WALK-DMC IS IMPACTED BY MUSCLE CHOICE

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INTRODUCTION
Muscle synergies may be a useful framework to clinically evaluate how muscles are recruited and coordinated [1]. However, the choice of muscles to measure with electromyography (EMG) in the clinic can differ between treatment centers. Prior work has shown that muscle choice can impact synergy outputs including summary measures such as total variance accounted for (tVAF) [2].

One clinical measure from synergy analysis, tested in children with cerebral palsy (CP), is the dynamic motor control index during walking (walk-DMC) which has been shown to decrease with functional impairment and may also be associated with post-treatment outcomes [3, 4]. Prior work on walk-DMC has focused upon data from a data set of 4 muscles. The goal of this work was to examine how walk-DMC is impacted by using a second clinical muscle set which expands the number of muscles measured from 4 to 8.

METHODS
We analyzed clinical pre-treatment EMG data previously collected during gait at the Clinical Motion Analysis Laboratory of the University Hospital Pellenberg, Belgium (CMAL-Pellenberg) from 147 individuals with CP, Gross Motor Function Classification System (GMFCS) Levels I (M/F: 27/22, age: 9.9±4.0 yr, height: 1.3±0.2 m, mass: 33.7±16.9 kg), II (M/F: 32/27, age: 9.5±3.5 yr, height: 1.3±0.2 m, mass: 27.4±11.5 kg), and III (M/F: 26/13, age: 9.3±3.2 yr, height: 1.3±0.2 m, mass: 28.1±11.4 kg). An unimpaired control group of 12 individuals (M/F: 5/7, age: 10.3±3.0 yr, height: 1.4±0.2 m, mass: 40.6±16.7 kg) was also analyzed. For each individual, EMG data were analyzed from a random limb from 4 muscles (medial hamstrings, rectus femoris, gastrocnemius, and tibialis anterior) or 8 muscles (adding gluteus medius, lateral hamstrings, vastus lateralis, and soleus).

EMG data were preprocessed with a 20 to 500 Hz band-pass filter, then rectified, and a linear envelope was taken using a 10 Hz low-pass filter. Synergies were calculated using nonnegative matrix factorization. The total variance accounted for by one synergy (tVAF₁) was calculated for each individual. Walk-DMC was calculated as a z-score defined as 100 + 10[tVAFavg - tVAF₁] / tVAFSD where tVAFavg and tVAFSD are the average and standard deviation of tVAF₁ from the controls.

RESULTS AND DISCUSSION
For both the 4 and 8 muscle datasets there were significant differences between the control group and all three CP impairment levels for both tVAF₁ and walk-DMC (one-way ANOVA with a Tukey-Kramer post-hoc, p<0.01 all comparisons), which is consistent with prior work [3]. From the 4 to the 8 muscle set tVAF₁ of the control group decreased by an average of 3.6 percentage points (S.D. 3.2 percentage points) from 67.4% (4.5%) to 63.8% (3.3%). The average change in tVAF₁ from the 4 to the 8 muscle set was similar between all three impairment levels of CP with an average decrease of 0.5 (2.2) percentage points. Walk-DMC scores were lower when calculated with 8 muscles than when calculated with 4 muscles (Figure 1). The average walk-DMC score changed from 80.4 (10.3) to 64.1 (12.2), 70.9 (11.9) to 49.2 (16.0), and 61.5 (11.6) to 37.8 (14.3) for GMFCS Levels I, II, and III respectively.

CONCLUSIONS
The decrease in tVAF₁ of the control group matches prior work in the upper limb simulations which found that small muscle sets can be described better by fewer synergies than larger muscle sets [2]. However, we did not see this decrease for the individuals with CP. This suggests that in CP the added muscles are more highly correlated with the existing muscles which may reflect a more synergistic recruitment in CP. With 8 muscles, the differences between the unimpaired controls and the individuals with CP were found to be greater resulting in decreased walk-DMC scores.

REFERENCES
1. Ting et al. NEURON, 86, 38-54, 2015

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