

Project Title: Pilot Study to Assess the Application of Haptic Technology to Functional Improvement in Persons with Mild and Moderate Traumatic Brain Injury

Principal Investigator: Leighton Chan, M.D., M.P.H.

ABSTRACT

Traumatic Brain Injury is a complex condition that is not completely understood. Our laboratory is working towards determining the feasibility of haptic technologies to assess and treat a population of individuals who have mild to moderate TBI. We are using the haptic along with a computer system to create challenging and engaging virtual environments and extract objective measures concerning their orientation, motor, and cognitive skills. We have performed a pilot study using college students and showed that they were highly engaged, and that objective measures could be extracted. These measures showed that fine motor learning occurred over a course of three trials in the virtual environment. We have since expanded our virtual environments to include a gun disassembly task, sandwich making task, and a letter spelling task which has similarities to Scrabble. We have also programmed two spatial orientation tasks, a maze that can be navigated from two viewpoints, within or above, and a network of corridors that is navigated only from within.

We have received feedback from Brain Injury Services, Inc., an organization that provides services to persons with TBI. The group came to the lab to provide insight on how to improve our physical and virtual environments. We have a protocol in place for which we will be collecting data from these TBI patients and others recruited through the CNRM Recruitment Core. We will be looking at the ability of the virtual environments to engage and challenge the individuals as well as determining objective measures for analysis. We will also be comparing outcomes from the virtual environment to those from classic measures, including the Purdue Pegboard and Wolf Motor Function Test.

Project Title: Effects of Rapid Reciprocal Exercise vs. Light Therapy in TBI

Principal Investigator: Diane L. Damiano, Ph.D.

ABSTRACT

Objectives:

We will: 1) compare performance of healthy volunteers and ambulatory adults with traumatic brain injury (TBI) on a range of motor, neurobehavioral and brain imaging outcomes; and 2) evaluate effects of rapid, reciprocal arm and leg exercise with an elliptical trainer on high-level motor coordination and balance, and neurobehavioral and cognitive functioning in persons with TBI. Outcomes will be compared to those from a novel intervention for improving mood and cognition, Bright Light Therapy (BLT). Brain connectivity and changes in connectivity in response to interventions will be quantified. We hypothesize even highly functional adults with TBI will have poorer scores on all measures than controls; exercise will lead to significant improvements in motor performance and balance compared to BLT; and neurobehavioral and cognitive function will improve with both interventions. We further hypothesize that improvements in cortical connectivity and representation will relate directly to functional ones.

Study Population:

80 adults (50 with TBI) will be recruited so that 20 with TBI and 20 healthy volunteers complete the study. Only the TBI group will receive intervention.

Design:

Healthy controls will have a single assessment that includes motor, neuropsychological and brain imaging tests. Participants with TBI will perform both interventions: 3 months of fast elliptical training or Bright Light Therapy in randomized order with a four-week washout period between them. Assessments will occur at 0, 3, 4, and 7 months. The exercise device will be an elliptical trainer that exercises the legs and arms with the emphasis on maintaining a fast speed. Mild resistance will be provided initially and progressively increased once speed is optimized. An in-home light box will be used for the other intervention. Each intervention will be performed in the home 5 days per week for 30 minutes, over 12 weeks.

Outcome Measures:

Performance on complex motor & balance tasks will be assessed with 3D motion capture & EMG, the Smart Balance Measurement System and the High Level Mobility Assessment Tool (Hi-MAT). Primary outcomes are Hi-MAT score reaction time during balance testing and the Hamilton Rating Scale for Depression (Ham-D). Secondary outcomes will include walking speed and device cadence, PTSD Checklist (PCL-17), and relevant portions of the Automated Neuropsychological Assessment Metrics (ANAM) battery, among others. Cortical connectivity will be quantified using resting state functional connectivity magnetic resonance imaging (MRI) and Diffusion Tensor Imaging (DTI), which evaluates white matter tracts. Cortical activation patterns will be quantified with fMRI.

Project Title: Effect of Aerobic Exercise Training on Cardiorespiratory Function in Patients with Traumatic Brain Injury
Principal Investigator: Diane L. Damiano, Ph.D.

ABSTRACT

Objective:

The broad objective of this exploratory project is to inform clinical studies and trials on the use of aerobic exercise training (AET) as an intervention for improving cardiorespiratory fitness in patients with traumatic brain injury (TBI). AET-induced adaptation of cardiorespiratory fitness and fatigue severity will be characterized, and time-course for changes in mood reactivity will be determined. We hypothesize that 1) AET will improve both cardiorespiratory fitness and fatigue severity and 2) mood will at first worsen in response to AET but that mood reactivity will then decrease at some point during the intervention.

Subjects:

Thirty-six adult subjects with a clinical diagnosis of non-penetrating TBI (mild, moderate, and severe) will be enrolled. Subjects will be recruited from NIH, affiliated hospitals/clinics, and in the community. Enrollment is open to both military and non-military personnel.

Design:

This is a pilot study with a pre-experimental, test-intervention-retest design. Cardiorespiratory fitness, fatigue severity, cognitive performance, and changes in mood reactivity will be measured at baseline. The subjects will then participate in a 12-week treadmill exercise training intervention protocol known to improve cardiorespiratory fitness in the general population. Following the 12 weeks of AET, cardiorespiratory fitness, fatigue severity, and cognitive performance will be retested and compared to baseline. Changes in mood reactivity will be assessed monthly.

Outcome Measures:

AET-induced change in cardiorespiratory fitness as measured by peak oxygen consumption (VO₂) is the primary outcome measure and will be measured by pulmonary gas exchange analysis during treadmill exercise tolerance testing. The Fatigue Severity Scale (FSS) is the principal measurement tool for the fatigue outcome variable. FSS scores will be interpreted in relation to information from the Medical Outcomes Study 36-Item Short Form (MOS-36SF), Becks Depression Inventory (BDI), The Pittsburgh Sleep Quality Index (PSQI), International Physical Activity Questionnaire (IPAQ) and the Profile of Mood States Short Form (POMS-SF). Change in mood reactivity will be measured as the difference in the POMS-SF scores before and after 30 minutes of recovery. The outcome variable for time-course related change in mood reactivity is the week of onset for significant improvement in mood reactivity.

Progress:

We have established the final protocol, fully executed the GMU sub award, received approvals for the NIAMSD/NIH, USUHS/HJF, and GMU, and hired personnel including a postdoctoral research fellow and a research coordinator. The project is now enrolling subjects.

Project Title: Development of a Robotic Telerehabilitation System for Warriors with TBI

Principal Investigator: Diane L. Damiano, Ph.D.

ABSTRACT

Survivors of brain injury such as the traumatic brain injury (TBI) and stroke often experience residual physical impairments such as spastic hypertonia, muscle contracture, and balance deficits. Physical therapy has been considered important during the acute and chronic phase of recovery from those brain injuries, and the success of rehabilitation has a major effect on a person's quality of life post injury. The amount of physical therapy, determined by the clinicians, is often less than optimal which may limit the degree of recovery due to the nature of the in-person assessment; the assessment tends to be subjective which may not guarantee that the patients will receive optimized treatment and training. Furthermore, the improvement resulting from physical therapy may wane over time partly due to the difficulty of maintaining the required frequency of treatment. There is a need for a robotic device that moves patient's joints under accurate and quantitative control and allows quantitative measurement. Access to robotic devices that allow timely, convenient, and frequent treatment at remote locations such as a home community and a military base will greatly improve treatment options for patients with brain injury. For those patients who do not have direct access to major hospitals due to geographical distances, this project develops tele-robotic system capable of remote therapy and assessment. The robotic system can also contribute to improve accuracy and reliability of physical assessment.

In the first year, this project developed a tele-robotic system consisting of a haptic mannequin device (HMD) and a wearable stretching device (WSD) for the elbow joint. Under negligible network latency (less than 10 msec), the two devices (HMD and WSD) can be safely connected and controlled via the internet for remote therapy and assessment. The HMD simulated the haptic feel of responses (measured by the WSD) from the spastic elbow joint so that clinicians can remotely feel it during manipulation of the HMD. The real-time operation of tele-assessment tasks may not be safe in the existence of significant network latency (greater than 30 msec) which is often observed between states and countries. Thus, the use of real-time tele-assessment might not be a practical solution. In the second year, this led us to develop an alternative solution to implement remote assessment by developing a mathematical model of spastic elbow joints. The data (joint angle, velocity, and resistance torque) collected from patients' spastic elbow in remote location are transferred via the internet to hospitals, and are converted into mathematical models which will be programmed in the HMD. Then the clinicians will be able to manipulate the HMD to do physical assessment in a same way they do in in-person physical assessment.

Project Title: Evaluation of the Safety and Efficacy of the BrainPort! Balance Device

Principal Investigator: Yadira M. Del Toro, D.P.T., V.R.T., CPT, SP

ABSTRACT

We are conducting a study to evaluate the safety and efficacy of the BrainPort™ balance device in active duty service members with traumatic brain injuries. Mild to moderate TBI patients represent a population that have not been investigated with this device who could benefit from short term use of the BrainPort™ to aid with static and dynamic balance. In addition, military personnel have a higher rate of TBI than civilians and therefore the BrainPort™ device may be especially useful in this population.

This study is a prospective double-blinded randomized controlled trial comparing the stability of subjects assigned to the BrainPort™ training group (Group 1) with the standard of care plus placebo (sham) device training group (Group 2). The subjects to be enrolled will be 50 active duty military TBI patients with balance and posture-related disturbances. All subjects will be trained on the BrainPort™ or placebo device during six 60-minute sessions at the investigational site over a period of 2 weeks (two sets of 3 consecutive clinic training days). Following clinic training, subjects will continue with daily static and dynamic balance exercises and BrainPort™ (or placebo device) training sessions at home for 20 minutes twice daily for 12 weeks. Assessments of balance, gait, and stability will be completed at baseline, every 2 weeks, and one final assessment on week 12.

The primary objective of the study is to determine whether electro-tactile stimulation of the tongue, using the BrainPort™ balance device, can improve postural stability and balance as measured by improvement in performance of a series of clinically accepted balance performance measures in subjects with documented balance dysfunction caused by traumatic brain injury (TBI) as compared to standard of care.

Specific Aims:

1. To determine the safety and efficacy of the BrainPort™ device in improving postural stability in a TBI population.

Exploratory Aim: To determine if the safety and efficacy of the BrainPort™ device in improving postural stability in a TBI population is affected by the cause of the balance dysfunction (to help future investigations stratify patient involvement).

2. To determine if the BrainPort™ training group will show greater improvement on postural stability than the standard of care plus placebo device training group.

Even in peacetime, military personnel have a higher rate of TBI than civilians. Of all the individuals medically evacuated to the Walter Reed Army Medical Center who sustained injuries from hostile forces during the Iraq and Afghanistan wars, 28% had a TBI. In addition, the Defense and Veterans Brain Injury Center (DVBIC) reported that 59% of an “at-risk” group of injured soldiers returning from Afghanistan or Iraq to Walter Reed (2003-2004) suffered a blast injury affecting brain function. Service members with balance and gait deficits secondary to TBI or blast exposure could benefit from additional rehabilitation interventions to assist them in recovering from these deficits. Use of this device may increase postural stability and decrease the risk of falls in an inpatient acute setting. It has potential benefits in facilitating tolerance for balance and gait training. While substitution is the primary mechanism by which the device is thought to improve patient balance functioning, the device could assist with short term rehabilitation objectives and allow concurrent adaptation and neuroplasticity effects.

Project Title: Novel cognitive rehabilitation approaches for OIF/OEF TBI patients

Principal Investigator: Louis M. French, Psy.D.

ABSTRACT

Purpose

The purpose of this pilot study is to determine a novel computer-based program's feasibility to meet post-discharge needs for subjects complaining of deployment-related cognitive deficits. The feasibility will be demonstrated in terms of improvement in subjective complaints, cognitive improvement on neuropsychological testing, as well as compliance and satisfaction with the computer program.

Research Design

A randomized, controlled study design will be used to evaluate the efficacy of novel computer based cognitive training programs. Patients are randomly assigned to one of two computer based cognitive training programs or to a standard of care control group which receives normal in-person therapy at Walter Reed Army Medical Center (WRAMC) to include but not necessarily limited to cognitive Speech-Language Pathology services and/or cognitive Occupational Therapy services. This study is sponsored and funded through the Center for Neuroscience and Regenerative Medicine (CNRM) and the Henry M. Jackson (HJF) Defense and Veterans Brain Injury Center (DVBIC).

Methodology /Technical Approach

Participants: Participants in this pilot study will include 126 total subjects, including 75 subjects with mild to moderate TBI. 25 subjects would be randomized to the Dakim Brain Fitness program by Dakim, Inc., 25 subjects would be randomized to Brain Fitness Classic by PositScience and 25 subjects randomized to a therapeutic standard of care control group. An additional 51 subjects to each of the computer rehabilitation conditions and 10 to the control group) with report of cognitive dysfunction that did not meet criteria for a TBI diagnosis will also be enrolled for the purposes of an additional exploratory analysis.

Study Flow:

Randomly assign each subject to one of three groups: Dakim Brain Fitness, Brain Fitness Classic or a standard of care control program for 6 weeks. Under the circumstances that a participant leaves the facility or chooses to terminate their participation in the study prior to completing their 6 week program, that participant's data will kept in the study so as to minimize bias. Intent-to-treat (ITT) analysis will be performed using the last observation carried forward (LOCF) method of imputation. Discharge testing at the end of their care will be completed, whether they remain for the entire 6 week period or not. If participants drop out while the recruitment process is still occurring, the investigators will recruit further to fill those spots.

Evaluation of Efficacy of Rehabilitation:

Pre and post-testing and surveys will include the Mayo-Portland Adaptability Inventory - 4 (MPAI - 4) (Appendix I), Neurobehavioral Symptom Inventory (NBSI) (Appendix II), the Satisfaction with Life Survey (SWL) (Appendix III), the Post-Traumatic Stress Disorder Checklist – Civilian Version (PCL-C), and the Automated Neuropsychological Metrics (ANAM) (Appendix IV). The MPAI – 4 will be the primary outcome for patient self-report of symptoms. The NBSI and SWL surveys will also measure subjective complaints. The ANAM will be the primary measure of improvement in cognitive efficiency. Self-report questionnaires program satisfaction as well as compliance in terms of attendance will also be measured. While it is not expected that the number of subjects in the non-TBI group will be sufficient to explore the relative outcomes among diagnoses, this will be explored as the basis for a future study.

Project Title: Exploring the Natural History of TBI within a Military Cohort – A Longitudinal Database and Blood Banking Study

Principal Investigator: Louis M. French, Psy.D.

ABSTRACT

The purpose of this study is to improve our understanding of traumatic brain injury (TBI) within a military cohort by developing a database that contains neurobehavioral, neurocognitive, neuroimaging, blood specimen, and sensory/motor data from service members who (a) have sustained a mild, moderate, or severe TBI and (b) have sustained a non-TBI related injury such as an orthopedic or soft-tissue injury (“injured non-TBI trauma controls”). The data collected for this study will provide the foundation for the development of hypothesis-driven protocols, and will ultimately advance our understanding of the body’s pathophysiologic response to TBI and those contextual, social, emotional and environmental factors that may have an impact on outcomes and health care needs in a military population.

Up to 800 male and female participants from Walter Reed Army Medical Center (WRAMC) and Walter Reed National Military Medical Center (WRNMMC) with confirmed or suspected TBI (mild, moderate, or severe) will be enrolled in the study. Additionally, up to 400 injured non-TBI trauma control subjects will also be enrolled, for a total of 1200 subjects. The study will be composed of two arms: (1) a comprehensive arm, and (2) a brief arm. Subjects will have the opportunity to participate in either arm of the study.

The comprehensive arm will consist of neurobehavioral assessments, neurocognitive assessments, neuroimaging evaluations, blood draws, and sensory/motor assessments. A medical chart review will also be completed by a study investigator, and an assessment interview will be conducted with each participant. Subjects will be assessed as soon as possible after injury (baseline assessment), and will participate in intensive clinical evaluations or telephone/web-based follow-up assessments annually thereafter for up to 15 years. The intensive clinical evaluations will take place at WRAMC and/or WRNMMC at baseline and during Years 1, 3, 5, and 10. Subjects will complete the telephone/web-based follow-up assessments at home during Years 2, 4, 6-9, and 11-15.

The brief arm will consist of neurobehavioral assessments, a computerized neurocognitive assessment, a medical chart review, and an assessment interview. Subjects will be assessed at WRAMC or WRNMMC as soon as possible after injury (baseline assessment), and will participate in telephone/web-based follow-up assessments annually thereafter for up to 15 years. Subjects will complete the telephone/web-based follow-up assessments at home.

Project Title: Cognitive Assistive Technology and Service Delivery for Service Members with TBI at WRAMC

Principal Investigator: LTC Sandra Harrison-Weaver

ABSTRACT

Traumatic Brain Injury (TBI) is a common injury across the United States. Long-term complications from TBI injuries are typically associated with cognitive and behavioral deficits. Individuals in the military are at an increased risk of TBI due to the nature of training and the job duties, both during peace and war times. One common compensatory strategy for those who have sustained a TBI is the use of Cognitive Assistive Technology (CAT). The purpose of this study is to determine existing practices and patterns for CAT device prescription for individuals with TBI.

This study will be a retrospective analysis of available medical/health records of service members who experienced TBI and were evaluated and/or treated at Walter Reed Army Medical Center (WRAMC). We propose to review up to 1,000 medical records of service members identified as having sustained a TBI who were seen at WRAMC between 2005 and 2009. We aim to explore the prescription patterns and/or determine the clinical pathways present at WRAMC to prescribe CAT devices to these service members. The rate of TBI among US military service members has increased significantly due to recent conflicts in the Global War on Terrorism (GWOT). To date, almost 1,700 service members with mild to severe forms of TBI have received care at WRAMC. Additionally, the United States Army Surgeon General estimated the prevalence rate for deployed service members who have sustained a concussion to be between 10 and 20%.

TBI may negatively impact both the physical and cognitive status of an individual and may result in functional dependence or limited community-societal participation. Cognitive Assistive Technology (CAT) devices are often prescribed to individuals after TBI to fill the gap between cognitive capacity and demands for successful community re-entry. CAT devices, sometimes called cognitive orthotics, are designed to be used for individuals with cognitive impairments as a means to support weakened or poor cognitive functions. Evidence suggests that the use of PDAs results in improvement of functional performance and community participation for those with TBI. This study also found that the provision of a PDA in conjunction with training and follow-up resulted in the improvements in performance of everyday life tasks. Unlike medical or rehabilitation services, provision of CAT devices emanates from several resources, with multiple health-care professionals associated with decision-making processes for selection and prescription of CAT devices. This may result in lack of integrative and optimized CAT service provision. Due to a paucity of outcomes data, effectiveness of these devices in meeting both short-term and longterm needs of the recipients is unknown.

The research that is being conducted is a retrospective medical chart review of up to 1,000 service members with TBI who received services at WRAMC. During the medical chart review, the clinical pathway for the prescription of CAT will be identified.

Project Title: Natural History of TBI- Subacute to Chronic Neuroimaging

Principal Investigator: Gerard Riedy, M.D., Ph.D.

ABSTRACT

Imaging studies on patients with definitive or suspect TBI are limited in number. Those containing MRI data on patients with injuries from a military setting are even fewer. Typical studies include less than 30 patients and have median time from index event to imaging of weeks to months. Studies focus on a single methodology, such as changes in fractional anisotropy, and seldom consider a comprehensive evaluation. This is not surprising in that most patients with mild symptoms never receive any neuroimaging, or at most, CT for clinical purposes. Moderate to severe patients are difficult to image with MR. In most hospitals, there is no one service responsible for triaging, admitting, and managing the diversity of patients suffering head injury. These factors, coupled with other logistical and financial challenges, make the study of acute TBI extremely difficult, and have perpetuated a belief that mild TBI may be “invisible” on neuroimaging.

The National Capital neuroimaging core project, which includes Walter Reed, National Naval Medical Center, and USU, has been funded to implement a comprehensive group of neuroimaging studies employing the most advanced techniques available to study all Traumatic Brain Injury (TBI) patients that pass through the major Army and Navy Hospitals in the National Capital Area. This baseline project is designed to evaluate TBI patients returning from the areas of conflict to produce an imaging starting point for follow-up studies on both the natural progression of TBI and evaluation of interventional and rehabilitation treatments for these patients. The CNRM project is an ideal compliment to this “first pass” core neuroimaging project, as it will afford proper imaging follow-up on these TBI patients as they traverse their various treatment regiments and attempt to integrate back into their daily activities.

The first step in developing new imaging methodologies to diagnose and monitor TBI is to adequately evaluate the technology we currently have available. A logical starting point is those methods that have shown promise in the literature in small pilot studies that evaluate TBI in both the civilian and military setting. Our main hypothesis is that an integrated neuroimaging examination employing a combination of the most advanced imaging techniques currently available will demonstrate changes in TBI patients beyond the current standard imaging technology, and that these changes will correlate with clinical findings and outcome measurements. We propose to perform repeated comprehensive MRI neuroimaging examination on TBI patients at 6 months, 1 year, and 3 years following the baseline sub acute study.

Project Title: Baseline Prognostic Factors for Post-traumatic and Post-deployment Chronic Headache

Principal Investigator: Ann I. Scher, Ph.D.

ABSTRACT

Migraine or headache is a common problem in the active duty population in the recently deployed population, and is a cardinal symptom of traumatic brain injury (TBI). While there is increasing appreciation of the clinical burden of chronic post-traumatic headache (PTH) in the military population with traumatic brain injury, there are significant research gaps related to the epidemiology of PTH including lack of understanding of natural history, whether there are predisposing factors that predict the development or prognosis of headache post trauma, and, most basically, the features that distinguish PTH from other forms of chronic headache. Although diagnostic criteria for posttraumatic headache (PTH) are included in the International Classification of Headache Disorders (ICHD-IIR), these criteria are somewhat arbitrary and were not empirically defined. This lack of precision about the PTH phenotype limits the rigor of observational and interventional studies of PTH and is a primary research gap. Lack of understanding about predisposing risk factors for the development of PTH is also an important research gap. It will benefit our soldiers if we can identify those who are at greatest risk of developing chronic headache post-trauma and who might therefore benefit from early and aggressive treatment with headache prophylactic agents.

The proposed observational study will address the following research questions:

- 1) Epidemiology: What is the incidence, prognosis, and natural history of headache disorders in a deployed military population with or without exposure to TBI?
- 2) Phenotype: Which constellation of symptoms, if any, distinguishes PTH from “regular” chronic headache and from TBI occurring without headache?
- 3) Relationship to Injury: To what extent is chronic PTH related to injury severity or modality?
- 4) Risk Factors: Which factors predict PTH incidence or prognosis, including but not limited to post-traumatic stress disorder (PTSD), co-existing non-headache chronic pain, pre-existing migraine, family history of pain disorders, or replicated pain genes for other chronic pain disorders?

Project Title: Computerized Dynamic Posturography in the Military Population

Principal Investigator: COL Barbara Springer, PT, PhD, OCS, SCS

ABSTRACT

Individuals who complain of balance impairments and/or dizziness following TBI are often referred to physical therapy. The battery of clinical assessments for these patients includes Computerized Dynamic Posturography (CDP). CDP is used to detect impairments in the body systems that contribute to balance. The Sensory Organization Test (SOT), Motor Control Test (MCT), Head-Shake Sensory Organization Test (HSSOT), enhanced Sensory Organization Test (eSOT), Perception Time Test (PTT), Gaze Stability Test (GST) and Dynamic Visual Acuity (DVA) test are specific components of CDP designed to identify impairments in the visual, vestibular and somatosensory systems. During the SOT, the individual stands on a dual force plate measuring postural sway. This test is used to evaluate the individual's use of somatosensory, visual and vestibular input to maintain balance. The MCT examines the individual's automatic postural response. The HSSOT was developed to further challenge the individual's balance systems. Although frequently used, no normative values for the HSSOT are currently published in the literature. The eSOT is a clinical measure used frequently to further challenge the subject in order to detect subtle balance impairments not reflected during SOT or HSSOT testing. This test has not been evaluated for its effectiveness in detecting balance impairments and has no normative values. Assessing eSOT scores in the normal military population may allow for a more advanced standard dynamic balance test to be used with this population. The PTT, GST and DVA test applications identify deficits with the vestibular ocular reflex (VOR). Damage to this reflex can occur as the result of a concussion or mild TBI.

When this reflex is damaged, it is difficult for an individual to stabilize their gaze on an object. These tests rely on the individual's Static Visual Acuity (SVA) results. During the PTT, the subject remains stationary while each optotype is presented on the screen for different lengths of time. This test is used to determine how long the optotype must be present for the subject to accurately perceive it. During the GST, the subject is asked to identify a set size optotype while turning their head at various speeds. The goal of this test is to determine the maximum speed that the individual can move their head while maintaining visual acuity. During the DVA test, the subject is asked to read a variable sized optotype while moving their head at a set speed to determine the amount of change in acuity between static and dynamic conditions at a specific speed. Both the GST and DVA test have known normative values in the general population. The SOT, MCT, DVA and GST have been normalized based upon a healthy population aged 18-89.

However, there exists a paucity of data concerning normative values for higher functioning individuals. It has been suggested anecdotally that the demands of a military job, especially the infantry, similarly require a higher skill set to maintain balance and gaze on a target while moving in a highly distracting environment. Our current testing protocols to evaluate deficits in this area, as well as to assist in determining readiness to return to duty, are based on the norms developed from the non-military population. These values may not be sensitive enough to detect deficits in this highly trained subset or to appropriately judge safe return to duty. While the HSSOT and eSOT are often used to evaluate an individual's balance, they have no normative values. Without normative values these tests cannot effectively add to a clinician's examination.

This new data will be used to establish a normative reference database for use in the evaluation and treatment of military personnel and will contribute to the overall mission of the study sponsor (CNRM). The purpose of this study is to collect postural control and dynamic visual data on healthy soldiers, compare this data to current normative values for the general population, and evaluate differences in performance between age groups within the Army. A secondary purpose is to collect normative values for the HSSOT and eSOT in a military population, and determine any differences in performance due to age.

Project Title: Effects of Time Varying Velocity in BWSTT (Body Weight Supported Treadmill Training) post TBI
Principal Investigator: Hyung S. Park, Ph.D.

ABSTRACT

Survivors of traumatic brain injury (TBI) experience residual physical impairments, particularly in balance and ambulation. These physical limitations interfere with activities in daily living, e.g., from dressing and eating to driving, walking and exercising. Body weight supported treadmill training (BWSTT) has been frequently used in recent years for gait rehabilitation of patients with neurological impairment due to its availability and effectiveness. During BWSTT, the patient wears a harness that supports part of his/her body weight and protects him/her from stumbling while walking on a motorized treadmill at a constant velocity selected by the clinician. Improvements in gait parameters were observed after training in many studies of BWSTT in individuals with acquired brain injury from a stroke. BWSTT also allows gait training within a small area and facilitates research investigating gait biomechanics in those with ambulation difficulties. While BWSTT offers convenient gait training, the effectiveness of BWSTT is not greater than conventional gait training (CGT). In a comparative study with 146 individuals with SCI, BWSTT and CGT did not produce different outcomes. In a study with chronic patients post-TBI, the group which received CGT showed greater improvement in gait symmetry during over ground walking than did the group which received the BWSTT. Overall, it appears that BWSTT is considered clinically useful due to its effort saving capability; however, the effectiveness needs to be proven further.

One potential explanation for the equal or inferior effectiveness of BWSTT over CGT may be the constant treadmill velocity that distinguishes it from over ground stepping. In over ground walking, the walking speed is not a constant and people plan and change walking speed according to their sensory information; however, setting a constant speed in BWSTT may make too regular gait patterns and the BWSTT may not have greater effects on high functioning individuals such as mild to moderate TBI than on low functioning individuals such as SCI (spinal cord injury).

To further improve the performance of the BWSTT, this project proposes to implement time varying velocity during BWSTT and to test the effectiveness of the proposed method compared to a constant velocity program. Most BWSTT programs have used a constant velocity or multiple levels of velocity at different training sessions (constant velocity in a single session). Considering the over ground walking velocity in daily living is not constant, simulating the time varying velocity will be more realistic and, moreover, the patients may develop motor adaptation skills by adjusting their gait pattern to changing velocities. There is evidence that those with spinal cord injuries can relearn to step more effectively if challenged with varying velocities during locomotor training. Other recent gait studies utilized split belt treadmill capable of controlling speed independently at each foot; however, a constant speed was used at each foot during a training session and there is a paucity of information on the effect of using randomized time varying velocity in BWSTT.

To develop and evaluate an effective treadmill training method, this project proposed the following two specific aims: 1) To develop a novel treadmill controller which is capable of implementing variable velocity at the treadmill and monitoring subject's gait pattern to guarantee safety while optimizing treatment effects; and 2) To test the effectiveness of using randomized time varying velocity in the BWSTT. This report presents development of a novel treadmill speed adaptation controller with which a subject can voluntarily change walking speed similarly with the over ground walking. In addition to the development, this report presents the evaluation of performance and safety of the new treadmill speed controller (UDW-User Driven Walking). From a user study with 10 healthy subjects, the performance and safety of the proposed controller was evaluated by comparing the gait kinematics of UDW, over ground walking (OGW) and the typical treadmill walking (TDW-Treadmill Driven Walking).