

# Sagittal Gait Kinematics and Pelvic Incidence-Lumbar Lordosis Mismatch of Patients with Cerebral Palsy

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## INTRODUCTION:

Sagittal spinopelvic alignment (SPA), which includes the concept of pelvic incidence-lumbar lordosis (PI-LL) mismatch, is an accepted paradigm in the realm of adult spinal deformity. Literature suggests that typically aging individuals with spinopelvic imbalance due to progressive loss of lordosis demonstrate increased pelvic retroversion and knee flexion. Previous studies have demonstrated nearly 2/3 of patients with cerebral palsy (CP) present with PI-LL mismatch. However, the impact of PI-LL mismatch on the gait of patients with CP has not been investigated. Pathological gait patterns observed in CP, often attributed to lower limb muscle and joint contractures/spasticity/deformities, may also be correlated to sagittal spinopelvic alignment factors which are inherent to the pelvis and spine. The aim of this study was to compare sagittal kinematic parameters of the trunk, pelvis, and lower limbs in persons with CP with and without PI-LL mismatch.

## METHODS:

Barefoot, unassisted three-dimensional motion analysis (3DMA) data from individuals with CP (GMFCS I, II) consecutively referred to an accredited motion laboratory (between 2020 to 2022 inclusive) was retrospectively analyzed in this IRB-approved study. Patients with spinal implants and/or radiographic imaging >6 months apart from 3DMA were excluded. Fisher's exact tests were utilized to assess differences in categorical demographic variables.

Gait kinematics collected for a minimum of 6 trials during self-selected walking speed were averaged. PI and LL were measured radiographically, and mismatch was defined as a PI-LL difference  $>10^\circ$  or  $< -10^\circ$ . Mean trunk and pelvic tilt throughout the gait cycle, as well as mean and minimum knee flexion in stance, were calculated. Gait data of individuals with and without mismatch were compared within the cohort of patients with hemiplegia and separately within the cohort of patients with diplegia. Shapiro-Wilk tests assessed normality and independent samples t-tests/Mann Whitney U tests compared kinematic data and age. Significance was set at  $P \leq 0.05$ .

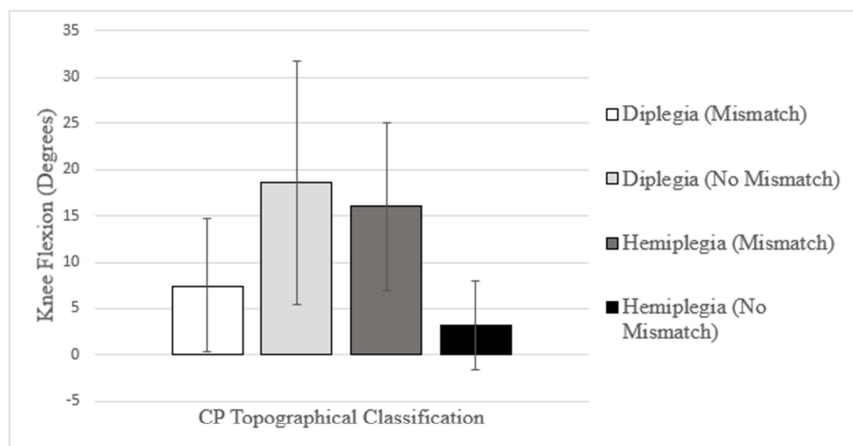
## RESULTS:

Twenty-six patients (15 diplegia, 11 hemiplegia) with an average age of  $28.7 \pm 11.9$  years were included. Nine of 15 (60%) patients with diplegia and 6/11 (55%) patients with hemiplegia presented with mismatch, of which 14 (93%) presented with negative mismatch (LL  $>$  PI). There were no differences in age, race, ethnicity, or sex between patients with diplegia and hemiplegia.

Patients with diplegia and mismatch, compared to patients with diplegia and no mismatch, demonstrated decreased average knee flexion in stance ( $17.77^\circ \pm 6.72^\circ$  vs.  $26.45^\circ \pm 12.79^\circ$  respectively;  $P=0.043$ ) and decreased minimum knee flexion in stance ( $7.34^\circ \pm 7.15^\circ$  vs.  $18.65^\circ \pm 13.74^\circ$  respectively;  $P=0.004$ ), but no difference in average pelvic tilt or average trunk tilt during the gait cycle (**Figure**). Patients with hemiplegia and mismatch, compared to patients with hemiplegia and no mismatch, demonstrated increased minimum knee flexion on their affected sides in stance ( $16.0^\circ \pm 9.9^\circ$  vs.  $3.2^\circ \pm 5.4^\circ$  respectively;  $P=0.026$ ), but no difference in average knee flexion, average pelvic tilt, or average trunk tilt during the gait cycle (**Figure**).

## DISCUSSION AND CONCLUSION:

The magnitude of knee flexion in stance was associated with PI-LL mismatch in this cohort. The decreased knee flexion pattern observed in patients with diplegic CP and mismatch, due to increased lordosis, was of similar compensatory nature to the increased knee flexion pattern observed in typically aging patients with spinal deformity due to loss of lordosis. However, the increased knee flexion pattern observed in patients with hemiplegic CP and mismatch, due to increased lordosis, was the opposite of the pattern observed in typically aging patients with spinal deformity. Larger cohort studies investigating SPA of patients with CP may clarify the impact of PI-LL mismatch, and its directionality, and on sagittal knee kinematics during gait.



**Figure.** Differences in minimum knee flexion in stance between varying cerebral palsy topographical classifications with and without mismatch.