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Session OS13 Pediatric Gait

Complexity of muscle activity does not change in typically developing children walking on a treadmill at multiple slopes and speeds

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Research question: Does the complexity of the muscle activation patterns respond to changing movement patterns on a treadmill?

Introduction: A small number of synergies (groups of muscles activated together) can describe muscle activity as measured by electromyography (EMG) data during walking at different speeds and stepping patterns on a treadmill [1,2]. Simple patterns (i.e. all muscles activate together) can be described with just one synergy. Complex patterns (i.e. all muscles activate independently) require a combination of multiple synergies. In this study we quantify the complexity of synergies in children with normal motor control to assess if the complexity changes as speed and slope change while walking on a treadmill.

Materials and methods: Sixteen typically developing children walked on a treadmill for 9 combinations (stages) of speeds and slopes. Speeds were set to self-selected (SS), 110% of SS, or 120% of SS. Slopes were set to 0°, 6°, or 12°. Kinematic data was collected simultaneously with surface EMG from 5 muscles on each leg (gastroc., ant. tib., rect. fem., vast. lat., med. hams.). Kinematics for each stride were summarized using a modified version of the Gait Deviation Index (GDI) that only included the sagittal plane (GDIsag) [4]. A summary of muscle activity complexity was calculated from EMG for each stride using the Dynamic Motor Control (DMC) index, which is a scaling of the variance account for in the EMG data by just one synergy [3]. Both indexes are scaled similarly to the GDI. A value of 100 ± 10 indicates normal (within 1 st. dev.) and values below indicate deviations from normal. For GDIsag, this indicates deviations in the kinematics. For DMC, this indicates that one synergy describes greater variance in muscle activity, which is a less complex pattern.

Results: There were multiple significant differences between stages in GDIsag, but no significant differences in DMC (Fig. 1).

Discussion: Significant differences in GDIsag between stages indicate real differences in movement pattern as speed and slope are increased on a treadmill. No difference between DMC scores implies that typically developing children use similar synergistic patterns in response to changing movement patterns on a treadmill. The next step will be to be seeing if individuals with simplified motor control (i.e. fewer available synergies) are able to adapt their movement pattern on a treadmill.

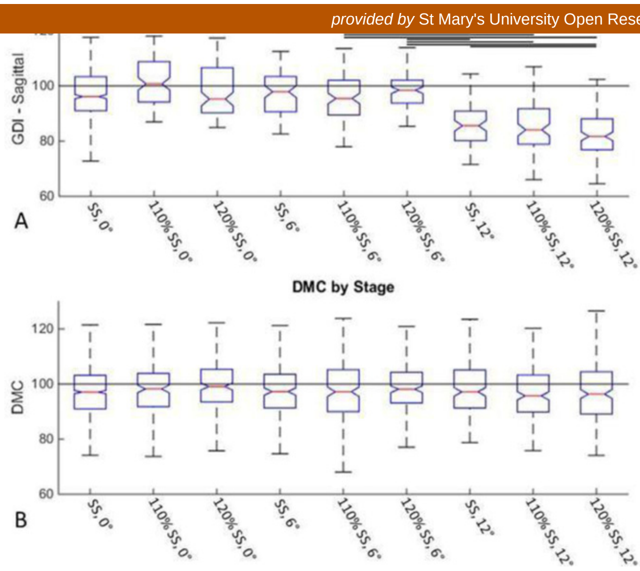

Fig. 1. Distribution of GDIsag (A) and DMC (B) by stage. Horizontal black lines indicate significant differences. There are no significant differences between stages for DMC.

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Session OS13 Pediatric Gait

Associations of the mechanical, anthropometric and gait contributors to the knee adduction moment during paediatric gait

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Research question: What are the relationships of the mechanical, anthropometric and gait contributors to the knee adduction moment during paediatric gait?

Introduction: The knee adduction moment (KAM) has been proposed as an indirect measure of dynamic knee joint loading and has been reported to be higher in obese children [1,2]. The KAM is primarily calculated from resultant ground reaction force (GRF) and lever arm length, both of which can be manipulated through weight-loss or medical interventions [1]. However, there is little data on the relationships of the mechanical, anthropometric and gait contributors to the KAM during paediatric gait. The objectives of the study were to examine the associations with the first (1st) and second (2nd) peak KAM (pKAM) with: (1) centre of pressure (CoP), KAM lever arm length, vertical and mediolateral ground reaction forces (GRF) and, (2) fat mass, height, step width, foot rotation, knee rotation and walking velocity.

Materials and methods: Fat mass was measured in fifty-five boys (9.60 ± 1.13 years old) using air displacement plethysmography. Mechanical and gait parameters were captured using three-dimensional gait analysis to model the lower limbs by plug-in gait. To control for the effects of body height (h) and weight (w) on forces, both raw and normalised associations were included. To assess the association between 1st and 2nd peak KAM and the contributing factors, step- wise forced entry multivariate regression analysis was conducted on variables significantly correlated with the KAM peaks ($p < .05$). Sample mean ± standard deviations are presented.

Results: Greater vertical GRF (1st pKAM 412.9 ± 126.9 N, 2nd pKAM 328.9 ± 128.6 N) and fat mass (24.42 ± 9.07%) predicted higher absolute 1st and 2nd pKAM (13.08 ± 7.93 Nm, 5.66 ± 4.27 Nm, respectively). Normalised vertical GRF (1st pKAM 1.14 ± 0.24 N/w, 2nd pKAM 1.14 ± 0.24 N/w) was a significant predictor of normalised 1st and 2nd pKAM (0.24 ± 0.27 Nm/w h, 0.09 ± 0.12 Nm/w h, respectively). Greater external foot rotation (1st pKAM −11.06 ± 15.02) predicted higher raw and normalised 1st pKAM.

Discussion: The contribution of greater fat mass to the KAM confirms previous findings on the effect of obesity on frontal plane knee loading during gait [2]. Greater external foot rotation may indicate reduced stability and has been reported in obese individuals and patients with osteoarthritis. These findings have implications for conservative interventions such as weight loss or in-toe walking to alter dynamic knee joint loading. Further research into the long term effects of obesity and gait parameters on knee joint loading is warranted.

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Session OS13 Pediatric Gait

Gait patterns of children with Charcot-Marie-Tooth disease

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Research question: What are the distinct gait patterns of children with Charcot-Marie-Tooth disease (CMT)?

Introduction: Gait abnormalities reported in children with CMT include foot-drop, reduced ankle push-off and increased knee and hip flexion or 'steppage-gait' for swing clearance. The purpose of this study was to describe the 3D gait patterns of children with CMT and distinguish differences based on the ability to heel and toe walk using the CMT Pediatric Scale (Burns et al., Ann Neurol, 2012).

Materials and methods: Temporal-spatial parameters, peak joint angles, moments and powers during gait were captured with an 8-camera Vicon Nexus motion capture system using the lower body Plug-in-Gait model in 60 children with CMT (34 male, 11 ± 3.1 yrs, 147 ± 16.8 cm, 44 ± 17.4 kg, 49 CMT1, 4 CMTX, 2 CMT4C, 5 unknown) and were compared to normative reference data from 50 typically developing children (15 male, 10 ± 3.8 yrs, 140 ± 19.6 cm, 39 ± 19.0 kg). A gait profile score (GPS) was calculated to provide a summary of kinematic variables (Baker et al., Gait Posture, 2009). Data were subdivided into 3 groups denoting increasing severity signs of dorsi- and plantarflexion weakness: no difficulty heel walking; difficulty heel walking; difficulty heel and toe walking.

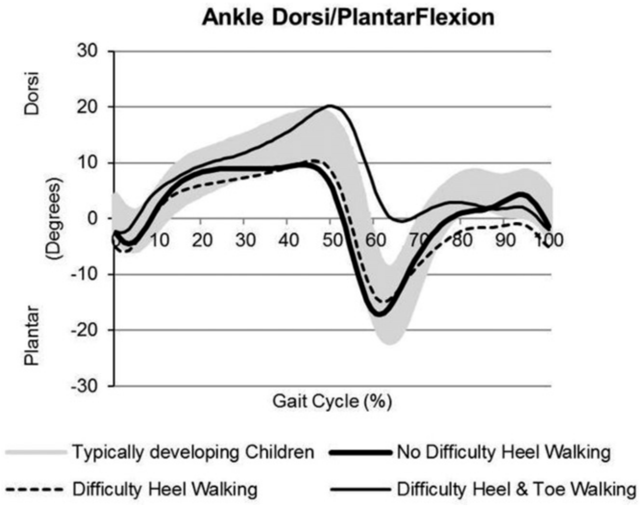

Fig. 1. Ankle dorsi/plantarflexion of typically developing children (grey area ± 1 SD) and three CMT groups: no difficulty heel walking; difficulty heel walking; difficulty heel and toe walking.

Results: Children with CMT showed a significantly higher GPS, reduced peak ankle dorsiflexion during the swing phase of gait and reduced ankle plantarflexor moment in loading response, compared to normative reference values ($p < 0.001$). There were no signs of reduced ankle plantarflexion, ankle power at push-off or any compensation through increased hip and knee flexion in swing ($p > 0.05$). Instead, children with CMT had a significantly increased hip abductor moment in single support and increased hip rotation in mid-swing suggesting an alternative compensatory strategy ($p < 0.001$). When data were sub-grouped and compared to normative reference data, the 'difficulty heel and toe walking' group showed reduced ankle range in swing, reduced ankle plantarflexion at push-off and reduced ankle power at push-off ($p < 0.03$) (Fig. 1).

Interestingly peak ankle dorsiflexion in stance was increased in the 'difficulty heel and toe walking' group whereas in the other groups it was reduced ($p < 0.05$). Otherwise the 'no difficulty heel walking' group was similar to normative data.

Discussion: Several different gait patterns were identified in children with CMT, with increasing gait abnormalities in more severe cases. Classifying gait patterns based on disease severity may be a valuable tool in clinical decision making, assessing disease progression and phenotyping-genotype correlation studies.

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