TATRC TIMES

November 2018 • Volume 4, Qtr. 4

AAMTI Project Spotlight: Dual-Task Stability Assessment Utilizing a Wearable Motion Analysis System: Diagnosis and Management of mTBI

Despite the proliferation of state of the art traumatic brain injury (TBI) centers throughout the Department of Defense (DoD), the diagnosis and management of most mTBI cases occurs at the small unit level. Combat medics relying on the Military Acute Concussion Assessment (MACE) are often the first medical providers to assess injured Soldiers. While readily available and easy to implement, the MACE has limitations in diagnostic accuracy which further diminishes if not implemented within 12 hours of injury. Furthermore, it provides little value for tracking recovery and informing return to duty (RTD) decision making. As such, current RTD criteria are generally based on time (24 hours rest for first injury, 7 day rest for second injury in a single year) or subjective symptom resolution which normalize within 3-10 days.

Increasingly the current best evidence suggests these criteria are insufficient as acutely injured individuals demonstrate deficits in dynamic balance control that persist as long as 2-months post-injury. Furthermore, recovery of balance control actually regresses immediately following rapid return to activity. Improper management of mTBI may result in increased risk for adverse sequela such as re-injury, musculoskeletal injuries, occupational mishaps, and depressive and substance abuse comorbidities. Coupled with long-term consequences such as chronic symptom and degenerative neurologic disease development, these adverse sequela may severely affect operational readiness and strain DoD and Veterans Affairs health and disability systems.

Persistent gait balance control impairments have been exposed using a dual-task gait assessment paradigm (functional task with concurrent cognitive task), which more accurately depicts the demands of everyday activity. Unfortunately, these laboratory studies utilized sophisticated camera-based motion analysis systems to record highly sensitive biomechanical markers, limiting their clinical utility. Therefore, the purposes of this AMEDD Advanced Technology Initiative (AAMTI) funded project are to 1) develop a clinical dual-task gait balance control assessment for use by first line medical providers in clinical and forward environments, 2) assess its reliability and clinical feasibility, and 3) provide the foundation for translation into a universally accessible smart phone based application.

Twenty (10F) healthy adults participated in this repeated-measures study. A portable clinical instrument was designed consisting of a wearable sensor system (one sensor over the low back as a center of mass proxy and one on each ankle to record gait events), a single laptop, and Superlab software which automated the protocol and administered cognitive tasks through a wireless headset (Fig. 1). All subjects performed a simple walking task consisting of an 8m level walk, a 180 degree turn, and returning 8m walk in each of three walking conditions (walking only, walking while performing a Stroop task, walking while responding to spelling and arithmetic questions). Cognitive tasks were selected for their ability to challenge different aspects of executive function. The concurrent performance of a gait and cognitive task results in decrements in balance control and/or cognitive task function due to limitations in processing resources which is exacerbated by the diffuse axonal injury associated with mTBI.

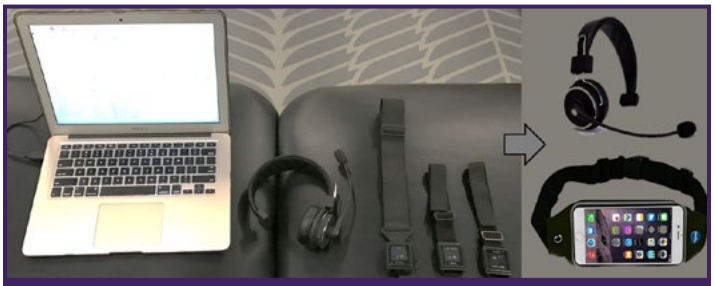

Figure 1: The assessment tool consists of a wearable IMU system, wireless headset and automated Dual-Task protocol. The desired end state is to package the assessment into universally available smart phone based application.

To assess reliability, the assessment was repeated in both laboratory and non-laboratory environments, by two different raters, and on two separate days. Eight gait event-specific peak accelerations along three orthogonal axes (Fig. 2) were collected and analyzed using an eight item Cronbach's α and Intrarater Correlation Coefficient. Cronbach's α values of .881 to .980 for the eight metrics and ICC values of .868 to .987 indicate excellent internal consistency and inter-rater reliability.

The assessment was then implemented in a collegiate sports medicine clinic with 26 Division One athletes. The assessment, performed by an athletic trainer, took 8:30 minutes ± 35 seconds on average. As the ImPACT assessment and SCAT5 (currently accepted standard in athletics) take 25 and 10-15 minutes respectively, our assessment time of less than 10 minutes establishes its clinical feasibility. In an additional pilot study, a single injured female Division One athlete who sustained an acute mTBI was assessed longitudinally over a 2-month post-injury period. Multiple peak accelerations along the medial-lateral axis demonstrated a dramatic reduction immediately post-injury and gradually improved over the assessment period, demonstrating the sensitivity of the assessment metrics to both immediate changes in balance control and subtle changes associated with recovery (Fig. 3).

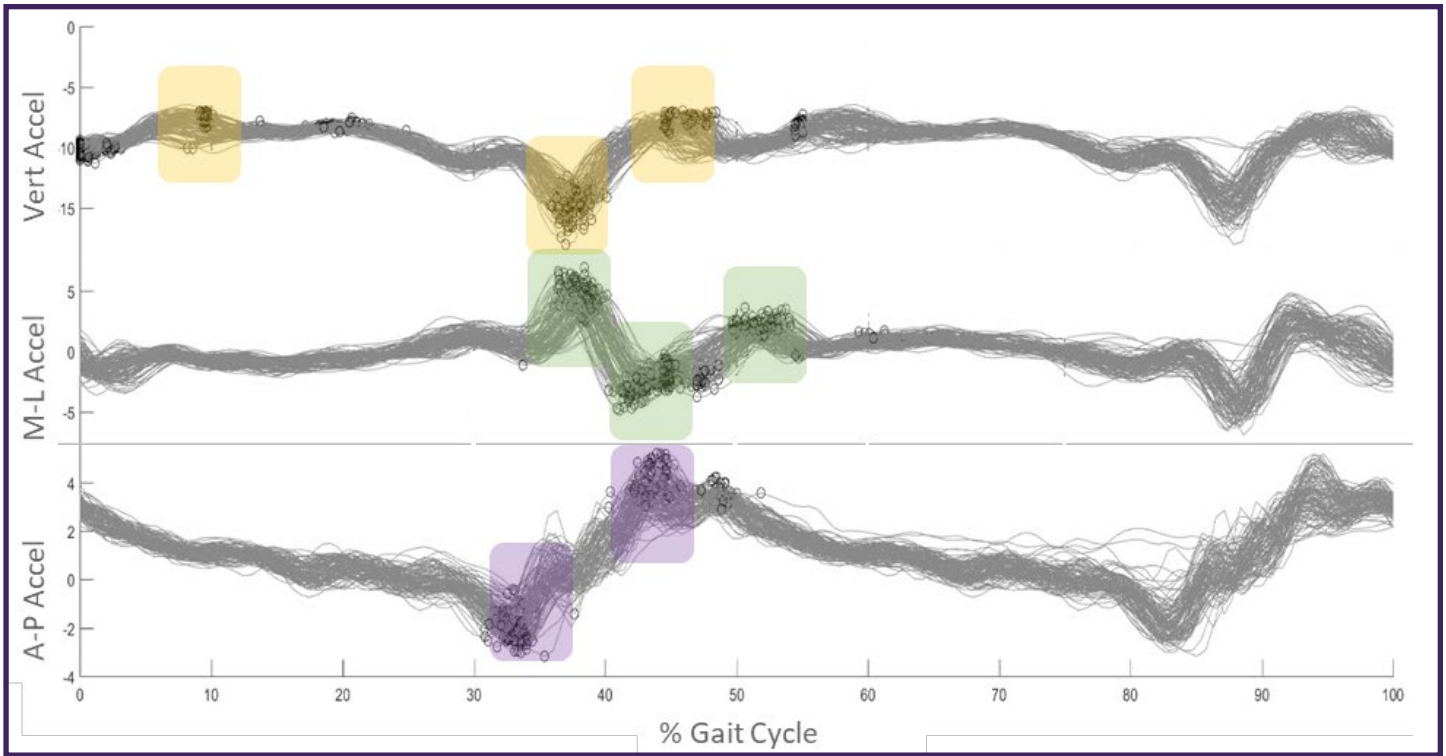

Figure 2: Three axis acceleration profiles during a single gait cycle for each trial. Gait event specific peak accelerations are highlighted.

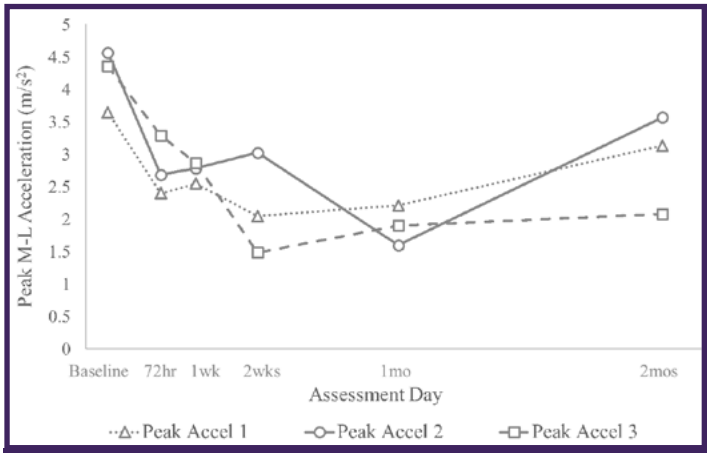

Figure 3: Three M-L peak accelerations for an injured Division One athlete including a pre-injury baseline and five post-injury assessments. Note the acute decline in peak accelerations continuing through 2 weeks, then improving gradually out to 2 months.

At this time, we have developed a feasible clinical instrument that is both reliable and sensitive to subtle changes in dynamic balance control for use in mTBI diagnosis and management. We recently began a longitudinal study to more fully describe recovery profiles for these balance control metrics and establish normative databases. We are also collaborating with the Joint Base Lewis McChord Intrepid Spirits Traumatic Brain Injury Center of Excellence to perform a longitudinal study employing our clinical instrument with mTBI injured Service Members. Data from these investigations will be used to develop a machine-learning algorithm to automate assessment grading, providing clinicians with a real-time objective measure of dynamic balance control. The automated algorithm will then be packaged into a smart phone based application, leveraging the device's internal sensors to produce a highly compact, readily available, objective clinical mTBI assessment instrument (Fig. 1).

"Development of an objective, smart phone based, clinical dynamic balance control assessment has the potential to radically alter diagnosis and management of mTBI throughout the DoD and at all levels of athletic competition," stated MAJ William Pitt, the AAMTI Innovator for this study.

Successful completion of this project will result in a powerful tool able to be implemented at the lowest levels of medical care, improving diagnosis and management of mTBI injury. The effects will be improved Service Member quality of life, increased operational readiness, and reduced military health system burden through more rapid recovery, reduced re-injury and musculoskeletal injury, and reduced incidence of long-term post-concussive symptom development.