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**A cross sectional study investigating dynamic balance when stepping in children with cerebral palsy**

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## **1. Introduction**

Dynamic balance while taking a single step has been modelled as a 'throw and catch' of the centre of mass (COM) of the body [1]. Children with Cerebral Palsy (CP) have altered anticipatory postural adjustments (APAs) during gait initiation [2]. These APAs may affect the 'throw and catch' of the COM when stepping to a precise target.

## **2. Research question**

How does the modulation of APAs vary between children with CP and typically developing (TD) children when stepping to medially or laterally placed targets? What is the association between these APAs and symptom severity, movement quality and impairment profile?

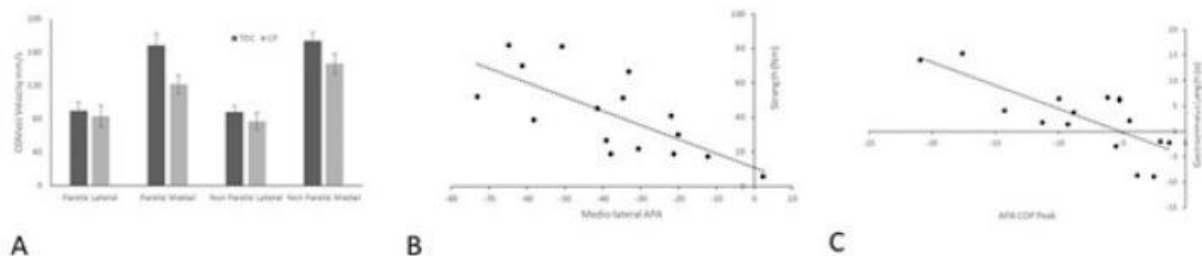
## **3. Methods**

Children undertook a constrained stepping task. They stepped to laterally and medially placed targets with either leg, in a randomised order. Movement of the centre of pressure (COP) and markers at the pelvis and foot were measured via a force plate and 3D motion analysis. Motion of the centre of mass (COM) was estimated via pelvic markers. APAs were assessed prior to leading leg lift-off in medio-lateral and antero-posterior directions. Stepping error was calculated. Baseline characteristics of children with CP included Gross Motor Function Measure (GMFM), Quality Function Measure (QFM), leg muscle hypertonia (Tardieu test) and strength (manual dynamometry).

## **4. Results**

Sixteen ambulant children with CP (11.58 years  $\pm$  2.91) and 14 TD children (12.15 years  $\pm$  2.18) were assessed. In children with CP, APAs in the medio-lateral direction were 20–30% smaller, with reduced modulation of the COM estimate with target position. Medio-lateral COP motion was associated with movement quality assessed by QFM subsections, GMFM ( $r = 0.66$ – $0.80$ ) and hip abductor strength ( $r = 0.75$ ). Antero-posterior APAs were significantly smaller when stepping with the non-paretic leg in children with CP (Fig. 1). APA size was positively related to the length of the

contralateral, paretic gastrocnemius ( $r = 0.77$ ). Stepping error was higher in children with CP.



**A** Difference in medio-lateral centre of mass estimate (ML-COM<sub>est</sub>) velocity when stepping with the paretic (or weaker for TD) and non-paretic sides to lateral and medial targets.

**B** Relationship between medio-lateral centre of pressure (ML-COP) peak and mean hip abductor strength. A negative value of ML-COP indicates a greater lateral motion

**C** Relationship between anterior-posterior centre of pressure (AP-COP) and gastrocnemius length. A more negative COP indicates greater posterior motion.

Fig. 1

Fig. 1. A. Difference in medio-lateral centre of mass estimate (ML-COM<sub>est</sub>) velocity when stepping with the paretic (or weaker for TD) and non-paretic sides to lateral and medial targets; Fig. 1. B. Relationship between medio-lateral centre of pressure (ML-COP) peak and mean hip abductor strength A negative value of ML-COP indicates a greater lateral motion; Fig. 1. C. Relationship between anterior-posterior centre of pressure (AP-COP) and gastrocnemius length A more negative COP indicates greater posterior motion.

## 5. Discussion

We have developed a novel measure of dynamic balance, which shows that children with CP have smaller APAs and difficulty modulating these balance mechanisms between targets. The APA size was associated to proximal muscle strength and gastrocnemius length. Physiotherapy interventions may target these deficits in order to improve stability while stepping during simple functional tasks. Current outcome measures use subjective scoring or may have ceiling effects in this group of children. This novel outcome measure provides quantifiable measures of dynamic balance that can be used to evaluate clinical change in dynamic balance while stepping. Further work is required to determine the reliability of this measure.