The purpose of this paper is to suggest tests and outcome measures that can be incorporated into a future research study to further investigate the specifics of how vestibular rehabilitation can improve outcomes in military personnel with concurrent TBI.

The following outcome measures have been evaluated by the American Physical Therapy Association Vestibular EDGE (VEDGE) task force, as well as published in the Mild Traumatic Brain Injury Toolkit published by the Army Medical Department's Borden Institute.^{1,5} These measures have been evaluated by both groups as the best outcome measures and tests to be used with patients with vestibular symptoms, thus extensive justification of the reliability and validity of each measure will not be provided. The following tests and outcome measures are listed below generally in terms of more highly recommended to less recommended. However, all listed tests and outcome measures were

selected due to their recommended use in research and appropriateness for use with military personnel.¹

Outcome Measures and Tests:

VOR/Gaze/Cervicogenic

[Dynamic Visual Acuity Test - Non-Instrumented \(DVAT NI\):](#)

The Dynamic Visual Acuity Test - Non-Instrumented is a test of vestibulo-ocular reflex (VOR) function and eye gaze stabilization during passive rotational head movement.⁶ A Snellen eye chart or clinically equivalent chart (such as the ETDRS chart) is needed to perform this test.¹ For the test the subject starts seated a specific distance from the chart (4 meters for ETDRS chart and 20 feet for the Snellen chart) and is tested on their static visual acuity by reading the lowest line possible (with three or fewer errors) while their head is stationary.¹ The clinician then passively flexes the subject's head 20-30 degrees and oscillates it horizontally at 2Hz.⁶ Then subject then reads the lowest line possible with three or fewer errors. The difference between the number of lines between the static and dynamic portions of the test determines the result.¹ Greater than two lines difference in the results is a positive sign for oscillopsia.¹ This instrument is of value for individuals in the military because it should be used with individuals with suspected UVH including those who have experienced a TBI.¹ This measure is also one of the main measures utilized in the Military Functional Assessment Program which is used to determine a soldier's competency level after TBI.⁷ This test can be used at any stage of recovery, it's low-cost and has a quick administration time.^{5,6} It's commonly utilized in conjunction with the Head Impulse Test and/or the Head Shaking Nystagmus Test.⁶

[Head Impulse Test/Head Thrust Test \(HIT/HTT\):](#)

The Head Impulse test also known as the Head Thrust test is used to assess VOR integrity.¹ Specifically the angular vestibulo-ocular reflex (aVOR) as it relates to the horizontal semicircular canal (HSCC) and superior vestibular nerve function.⁸ This test is best used with subjects who are experiencing dizziness,

vertigo, oscillopsia, and imbalance.¹ It's also helpful as a differential diagnostic tool as the test is not positive as a result of migraine or cerebellar stroke.¹ To begin the therapist first clears the patient's cervical spine and vertebral arteries for any impairments or insufficiencies.⁸ Once both are cleared and it's been assured the subject has a pain from range of motion (ROM) the therapist then faces the subject and grasps their head by their ears.⁸ The therapist then passively flexes the subject's head 30 degrees and laterally rotates the subjects head right and left in a 20-30 degree motion arc.⁸ The subject should keep their eyes open and fixed on a target (typically the therapist's nose). The horizontal oscillations should be performed by the therapist to relax the subject.¹ After patient is relaxed quickly laterally rotate the subject's head 10 degrees to one side and stop the movement while watching the subject's eyes. A refixation saccade after their head is motionless is indicative of vestibular hypofunction on the side that the head was rotated toward.⁸ The test can be repeated to confirm the compensatory saccade's presence but the response decreases with repeated trials. Administration is less than one minute.¹ This tool has been recommended for use by the APTA VEDGE taskforce for both acute and chronic peripheral vestibular dysfunction and is appropriate for research.^{5,8} This instrument is of value for individuals in the military because it should be used with individuals with suspected UVH including those who have experienced a TBI.¹ It's commonly utilized in conjunction with the Head Shaking Nystagmus Test.⁶ When the HSN test and HIT are used in combination there's a higher likelihood of vestibular dysfunction.⁹

[Head Shaking Nystagmus Test \(HSN\):](#)

The Head Shaking Nystagmus test is used to assess dynamic vestibular asymmetry and peripheral vestibular disease.^{1,9} It's a simple screen for subjects with vertigo, dizziness, oscillopsia, and imbalance.¹ Infrared or Frenzel goggles are highly recommended for this test.⁹ Electronystagmography, or videonystagmography may also be used to view any nystagmus that may be present.⁵ These devices improve both the clinician's ability to see the subject's eyes and prevent the subject from fixating on a

target which can suppress the nystagmus.¹ The test starts with the subject in sitting and the therapist should first assess the patient for spontaneous nystagmus.¹ If negative then the therapist can continue. The patient should close their eyes and flex their head forward 30 degrees. The therapist then laterally rotates the subject's head back and forth 45 degrees in each direction at a rate of 2Hz (20 times in 10 seconds).¹ The therapist stops the movement with the head in a neutral position and asks the subject to open their eyes. Three or more consecutive beats of nystagmus is positive.¹ If the nystagmus beats toward the active side it's indicative of vestibular imbalance, whereas vertical nystagmus, prolonged nystagmus, or dysconjugate nystagmus is indicative of a central etiology.^{1,9} Administration time is less than 2 minutes.⁹ This tool has been recommended for use by both the APTA VEDGE taskforce and the TBI EDGE taskforce and is appropriate for research.^{5,9} Instrument is of value for individuals in the military because it should be used with individuals with suspected UVH including those who have experienced a TBI.¹ This test can be used at any stage of recovery, it's low-cost and has a quick administration time.^{5,6} It's commonly utilized in conjunction with the Head Impulse Test and/or the DVAT_NI.⁶ When the HSN test and HIT are used in combination there's a higher likelihood of vestibular dysfunction.⁹

BPPV Measures

[Dix-Hallpike Maneuver:](#)

The Dix-Hallpike Maneuver is the gold standard in diagnosing posterior canal BPPV.¹ This maneuver is used in a vestibular examination when the subject reports symptoms of vertigo, dizziness, and imbalance.¹ It's especially useful in subjects who report a history of vertigo due to gravity related changes in head position.¹ When the Dix-Hallpike Maneuver is performed, if positive for BPPV, subjects will experience vertigo as well as upward and ipsitorisional nystagmus.¹⁰ Dix-Hallpike provokes vertigo and nystagmus within 5 to 20 seconds of maneuver positioning but symptoms should resolve in less than 60 seconds.¹ These symptoms combined with history of positional vertigo, confirms the diagnosis of posterior canal BPPV.¹ While performing the test it's recommended that the clinician wear Frenzel or

infrared goggles.¹⁰ This improves the clinician's ability to see the subject's eyes and prevents the subject from fixating on a target which can suppress the nystagmus.^{1,10} However, the test can still be performed in room light if goggles aren't available.¹⁰ The patient initially sits in long-sitting on a mat, positioned so that when in supine the subject's head is supported solely by the examiner with only the subject's shoulders and body on the mat. The therapist then quickly moves the subject into supine while supporting the weight of the head in 45 degrees of rotation to the right and 20-30 degrees of extension.^{1,10} For the right Dix-Hallpike the subject's head is rotated to the right and for the left Dix-Hallpike the subject's head is rotated left.¹ The subject stays in this position for 60 seconds while the clinician waits for the vertigo and nystagmus (if present) to dissipate, then the subject is returned to long-sitting.¹ Administration time is less than 5 minutes.¹⁰ This test received the highest level of recommendation from the VEDGE task force and should be utilized to evaluate subjects with both acute and chronic positional vertigo complaints.⁵ It's also been evaluated for use following head trauma making it one of the highest rated tools available for assessing vestibular symptoms following head injury.¹

Roll Test:

The Roll Test is a provocation test used to identify the presence or absence of horizontal canalolithiasis or cupulolithiasis.¹¹ This test is appropriate for individuals with complaints of dizziness, vertigo, or imbalance. This test is most useful for individuals with a history of BPPV but a negative Dix-Hallpike maneuver.¹ Electronystagmography, videonystagmography, a video recorder, and infrared or Frenzel goggles can be used to view any nystagmus that may be present.⁵ These devices improve both the clinician's ability to see the subject's eyes and prevent the subject from fixating on a target which can suppress the nystagmus.¹ However, the test can still be performed in room light if none of the above equipment is available. The test starts with the subject in supine with their head supported in 20 degrees flexion by the clinician. The clinician quickly laterally rotates the subject's head 90 degrees and

maintains the position for at least 60 seconds. The subject's entire body can be rotated 90 degrees if modification for orthopaedic impairments is needed; however, the head position is the primary factor in this test. For the right Roll Test the subject's head is rotated to the right and for the left Roll Test the subject's head is rotated left.¹ The clinician should observe the subject's eyes for nystagmus and whether it's geotropic (toward the earth) or apogeotropic (away from the earth).^{1,5} The Roll Test provokes vertigo and nystagmus within 5 to 20 seconds of moving into the test position but symptoms should resolve in less than 60 seconds.¹ The subject's head should be returned to the neutral starting test position when the nystagmus subsides or in the absence of nystagmus.¹ When the subject's nystagmus is less than 60 seconds in duration and geotropic it's indicative of canalithiasis; while nystagmus that's greater than 60 seconds in duration and apogeotropic is indicative of cupulolithiasis.¹¹ Administration time for the Roll Test is less than 5 minutes.¹¹ The VEDGE task force rates this tool 2/4 in terms of recommendations for use due to the variability in technique and the need for more extensive reliability and validity data, however they do recommend its use in research.⁵ The APTA TBI EDGE taskforce also recommends its use.¹¹ In addition, Weightman et al. recommend its use for individuals with brief, episodic, positional vertigo that occurs either spontaneously or after head trauma, making it a beneficial test for individuals with concurrent TBI and vestibular symptoms.¹

Activity/Participation Measures

[Dizziness Handicap Inventory:](#)

The Dizziness Handicap Inventory (DHI) is a self-report questionnaire that measures an individual's perception of their disability due to vestibular system dysfunction.¹ The 25 item questionnaire is broken up into three subsections, emotional (9 items), functional (9 items), and physical (7 items) and scored out of a possible 100 points. The response options for each question include: yes (4 points), sometimes (2 points) and no (0 points).¹ The test can be taken via pen and paper or electronically and takes 5 minutes each to administer and score.¹ For individuals with vestibular disorders this outcome measure is

the standard for disease specific quality of life and health status¹ It's been evaluated for use in military populations, specifically individuals with dizziness after brain injury as well as exercise-induced dizziness.¹ This tool can best be used to set objective treatment goals, assess treatment efficacy, and measure pre and post-intervention changes.⁵ This test is recommended for use in research by both the APTA Vestibular EDGE task force and the TBI EDGE task force.¹² The VEDGE task force highly recommends this outcome measure for individuals with acute and chronic vestibular impairments including: BPPV, peripheral canal involvement and central canal involvement.¹² This measure is one of the main measures in the Military Functional Assessment Program which is used to determine a soldier's competency level after TBI.⁷ This is an excellent outcome measure to use with service members who have complaints of vestibular symptoms.¹

Vestibular Disorders Activities of Daily Living Scale (VADL):

The Vestibular Disorders Activities of Daily Living Scale is a self-report measure designed to assess self-perceived disability due to vestibular impairments.¹³ This outcome measure is best for individuals with complaints of dizziness, vertigo, and imbalance.¹³ The outcome measure is a 28 item questionnaire comprised of 3 subscales: instrumental (complex tasks outside the home), mobility and functional.^{1,13} Items are scored 1 to 10 with 1 equaling independence and 10 an inability to participate in an activity.¹ The tasks involved are higher level, socially complex activities (such as driving a car or riding an elevator) making it more conducive for use with an active, higher-functioning population.^{1,13} Administration time is 5 to 10 minutes with an additional 5 minutes for scoring.¹ This tool has been recommended for use in research by the APTA VEDGE taskforce and is appropriate for individuals with acute and chronic vestibular symptoms during specific and basic ADLs.¹³ It's best used to assess functional limitations and perceived disability due to vestibular impairments before and after activity.¹³ It's been used in the military population to assess vestibular complaints after blast exposure at acute, subacute, and chronic stages of injury.¹

Symptom Severity Scale

Motion Sensitivity Quotient Test (MSQ):

The Motion Sensitivity Quotient test is designed to assess motion provoked dizziness.¹⁴ It can also be used to identify functional movement triggers that provoke the subject's dizziness and to create individualized exercise programs for patients.¹ The test itself includes 16 quick changes in head and body position. The positions include variations of moving through sitting to supine, in and out of side lying, variations of the Dix-Hallpike Maneuver, head turns in sitting and standing, and head movements combined with forward flexion of the trunk.¹ Scoring is based on symptom intensity (subject report) and duration (timed with stopwatch).¹⁴ Improvement on the test is judged by decreased symptom duration and intensity, decreased number of positions that provoke the symptoms and increased amount of repetitions before symptom onset.¹ Administration time (including scoring) is 20-30 minutes.¹⁴ This tool has been recommended for use in research by the APTA VEDGE taskforce and is appropriate for individuals with acute and chronic motion provoked dizziness during activities of daily living. It's appropriate for the military population as it's been tested in individuals with traumatic brain injury, vestibular disorders, and community dwelling individuals who experience dizziness during ADLs.¹⁴

Postural/Dynamic Stability

Balance Error Scoring System (BESS) - Instrumented:

The Balance Error Scoring System objectively measures balance impairments in individuals post-concussion or mTBI. The instrumented BESS is similar to the BESS but requires the use of either inertial sensors or force plates to objectively measure subtle balance anomalies. The BESS is excellent for evaluating and assessing post-concussion complaints.¹⁵ For the test the subject is required to wear either inertial sensors or stand on a force plate for 6 different trials of 30 seconds each.¹⁶ Eyes closed with hands on iliac crest for every trial. Each trial is varied by changing the body position (feet together, SLS, or tandem stance), or standing surface (firm or foam).¹⁵ The sensors or force plate measures the

sway velocity (in m/s^2) for each individual.¹⁵ A modified BESS has been identified which has all the same components save that the foam surface is not utilized, which consequently requires only 3 trials to complete the measure.¹⁵ Administration time is less than 10 minutes.¹⁵ Interestingly a small cross-sectional study compared the BESS, modified BESS, instrumented BESS, and the instrumented modified BESS in teenaged subjects post-concussion and with a matched control.¹⁵ They found that the foam pad did not improve the ability to differentiate between the mTBI and control groups. However, they did find that instrumented modified BESS had the higher diagnostic accuracy of all four versions of the test.¹⁵ This could be beneficial when deciding between the instrumented BESS and the instrumented modified BESS. The instrumented modified BESS could save time and money while still potentially providing the most accurate data.¹⁵ While the instrumented version of the BESS has some data that inertial sensors might improve objective measures and increase sensitivity the evidence is currently mixed.^{15,16} Although the BESS has not been tested in the military population the BESS has been used to in individuals with self-reported balance complaints to correctly classify subjects with presence of TBI in those with mTBI.¹⁵ Additionally, the APTA VEDGE taskforce and TBI EDGE task force recommend the measure for use with individuals in outpatient rehabilitation and who are able to ambulate independently.¹⁷ They also state this measure is reasonable to use with individuals in the acute injury phase (less than 6 weeks post injury) with a possible central vestibular diagnosis.¹⁷

[Sensory Organization Test \(SOT\):](#)

The Sensory Organization Test is a form of computerized dynamic posturography (CDP) utilizing a dual force plate and 3 sides surround.^{1,18} This test quantitatively measures an individual's ability to use various sensory conditions in order to maintain balance.¹⁸ For the test, subjects stand in the device on the force plate while 6 sensory evaluation conditions are applied.¹⁸ The sensory components of balance (vestibular, vision, and somatosensory) are systematically removed to determine which sensory component the subject is relying on most for balance.¹ Each of the 6 conditions is tested with three trials

of 20 seconds each. The system is able to produce an equilibrium score (for each trial and a composite), sensory analysis ratios (to identify individual sensory impairments), center of gravity (COG) alignment relative to their base of support (BOS), and a strategy analysis (to analyze which ankle or hip strategies are used).¹⁸ The administration time is only 15 minutes but the equipment used to administer the test can cost anywhere from \$80,000 to \$180,000.¹⁸ It's also suggested that the test be administered by a clinician trained specifically on the equipment's use.¹⁸ This tool has been recommended for use by both the APTA VEDGE taskforce and the TBI EDGE taskforce as appropriate for research.¹⁸ Although unable to highly recommend due to limited studies in the target group, the VEDGE task force indicates the SOT is reasonable to use for acute, subacute, and chronic vestibular disorders. The TBI EDGE task force also indicates the SOT is reasonable to use for individuals whose ambulatory status ranges from completely independent to moderately dependent.¹⁸ This measure is also one of the main measures utilized in the Military Functional Assessment Program which is used to determine a soldier's competency level after TBI.⁷ Additionally, the SOT has been used to assess balance deficits in subjects with mild to severe TBI making it a viable option for the military population.¹

Abbreviations and Acronyms

ADL: activity of daily living
APTA: American physical therapy association
aVOR: angular vestibulo-ocular reflex
BESS: balance error scoring system
BOS: base of support
BPPV: benign paroxysmal positional vertigo
CDP: computerized dynamic posturography
COG: center of gravity
Dix-Hallpike: dix-hallpike maneuver
DHI: dizziness handicap inventory
DVAT_NI: dynamic visual acuity test_non-instrumented
ETDRS: early treatment diabetic retinopathy study
HSCC: horizontal semicircular canal
HSN: head shaking nystagmus
HIT: head impulse test
HTT: head thrust test
mTBI: mild traumatic brain injury
MSQ: motion sensitivity quotient
ROM: range of motion
SLS: single leg stance
SOT: sensory organization test
TBI: traumatic brain injury
TBI EDGE: traumatic brain injury evidence database to guide effectiveness
UVH: unilateral vestibular hypofunction
VADL: vestibular disorders activities of daily living scale
VEDGE: vestibular evidence database to guide effectiveness
VOR: vestibule-ocular reflex

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