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PICO: In people with moderate-severe brain injuries, is body weight supported treadmill training more effective than conventional over ground gait training in improving kinematics of functional gait?

Introduction

Traumatic brain injury (TBI) is categorized as a disorder of major public health significance as it affects an estimated 6.5 million individuals[2, 3]. TBI most often occucrs from high velocity trauma such as motor vehicle accidents, falls, or acts of violence, as well as sports and military combat accidents[19]. The incidence of TBI is evident by two peaks; one in the second and third decades of life and again after the seventh decade of life[4]. It is esimated that approximately 1.7 million people sustainin a TBI annually[6], accounting for atleast 12% of all hospital admissions in the United states[7, 14]. These statistics demonstrate how TBI is an extraordinary medical problem in the US both economically[7] and in regards to personal health and longevity.

TBI may be catergorized as mild (concussion), moderate, or severe depending on presence of loss of conciousness, duration of post-traumatic amnesia (PTA), and Glasgow Coma Scale (GCS) score. Moderate TBI is classified with a loss of conciousness between 30 minutes and 24 hours, PTA lasting for 24 hours to 7 days, and a GCS score between 9 and 12. On the other hand, a severe TBI is defined by a loss of conciousness greater than 24 hours, PTA lasting 7 days or longer, and a GCS of 8 or less (coma)[11]. Level of recovery from a TBI is influenced by numerous factors including the injury severity, the body's quality and speed of recovery, brain functions affected by the injury, areas of brain function not affected by the injury, age, and other injuries sustained during the traumatic event[11].

Unfortunately, moderate and severe TBIs may result in lifelong physical, cognitive, and pscychosocial functional impairments. It can interfere with activities of daily living, mobility, and communication[13]. Despite the vast available literature on disruptions of cognitive and executive functions seen in patients with TBI, the study of motor deficits in this population is still relatively sparse[9]. Movement disorders including abnormal stregnth, coordination, balance and gait, are not only among the most labor intensive for rehabilitation specialists, but they also significantly decrease the person's qualtiy of life. In particular, loss of ambulation is shown to be especially devasating as it greatly influences independence[15]. Because of its significance, gait retraining and optimal gait performance has become an area of interest for rehabilitation specialists working with these patients.

Conventional or traditional gait training has various definitions and interpretations but typically includes indoor or outdoor ambulation over ground which may or may not include use of parallel bars, assistive devices, or therapist assistance. Specific methods may include weight shifting, stepping, walking forwards or backwards, side stepping, and strategies to improve speed, symmetry, quality, and endurance[12]. This conventional method of gait training may also be used in conjunction with strengthening, flexibility, coordination, and postural exercises as well as transfer and balance training.

Recently, gait reeductation and rehabilitation has gained a new tool in commerically available partial weight-bearing (PWB) gait retraining systems. This rehabilitation strategy was orginally dervied from promising research demonstrating improved quality of locomotion in spinalized cats following suspension in harnesses over treadmills[17]. Many studies have since investigated the benefit of body-weight supported treadmill training (BWSTT), a gait retraining technique performed on a treadmill with an overhead hareness system support that may be adjust the percentage of body weight supported. This new assistive technology has been clinically utilized for copious physical injuries including stroke, spinal cord injury, amputation, Parkinson's disease, TBI and cerebral palsy. Randomized control trials and systematic reviews have specifically addressed the value of this intervention for patients with incomplete spinal cord injuries, Parkinson's and stroke[1]. Unforunately, literature addressing the efficacy of BWSTT and PWBSTT use for individuals with TBI is very limited.

The purpose of this review is to outline the existing literature regarding utilization of BWSTT in the rehabilition of persons with moderate to severe TBI and to determine if BWSTT is more effective than conventional over ground gait training at improving the kinematics of functional gait in this population. Results from this clinical question will assist rehabilitation facilities in financial decisions regarding purchasing of such assistive technology devices for their patients following TBI and also justify the physical therapist's rationale in selecting the most appropriate gait training methods for these clients.

Summary of Evidence

Gait Characteristics Following TBI

In order to treat any dysfunction effectively and optimally, it is essential to know what impairments exist. Common gait deviations and abnormal patterns of movement commonly seen in patients with TBI include equinovarus, excessive toe curling, excessive hip and knee flexion, "scissoring thighs" and "stiff-knee" gait[13]. In most literature addressing this topic, biomechanical analysis is compared to information already obtained of ambulation patterns in healthy individuals [9 13, 18]. Gait characteristics and outcomes such as cadence, gait speed, step length, stance time, swing period and joint angle measurements are often utilized for assessment in these studies. Methods of gait analysis used in these kinematic studies include observational methods with or without video, kinematic measurement, kindetic force analaysis, energetics, or dynamic electromyography methods.

One particular retrospective study[13] set out to determine how temporal-spatial characteristics of gait differed in patients with TBI from healthy individuals as well as patients with stroke. A review of 478 patient files with videotaped gait analysis revealed the gait velocity of patients with TBI is almost half that of noninjured controls. In addition, increases in stride time, stance time for affected limb, and double limb support were seen along with decreases in cadence and step length in the TBI population when compared to the controls. When contrasted with stroke survivors, patients with TBI show increased gait velocity, equal stride time and cadence, and decreased stance time. It is important to note that a slower gait veocity is evident in patients within 1 year or at 15 years post TBI[13].

Similar results were found in a more recent observational study[9] investigating the residual locomotor effects of TBI on unobstructed and obstructed walking in high functioning subjects. In addition to the above spatio-temporal features of gait, this study considers toe clearance over an object obstructing the walking path and heel-toe proximity. Furthermore, this study compares locomotor ability with reputable outcome measures such as the Dynamic Gait Index (DGI), GCS, timed 10 meter walk, Berg Balance Scale (BBS) and timed single limb stance with eyes open and closed. These authors reveal a decreased crossing speed of the trail limb over obstruction and further distance of trail leg from the obstacle in those with TBI. Interestingly, this second study shows that the decrease in gait speed noted when comparing patients with TBI to healthy controls displayed is both studies[9, 13] is due to a decrease in step length, not cadence[9]. This study also justifies that the decreased step length shown in both studies is most likely due to subtle changes in joint angles across multiple joints and not primarily one. Both gait analysis studies[9, 13] demonstrate a more cautious gait following TBI and support need for research in independent assessment of gait speed components and in various environments with the TBI population.

Gait Training Methods

With more evidence mounting regarding how gait of patients with TBI differs from healthy individuals, attention shifts towards questioning which gait training approach best promotes able-bodied walking following brain injury. Two small cohort studies sought to directly answer this matter[16, 18]. Williams et al.[18] compare the effects of 7 gait training conditions (therapist facilitation, use of assistive device, TT without BWS, BWSTT, BWSTT+therapist assistance, BWSTT+upper extremity self-support (UESS) and BWSTT+UESS+therapist assistance) on the gait performance scales, temporal-spatial features, and kinematic measurements of individuals with brain injuries during ambulation. This study found signficant decrease in gait velocity during conditions with therapist assistance and assitive devices but interestingly found that if patients use UESS, they ambulate 3xs faster. Similarly, Visintin and colleagues[16] proved the importance of external factors and environment in affecting gait characteristics. They assessed qualitiative and quantative effects of ambulation with and without parallel bars, BWS and at increased treadmills speeds using EMG and joint angles in patients with spastic paretic gait which is often seen in patients following TBI[10]. Incongruous to the previous study[18] however, these authors [16] found that UESS during gait training in parallel bars contributes to asymmetrical gait, increased compensatory patterns, and decreased lower extremity EMG activity. Authors[18] also suggest gait training in BWS harness even without BWS may be beneficial because it leads to more normal swing phase, and decreases compensation, asymmetry, and clonus[16].

When determining the recovery patterns of walking ability in two patients with severe TBIs using BWSTT[20], both the acute and chronic patient in these case studies show modest improvements in spasticity, strength, and functional ambulation category during an 8 week period. This training involved BWSTT for one hour twice a week but no exact BWSTT protocol is described within the article[20].

The promising results of BWSTT seen by Wilson's[20] two patients with TBI have not been duplicated on a grander scale thus far. Two randomized control trials have been conducted to compare the efficacy of BWSTT and conventional over ground gait training(COGT) at improving functional ambulation in individuals with TBI[1, 19]. One study looked at patients with chronic TBIs (ranging 7-23 years post-injury) with gait training for 14 weeks[1] . The other[19] concentrated on patients in the rehabilitation setting receiving gait training for 8 weeks. Both studies randomized subjects into groups receiving BWSTT twice a week or a group which received COGT. Patients in the rehabilitation setting also received traditional physical therapy twice a day[19]. In both studies, both groups demonstrated improvements regardless of which intervention was applied. Improvements were seen in step width towards normal[1], standing balance scale, functional ambulation categories, gross motor subscale, and FIM and FAM[18] in both the BWSTT and COGT groups. Both studies support that BWSTT is not found to be any more effective than traditional physical therapy with COGT at improving functional gait as both intervention groups improve similarly. While each treatment method may be beneficial, one is not found to be suprerior at this time. Brown[1] makes a valid point that the specificity of training over ground may have an effect on the results however since pre- and post-intervention outcome measurements are taken over ground.

Conclusion/Discussion

BWSTT has been widely studied in patients with incomplete spinal cord injuries, Parkinson's disease and stroke[1]. This article sought to determine if BWSTT is more effective than COGT in improving kinematics of functional gait in individuals with moderate to severe TBI. Despite two promising case studies utilizing BWSTT in patients with TBI[20] and improvements seen in patients with hemiparesis[8] and spasticity[16], randomized control trials have not demonstrated BWSTT to be more effective than COGT in neither the acute[19] nor chronic[1] TBI population at this time.

Evidence exists which may help to explain why so many systematic reviews are unable to find BWSTT more beneficial than COGT[1, 19, 20]. Williams[18] believes this is in part because studies to date do not consider UESS during training. In addition, protocols which solely focus on increasing gait velocity and decreasing BWS may fail to consider the impact that UESS may have for these individuals[18]. It is also suggested that BWSTT gait velocity and improvements made on a treadmill with a harness support and therapist assistance may not transfer to over ground ambulation velocity and gait patterns[1, 20].

Outcome measures frequently used in these studies such as DGI, BBS, Modified Ashworth, Functional Ambulation Categories, Rivermead Mobility Index, and Timed Up and Go[1, 8, 19 20,] may not be sensitive enough to assess the subtle improvements seen in gait with the TBI population. In response, Wilson[20] has developed the Missouri Assisted Gait Scale (MAG) in order better assess this walking progression. Results of his own study demonstrate that improvements in patients' walking ability is most evident when measured using the MAG scale[20]. Support is needed for further psychometric research and utilization of the MAG scale or other outcome measures to asses the efficacy in measuring improvement of gait in this specific population[19, 20].

Most of these studies begin their BWSTT protocol with 30% BWS based on an initial study and evidence that patients have limited heel strike at 40% BWS[1].

Most studies allow physical assistance when needed[1, 8, 17, 18, 19, 20,] byt studies vary regarding gait velocity. Some studies test at the individuals' comfortable gait speed[17, 18] while others use the fastest speed tolerated[1, 8]. BWSTT is also progressed differently for each study with some decreasing BWS 10% with 10 consecutive bilateral heel stirkes[1], others increase velocity while decreasing BWS as quickly as possible[8] or follow a previous protcol that is not adequately described[19, 20]. Currently, no optimal BWS protocol has been established and used standardly which makes reviewing articles and effiacy of this treatment intervention ambiguous and difficult.

Each study, including the randomized control trials, have small sample sizes, weakening each studies argument. Effect size and power are often not addressed in these articles. There is simply not enough evidence from trials to determine the effect of gait training with or without BWS for walking after TBI to conclude superiority of a gait training method.

A therapist may still choose to use BWSTT because it allows for earlier gait rehabilitation, simulation of "task-specific" walking movements, numerous repetition, earlier weight-bearing for strength increases and spasticity reduction, freedom for therapists to assist patients in componenets of gait [19, 20], provides a safe environment, enables practicing gait as a whole task, and BWS can be gradually decreased and controlled[1]. There are also disadvantages to BWSTT as it requires a substantial investment of time and money[1] and it's labor intensive, typically involving at least two staff members. If patients usually do not actively control their lower extremity movements, there is a greater chance that those using BWSTT will receive more passive assistance from the continuous treadmill and therapists, resulting in a more passive adaptation with less actual learning[1].

Recommendations for Future Evidence

As stated earlier, all studies in this review suffer from a small sample size. Therefore, larger samples are needed in future studies to improve the validity of conclusions. Unique difficulties in studying gait rehabilitation in a TBI population include nonhomogenity of gait deficits after TBI and that each individual has a unique recovery course that is not easily predicted with any assessment device[19]. Multiple articles support the need for BWSTT research in a more homogenous group of individuals with TBI to determine if a certain patient profile or characteristics would receive better outcomes from BWSTT [1, 17, 18, 19]. Controlling any single variable is an inherent problem with virtually all post-TBI studies. The patients are invariably receiving numerous therapies, medications, and interventions and spontaneous recovery plays a role as well. It is difficult to then isolate one factor for a study while keeping others constant[5]. There is a great need for future studies using established outcome measures sensitive to the specific change in this population[18, 19] as well as proper controls[16, 18, 19], and independent assessment of gait characteristics[9]. Trials with longer intervention periods should also be assessed to see if this will affect the results and outcomes of this method of gait training[1, 8].

Application to clinical practice & Capstone

Though BWSTT has not been found to improve kinematics of functional ambulation more than COGT, both strategies are found to be effective. A BWS system requires a large financial investment as well as increased manpower to implement. It is therefore important for a facility to be aware of the true cost-benefit when deciding if such a system should be purchased and utilized in their setting for their patients. According to inconclusive evidence, purchasing and utilizing this expensive equipment may not significantly improve a patient's functional gait anymore than COGT typically implemented in this setting. That being said, even if a facility does not have access to a BWS system, they can still provide their patients with quality, and possibly more effective care, using COGT. If a patient does participate in BWSTT, is important that they are weaned fully off of the support over time and practice COGT as well to increase the carryover from treadmill training to over ground ambulation[1].

Retraining gait with BWS while increasing the demand on locomotor system by removing parallel bars is worth considering in the early stages of gait retraining, since it plays an important role in facilitating symmetric gait pattern while discouraging asymmetries from developing. Parallel bars are not recommended for those with asymmetries since it may lead to increased compensation and BWS may be more beneficial for these patients since it promotes a symmetrical gait pattern by supporting weight centrally and discourages compensation[17]. In choosing to use BWSTT with patients, it may be best to not allow them to use UESS unless specifically working on functioning at faster gait speeds. If patients are allowed to self-select their gait speed, the therapist must ensure that they are not using UESS in order to make sure that gains made through training will transfer to over ground ambulation[18].

Research suggests that physical therapy may still be beneficial for individuals with disability resulting from a TBI that occurred many years prior[1]. Because slow walking velocity correlates with those within their first year post injury and again after 15 years, this may help us to guide treatments and patient education to this population. This slower velocity may be explained by brain plasticity, adaptation, and ongoing neurological improvement within the first year. Musculoskeletal deformities, decreased muscle strength, reduction in response time with age, and reduced compensation may be evident over time. Using this information, therapists can combat these specific issues in order to prevent the decrease in gait velocity noted[9, 13]. Other common motor impairments seen in the gait of individuals with TBI[9, 13] should be seen as a potential area of increased concentration during assessment and training in order to achieve optimal outcomes and select proper assistive devices.

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