Identifying Central Patterns of Motor Control in Pathological Gait

John S. Ward[1], Pallavi Sharma[1], Stanley Fisher[2], T. Adam Thrasher[1]
[1]University of Houston, HHP Dept., Houston, TX, 77004.
[2]Methodist Neurological Institute, Houston, TX, 77030.
John Ward is a doctoral student.

Introduction: The central pattern generator (CPG) for walking is an open loop system that drives lower limb movements in a relatively rhythmic fashion once motion has started with minimal need for additional afferent input. The role of the CPG in the pathological gait of Incomplete Spinal Cord Injury (ISCI) and Parkinson's Disease (PD) has not been studied thoroughly. Understanding how the CPG contributes to motor control in these special populations will serve as a standard upon which to compare new treatments to improve gait function. The purpose of this study was to identify the expression of CPG patterns in individuals with ISCI and PD during walking and compare them to normative values.

Methods: Thirty (N=30) subjects participated in this study equally divided amongst the following three groups: ISCI, PD, and healthy control subjects. Surface electromyography (SEMG) was used to record muscle activation from the medial gastrocnemius, tibialis anterior, biceps femoris-short head, and vastus lateralis bilaterally. A foot switch was used to mark right heel contact (Datalog, Biometrics). All SEMG signals were normalized with respect to Maximal Voluntary Isometric Contraction (MVIC). Participants then performed three trials of reciprocal over ground walking (OGW) for 10m using their preferred gait aids. Following this, subjects walked on a treadmill (TM) for three trials of 60s. SEMG data was rectified, filtered and time-normalized. Four basic muscle synergies representing the CPG were extracted from the data. The expression of these synergies during the gait cycle was computed using a least-squares method in MATLAB software. Goodness of fit of the CPG model was evaluated using the Coefficient of determination (r^2).

Results: All subjects demonstrated an increase in CPG representation during treadmill walking compared to over ground walking. Incomplete ISCI, PD, and control subjects demonstrated the following r^2 values for gait respectively 0.4 OGW, 0.55 TM; 0.8 OGW, 0.9 TM; 0.7 OGW, and 0.8 TM. The differences between groups was statistically significant ($p<0.05$).

Conclusions: The results suggest that individuals with PD present dynamic locomotor patterns more consistent with a CPG model of muscle activation when engaging in over ground and treadmill walking. Further studies are warranted to corroborate if the festination gait seen in PD is more rhythmic and how anti-PD medication affects CPG activity. ISCI subjects may have had poor coordinated action of their CPG due to trauma relevant to their cause of spinal cord tract injury.

Keywords: Central pattern generator, Parkinson's Disease, Spinal Cord Injury, Gait