O 095—How do postural parameters vary during gait in children with cerebral palsy? A 3D subject-specific skeletal segment registration technique

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1. Introduction

Postural parameters, calculated in static position on frontal and sagittal radiographs, are altered in ambulant children with cerebral palsy (CP) and are known to be related to gait abnormalities [1,2]. Most of these parameters are positional and could vary during gait. Their computation could be performed using gait simulation models that are usually generic or semi-personalized [2,3]. There are currently no studies investigating how subject-specific postural parameters are modified during gait in children with CP.

2. Research Question

How do postural parameters vary during gait in children with CP?

3. Methods

14 typically developing children (TD-group, age:11.7 ± 4 year) and 14 children with cerebral palsy (CP-group, age:11 ± 4 year, Hemiplegia:N = 4, Diplegia:N = 10) underwent gait analysis using Davis protocol [3] with additional markers on thighs and shanks. Subjects then underwent low-dose biplanar X-rays in standing position with the reflective markers still in place. Subject-specific 3D reconstruction of the spine, pelvis and lower limbs were performed with calculation of 3D radiological postural parameters in the static position: pelvic tilt(PT), sacral slope(SS), acetabular abduction(Acetabular_Abduction), anteversion(Acetabular_Anteversion) and tilt(Acetabular_Tilt) [4] as well as anterior (Ant_Acet_coverage) and posterior (Post_Acet_Coverage) acetabular coverage over the femoral head. 3D bones were registered on each frame of the gait cycle [5] (Fig. 1). A new technique developed for this study, utilizing finite element modeling, was used to reduce soft tissue artefacts. The same postural parameters were then computed during the gait cycle, using the 3D registered bones, at each time frame: means and ranges of motion (ROM) were calculated then compared between TD and CP.

4. Results

The TD-group had an Acetabular_Anteversion of 14 ± 5° (CP-group: 12.5 ± 4°) in static position that increased to an average of 18 ± 4° during gait only in the TD-group ($p < 0.001$). During walking, the average over the entire gait cycle of the Acetabular_Anteversion and Acetabular_Tilt was decreased in the CP-group (Acetabular_Anteversion: CP: 13 ± 6° vs TD:18 ± 4°, $p = 0.001$; Acetabular_Tilt: CP: 20 ± 8°vs TD: 25 ± 6°; $p = 0.011$, Figs. 2 & 3). Moreover, the average of SS during gait was increased in the CP-group when compared to TD (44 ± 6° vs. 34 ± 8°, $p = 0.002$). The ROM of the PT was significantly larger in the CP-group compared to TD (9 ± 3° vs. 6 ± 2°, $p = 0.05$) (Fig. 3).

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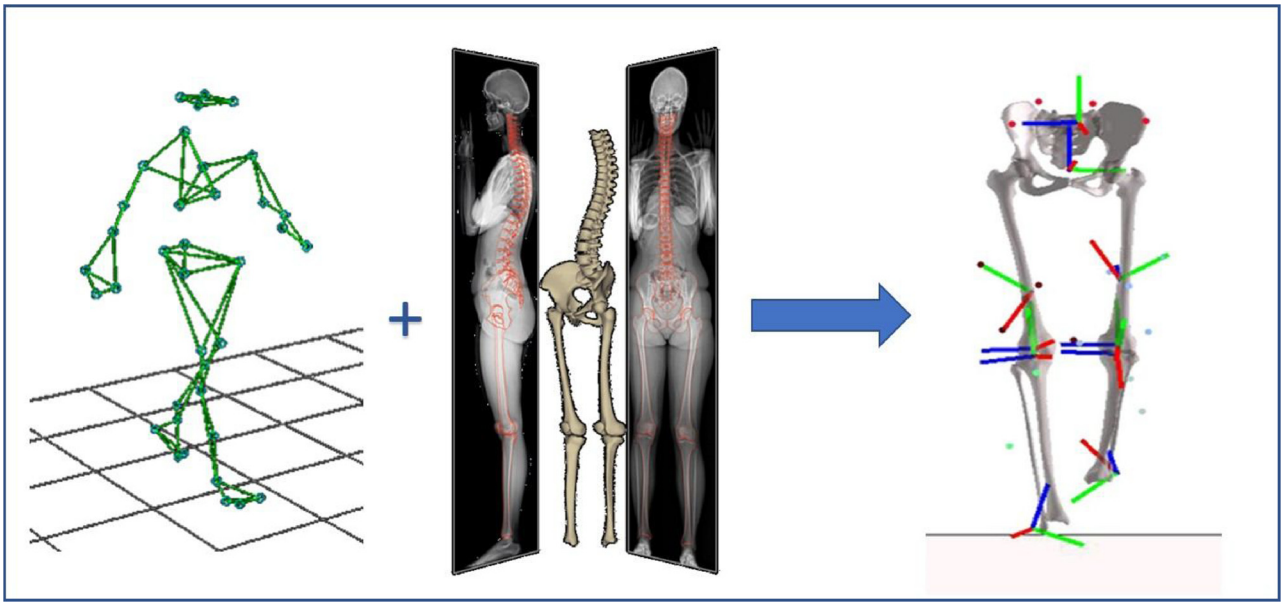

Fig. 1. Registration technique of 3D skeletal segments in gait analysis.

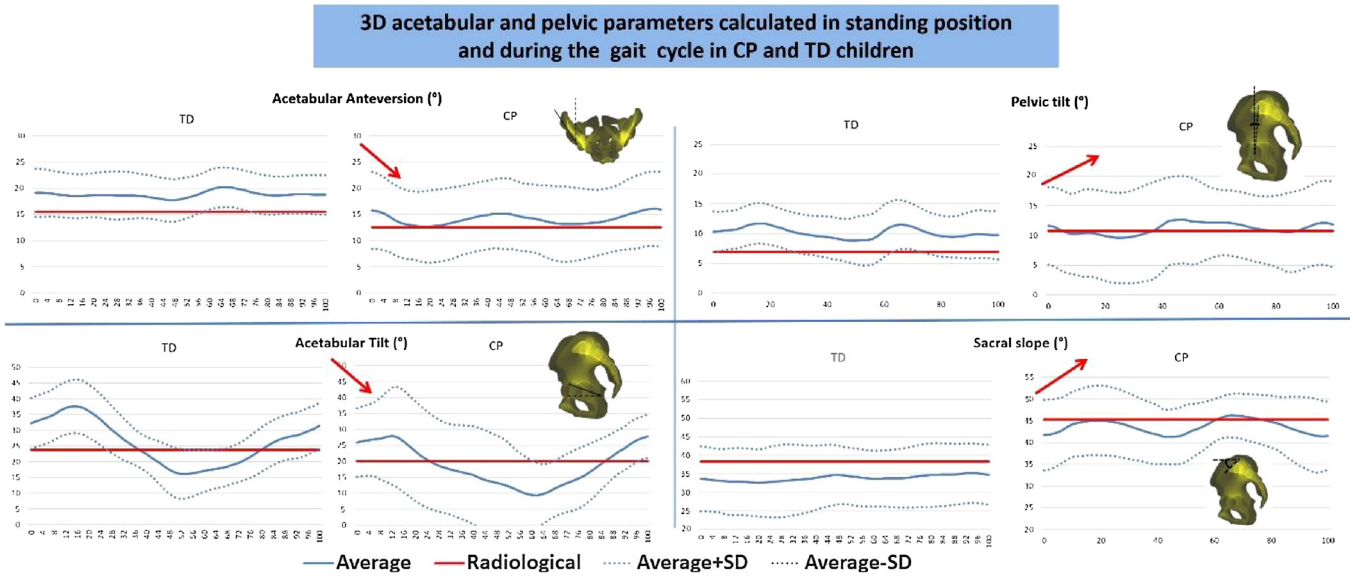

Fig. 2. 3D acetabular and pelvic parameters calculated in standing position and during the gait cycle in CP and TD children.

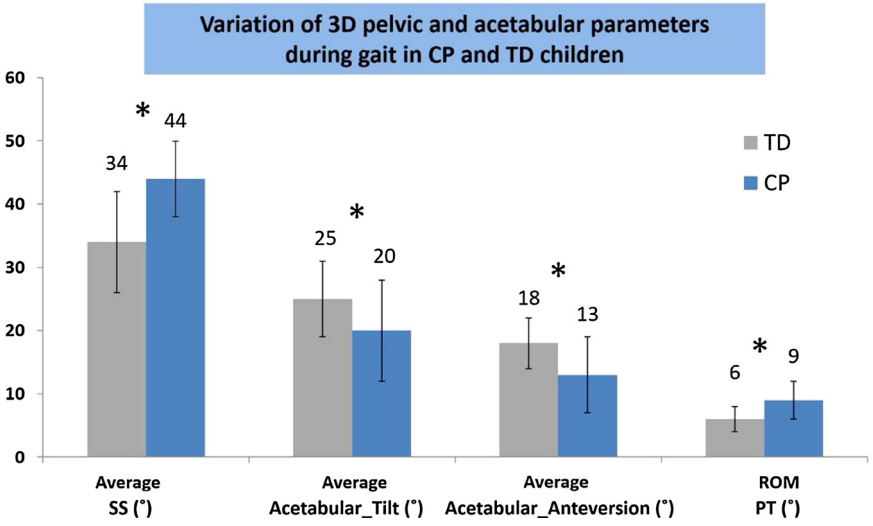

Fig. 3. Variation of 3D pelvic and acetabular parameters during gait in CP and TD children.

5. Discussion

This is the first study to compute 3D subject-specific postural parameters during gait in children with CP. The CP-group presented a higher ROM of PT during walking which could be related to altered spinal movement and stability during gait. Children with CP seem to present significant acetabular alterations in static and dynamic that might alter lower limb kinematics during gait. Future studies should investigate acetabular postural parameters in patients with different gait profiles to elucidate postural and compensatory behaviors in children with CP. The subject-specific skeletal registration technique could provide dynamic quantitative data for gait biomechanical modelling.

References

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