Title: Development of novel biomechanical outcomes using motion capture to characterize hand function in multiple sclerosis

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Background: Multiple sclerosis (MS) often significantly impacts upper extremity function. Currently, the most widely utilized assessment (Nine-Hole Peg Test [9HPT]) is limited to a single outcome measure of total time that can be insensitive to impairment in certain populations.

Objectives: To develop novel biomechanical outcomes that better characterize upper extremity function in people with MS (PwMS).

Methods: 15 PwMS and 15 healthy controls (HC) completed the manual dexterity test (MDT, an iPad adaptation of 9HPT) with both dominant and non-dominant hands. A Kinect® device was used to capture bilateral 3-dimensional, multi-joint hand motion while performing the MDT. An advanced mathematical model, using MDT data and closure coefficients derived from motion capture analysis, was then constructed to yield novel outcomes. Cross-sectional associations between the MDT outcomes (traditional and novel) and clinical characteristics (arm spasticity, dysmetria, upper extremity weakness) were evaluated. Cohen's d effect size was calculated to evaluate the ability of the MDT outcomes to distinguish MS and HC.

Results: 15 PwMS (mean age 55.91 years, disease duration 13.90 years) and 15 HC (mean age 40.45 years) completed the study. MDT Total Time (traditional) and the novel measure of Time to Grab showed a consistent large effect size between dominant hand (0.92 and 1.50) and non-dominant hand (1.10 and 1.10). The novel measure of Movement Delay showed a moderate correlation with disease duration of MS (dominant -0.55, non-dominant -0.52), which was not consistent for total time (0.52, 0.23). Movement Time (EH) and MDT Total Time were moderately correlated with Arm Spasticity for dominant and non-dominant hand (0.52/0.64, 0.46/0.49).

Conclusions: MDT Total Time showed an excellent ability to discriminate PwMs from HCs for both dominant and non-dominant hand movements which supports the continued use of MDT Total Time as a conventional measure. Several novel measures were also identified that demonstrated an excellent ability to discriminate PwMS from HCs and correlated with various clinical measures. Movement delay, movement time, time to insert, and time to grab all were moderately correlated with different clinical characteristics suggesting unique measurement properties. Further studies are needed to evaluate the sensitivity of these measures over time to disease progression.