Center of Mass Gait Patterns of Patients With Mild to Moderate Traumatic Brain Injury

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Introduction
It is estimated that as many as 3 million people in the US suffer a traumatic brain injury (TBI) each year and that about 700,000 of these injuries are severe enough to require hospitalization. Subjective complaints that occur in the absence of clinical or physical findings after TBI are often difficult to objectively assess. Symptoms of impaired balance and altered coordination have been particularly troublesome with as many as 30% of patients complaining of these problems following TBI. The purpose of the study was to assess the balance patterns of patients who had sustained a mild to moderate traumatic brain injury.

Statement of Clinical Significance
This study demonstrates that patients who have suffered mild to moderate traumatic brain injury have altered gait patterns which reflect their subjective complaints of imbalance and unsteadiness.

Methodology
Ten patients who had a documented TBI (i.e. a Glasgow Coma Score (GCS) between 9 and 12 within 24 hours following initial hospital admission; documented loss of consciousness) participated in this study. Mean age of patients was 40.9 (±11.3). Ten healthy, age, gender and body mass index-matched subjects were also recruited as controls.

A set of 28 reflective markers was placed on bony landmarks of each subject. A six-camera system (ExpertVision, Motion Analysis Corp.) was used to collect 3-D marker’s trajectories. Two forceplates (Kistler and Bertec) were used to collect ground reaction forces for a complete stride. A 13-link biomechanical model of the human body, consisting of six links for the lower extremities, four links for the upper extremities, one for the pelvis, one for the trunk, and one for the head, was used to compute the kinematics of the whole body’s COM. The 3-D trajectory of the whole body’s COM was computed from the weighted sum of the COM from each body segment. The linear velocities of the whole body’s COM were computed using the GCVSPL algorithm.

Results
Compared to the normals, the TBI patients displayed significant differences of the COM in the medial/lateral (M/L) and anterior/posterior (A/P) directions (p<0.05). Patients having experienced a traumatic brain injury demonstrated larger movements of the COM particularly in the M/L direction (p<0.0001) with a 39% increase as compared to the controls (graph 1). In addition, the patients displayed a decrease in A/P translation (p<0.021) as compared to the controls (graph 2). Concurrently, peak M/L velocity increased (p<0.002) while A/P velocity decreased (p<0.013) when compared to the
controls (graphs 1 & 2). There was no significant difference in Tinetti Balance Scores between patients and controls (27.5±0.3 and 28.0, respectively, p=0.16).

**Graph 1** M/L COM data  
**Graph 2** A/P COM data

**Discussion**

The results of this study illustrate the gait patterns TBI patients display following a mild to moderate head injury. Several of the patients reported ongoing bouts of imbalance and instability that were undetectable during a clinical exam despite what appeared to be a full recovery. Chou et al. reported similar gait patterns among the elderly population with instability.

Gait analysis was able to detect subtle alterations in balance while clinical scales (Tinetti Balance Scale) did not demonstrate a significant difference between the patient population and normal control subjects. Quantifying the gait pattern abnormalities provided further rehabilitation for the affected patients and subsequent rectification of the problem.

**References**


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