INVESTIGATING ABERRANT GAIT PATTERNS
IN INDIVIDUALS WITH
INCOMPLETE SPINAL CORD INJURY

Abstract
by
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Approximately 17,000 Americans have a traumatic spinal cord injury (SCI) every year, and there remains wide variability in the success of current rehabilitation paradigms. In particular, individuals with incomplete SCI (iSCI) avoid walking strategies that require energy absorption at the joints by means of eccentric muscle activity. To investigate this deficiency in individuals with iSCI, gait characteristics are analyzed using motion analysis techniques, musculoskeletal simulations, and simplified models of walking. In terms of motion analysis, individuals with iSCI are compared to matched healthy controls to identify specific gait deficits. The significant heterogeneity in gait patterns among individuals with iSCI makes it difficult to identify a single characteristic that captures their walking deficiencies. Instead, this research demonstrates how individuals with iSCI can be grouped according to aberrant walking strategy based on key gait metrics to better quantify deficits and target therapeutic interventions. Musculoskeletal simulations offer the benefit of quantifying individual muscle forces that cannot be directly calculated from experimental data, but neurologically impaired individuals such as those with iSCI are typically unable to perform the protocol necessary to drive such simulations using experimental EMG. Instead, a new method is presented for using EMG activation thresholds to inform
musculoskeletal simulations so that individual muscle contributions can be analyzed for individuals with iSCI. These individual muscle contributions provide a detailed look into how individuals with iSCI utilize muscle activity differently depending on their gait strategy. Finally, the dual-SLIP model of walking provides a means to further explore the effects of muscle co-contraction, which is not well captured in simulations, and unusual observed ground reaction forces (GRFs) in individuals with iSCI. Varying leg stiffness and step length in the model shows that it can capture the GRFs of both individuals with iSCI and healthy individuals walking at the slow speeds typical in rehabilitation. With models that capture GRF characteristics of individuals with iSCI and healthy controls, the energetics of this simple model lend insight into how the two populations comparatively utilize the passive characteristics of gait. Taken together, this research demonstrates ways in which a variety of techniques can be used to analyze and understand the gait characteristics of individuals with iSCI, ideally leading to superior rehabilitation outcomes.