Restoring Function After TBI: A Review of Physical Therapy Strategies for Balance, Gait, and Dual-Task Recovery

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ABSTRACT

Individuals with moderate to severe traumatic brain injury (TBI) often experience impairments in balance, gait, and dual-task ability, limiting their functional independence and community reintegration. These deficits arise from disruptions across sensory, motor, and cognitive systems, requiring comprehensive physical therapy (PT) assessment and intervention. PT evaluations incorporate strength, coordination, and sensory integration measures using standardized outcome measures such as the Berg Balance Scale, Functional Gait Assessment, and dual-task assessments such as the Timed Up and Go (cognitive). Treatment strategies include high-intensity training, gait and balance training, and vestibular rehabilitation, each targeting specific deficits to promote neuroplasticity and recovery. Technological interventions like the LiteGait®, virtual reality, and the Bioness Integrated Therapy System enhance therapy outcomes by improving safety, cognition, and balance. PTs must address psychosocial barriers and collaborate across disciplines to support holistic recovery. Ongoing evaluation using outcome measures guides treatment progression and readiness for community reintegration, highlighting PT's critical role in restoring functional independence post-TBI.

INTRODUCTION

Patients with moderate to severe traumatic brain injury (TBI) often have impaired balance, gait, and dual-task ability, which impacts their self-care, household, and community activities.[1] Balance deficits can be related to disruption of the complex integration between sensory, visual, and vestibular systems.[2] Individuals with TBI frequently demonstrate altered gait patterns, reduced walking speed, and impaired balance, particularly under dual-task conditions where cognitive and motor demands compete for attentional resources. Due to the multi-system effects that a TBI can have on cognition, sensory, and motor systems, there are limited available resources, leading to increased attentional demands while walking.[3]

Physical therapy (PT) plays an essential role in assessing balance and gait impairments, with quantitative and qualitative tools and outcome measures.[4] A physical therapy evaluation is multifaceted, including assessment of strength, range of motion, posture, balance, and gait while simultaneously considering cognition, sensory processing, and coordination. This assessment is the basis for treating balance, gait, and dual-task ability in people with TBI, which helps with re-integration back into the community.

ASSESSMENT OF BALANCE AND GAIT DEFICITS

Patients with TBI may experience impairments of the visual, vestibular, and proprioceptive systems, which are the primary mechanisms for postural control and balance.[5] Impairments in the ability to integrate information from these systems may also affect postural control and balance. TBIs can be diffuse, so other brain regions that maintain postural control may be damaged, including the cerebellum, pre-motor and motor cortices, and involvement of the vestibular system and cranial nerves. This can result in dyscoordination, weakness, spasticity, and abnormal motor planning, which further impairs balance in patients with TBI. As such, clinicians should examine these systems to determine if there are problems with their function or integration.[2,6]

In 2016, the Academy of Neurologic Physical Therapy (ANPT) published recommendations for outcome measures, including balance, when assessing patients with TBI, followed by additional recommendations in 2018 for patients with neurologic impairments.[4,7]

For patients with limitations in static and anticipatory standing balance, the Berg Balance Scale (BBS) is helpful in assessing fall risk, identifying treatment goals, and tracking progress. Patients who can ambulate with or without a device should have evaluations of their dynamic balance with the Functional Gait Assessment (FGA) or the FGA-Advanced (FGA-A).[2] Patients with TBI who are engaged in high level functional mobility in the community should be assessed with the High-Level Mobility Assessment Tool (HI-MAT) or Community Balance Mobility Assessment Tool (CBMT).[8,9]

ASSESSMENT OF DUAL-TASK DEFICITS IN TBI

Many daily activities involve concurrent motor tasks (walking while holding a box) or cognitive-motor tasks (conversing and driving).[10] Dual tasking requires the coordination

of multiple areas of the brain, including sensory, motor, and executive function, which can be disrupted in patients with TBI.[11]

A study demonstrated limitations in dual-task ability through use of the Stroop Word Task, which assesses attention and executive function based on the time to complete the task as well as the number of errors.[12] This study also demonstrated that people with a TBI exhibited greater difficulty, slower gait speed, and more caution when navigating obstacles, which may suggest increased reliance on attention for safety.

Although cognitive/communication impairments after TBI are usually evaluated by speech-language pathologists or occupational therapists, physical therapists also assess these deficits as they relate to balance and gait function. There are several tests that are recommended to assess dual-task ability across neurologic populations, including TBI. Standardized tests such as Walking While Talking (WWTT), Walking And Remembering (WART), and TUG-Cognitive (TUG-C) have shown excellent reliability and high inter- and intra-rater testing.[13] Dual-Task Cost (DTC) can be calculated with these outcome measures as follows: ((dual task performance-single task performance)/single task performance x 100). This provides a quantitative measure for changes in dual-task integration throughout the rehabilitation program.[3,14] Further research is needed to obtain data for dual-task cost related to TBI, but it remains a valuable assessment to monitor progress in dual-task ability.

TREATMENT OF BALANCE, GAIT, AND DUAL-TASK DEFICITS

Exercise is beneficial for individuals with chronic moderate-to-severe acquired brain injury. After six weeks of a moderate-to-high intensity program, a study demonstrated significant improvements in endurance, advanced gait, and ambulatory status, which were maintained six weeks after the program ended.[15] Exercise also improved physical, cognitive, emotional, and social functioning as well as overall well-being. Encouraging participants to reconnect with their "athlete" identity, based on their past involvement in sports, was highly motivating and contributed to positive psycho-social outcomes. This approach helped bridge the gap between their "old self" (pre-injury) and "new self" (post-injury), promoting a sense of self-affirmation and boosting their confidence. Overall, increasing physical activity while incorporating salient social aspects kept participants engaged.[15]

Patients with TBI can improve their balance through treatment strategies that integrate principles of motor learning to induce functional neuroplasticity.[16] However, there is limited evidence for the effectiveness of balance interventions in people with moderate to severe TBI.[17] Current treatment strategies to address balance in this population include high intensity training (HIT), vestibular rehabilitation therapy (VRT), and virtual reality (VR).

HIT has been utilized for dynamic balance retraining in neurologic diagnoses including stroke, SCI, and TBI, but there is a paucity of literature on HIT for patients with TBI. Although strokes and TBI have different mechanisms of injury, both involve damage to the white matter, leading to similar functional deficits.[18,19] For this reason, the evidence for people with chronic strokes has been extrapolated to people with chronic TBI. Studies have demonstrated sustained improvements in transfers, balance confidence, and dynamic balance with HIT when compared to low intensity controls.[18,20] More studies are needed to explore the benefits of HIT training for patients with chronic moderate to severe TBI.

Treadmill walking with support harnesses, such as the LiteGait® system, can be used to assist patients through partial weight support or as a safety harness, depending on the patient's abilities. It allows for repetitive gait training and high intensity training while maintaining safety, which can enhance neuroplasticity and motor learning.[21] Although research has not demonstrated the benefits of body-weight-supported treadmill training for people with an acquired brain injury, it is an effective approach for improving walking capacity and gait quality. The repetitive nature of this training is thought to re-establish sensorimotor systems in individuals with moderate to severe chronic brain injuries.[22]

VRT is also utilized by physical therapists to improve balance for individuals with chronic moderate to severe TBI. VRT can include gaze stability training, habituation to dizziness, and balance exercises. Gaze stability training involves focusing on a target coupled with head motion, which recruits the vestibular ocular reflex (VOR). Habituation exercises induce moderate dizziness to help the brain adapt and reduce the intensity of dizziness. Balance exercises usually focus on sensory integration to improve vestibular and other sensory inputs.[23] The evidence for VRT on balance is mixed but favors VRT over conventional PT.[23,24] VRT may also include canalith repositioning maneuvers (CRM) for patients with Benign Paroxysmal Positional Vertigo (BPPV), which can affect 4–38% of people with TBI.[25,26] The effectiveness of CRMs ranges from 60–85% but recovery may be more prolonged in patients with TBI.[27,28] These maneuvers can cause neck/back injuries, nausea, and dizziness, so they should be performed by only well-trained therapists.

VR programs are emerging as treatments to augment balance therapy and even improve cognitive deficits for people with TBI.[29] Some of these VR systems immerse individuals in environments with obstacles and other pedestrians, so they have to focus on safe ambulation in the community. A small systematic review found no significant differences in balance outcomes between VR and conventional PT, but the authors noted that VR has promising effects on the visual, somatosensory, and vestibular systems; it also includes

motor learning principles such as repetition, feedback, and motivation.[6] Given that VR is more accessible in clinical settings, its utilization offers clinicians the ability to augment balance treatment and integrate motor learning principles.

A study on avoiding collisions with virtual pedestrians showed that patients with moderate to severe TBI have locomotor limitations as well as reduced cognitive task accuracy under dual-task conditions.[29] With VR they can safely practice interactions with virtual pedestrians and less risk of falls and injuries As expected, participants with TBI had alterations in their gait and balance for obstacle avoidance. They also had difficulties with dual-tasking and avoiding pedestrians from multiple directions. This study demonstrated that increased task complexity had a greater impact on gait and balance.

Another technology, the Bioness Integrate System (BITS), has been utilized in the rehab setting to improve visual and spatial function. The BITS is a computer-based interactive tool that offers a variety of programs to improve visual, cognitive, and motor impairments in neurological populations. These activities are designed to improve reaction time, working memory, visuospatial perception, balance, and postural stability. These tasks can be measured for changes during a patient's rehabilitation treatment. There is limited research for its use in the TBI population, but other neurological conditions such as stroke have responded well to this training.[30]

CONCLUSION

Physical therapists play a vital role in the assessment and treatment of balance, gait, and dual-task deficits following chronic moderate-to severe TBI. There is mixed evidence for some of the above treatments, but these interventions have improved balance, mobility, and safety. PTs should assess patients with TBI to determine which treatment strategies are best for balance, gait, and dual-task impairments. Psychological and social barriers should also be considered, given their prevalence in this population and their potential role in community re-integration.[23] More research is needed to determine which treatment strategies are most effective for treating patients with chronic moderate to severe TBI.

Overall, progress is tracked throughout the rehabilitation program to determine when patients are ready for reintegration into the community or their work life. This includes regular assessments of gait speed, balance and fall risk, and cognitive recovery. Standardized outcome measures should be used to assess cognition, dual-task function, balance, gait, and functional mobility. These tools can guide physical therapists in determining functional abilities and progress during the rehabilitation process. The goal of rehabilitation is to help patients return to their community and work environments through physical, cognitive, emotional, and social recovery. This ensures that patients can function as independently as possible. Physical therapists should actively work within an interdisciplinary team to meet these goals.

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Disclosures

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