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VALIDATION OF A MARKERLESS SYSTEM FOR ASSESSING GAIT KINEMATICS AND KINETICS IN CEREBRAL PALSY CHILDREN

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1 INTRODUCTION

Cerebral Palsy (CP) is intensively studied in clinical gait analysis using the standard marker-based (MB) systems, which have many limitations associated with the placement of markers. Markerless (ML) systems use deep learning algorithms and are a potential alternative that offer practical and technical benefits to perform gait analysis [1]. There have been studies that research repeatability and concurrent validity of Theia3D in healthy adults, which have shown that spatiotemporal parameters and joint kinematics in the sagittal plane are similar to the MB systems [2][3]. However, there is still the need to test this system in order to assess abnormal gait conditions, such as CP. This project aims to determine whether ML systems estimate joint kinematics and kinetics similarly to the MB systems, while assessing Cerebral Palsy children during gait.

2 METHODS

Fourteen ambulatory CP children (10 males and 4 females), aged between 8 and 25 years, walked in a straight line at a self-selected speed, stepping over force plates. Participants wore comfortable sport shorts and females wore a sports bra. Data were collected using 10 infra-red Ocqus and Arqus cameras (Qualisys AB, Sweden), and 8 Miqus RGB video cameras (Qualysis AB, Sweden), which recorded at 85 Hz. The CAST marker set was used for the MB system, and the default model of Theia 3D (v 2023.1.0.310, Theia Markerless Inc., Kingston, ON, Canada) was used for the ML analysis. The pelvic and lower limb joint angles, moments and powers were compared using the root mean square difference (RMSD) and a paired t-test ($\propto$=5%) performed with a Statistical Parametric Mapping package in MATLAB (v R2023b, MathWorks, USA).

3 RESULTS

The average RMSD of the joint moments and powers in the sagittal and frontal planes are represented in Table 1, and the average joint angles in the sagittal plane are shown in Figure 1.

Table 1. RMSD of lower limb joint moments and powers.

	Moment (Nm/kg)		Power (W/kg)
Anatomical plane	Sagittal	Frontal	Sagital
Ankle	0.24±0.47	0.14±0.12	0.20 ±0.15
Knee	0.26±0.58	0.14±0.17	0.20 ±0.12
Hip	0.19±0.22	0.19±0.22	0.20 ±0.10

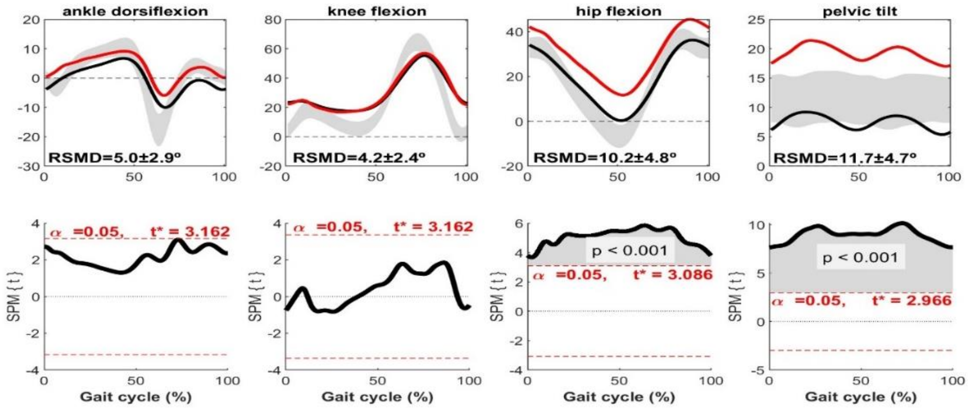

Figure 1. Pelvic and lower limb joint angles computed with the marker-based (red) and markerless (black) systems, and correspondent paired t-test performed with SPM1D.

4 Discussion and Conclusions

The pelvic and lower limb joint kinematics were highly comparable between the MB and ML systems in the sagittal plane, showing promising results to assess CP children, specially at the knee joint (RMSD<5.0º). Nevertheless, systematic offsets and significative differences were observed at the hip and pelvic joints (RMSD>10.0º). The modeling definitions of the pelvic joint differed between the systems and the discrepancies propagate to the hip joint, resulting in large systematic offsets throughout the gait cycle. The frontal plane showed acceptable differences, however, the utility of the ML system to assess CP children in the transverse plane is questionable due to the large differences and inconsistencies compared to the MB method (RMSD>10.5º).

Regarding the joint moments in the sagittal plane, significative differences were observed at the ankle in the swing phase and at the hip during the swing phase. Even though the knee joint moments did not obtain any significant differences, this joint showed the greatest difference between the MB and ML systems (RMSD=0.26±0.58Nm/kg). Abductor moments did not obtain any significant differences (RMSD<0.20±0.22 Nm/kg). All lower limb joint powers obtained significant differences during the swing phase, particularly at terminal swing (p<0.014).

The differences in the joint kinetics between the systems seem to arise from differences in the estimation methods of the joint centers and segment center of mass of each system. The ML system's algorithm needs improvement before its use to clinically assess CP children's kinetic parameters during gait.

Aknowledgments

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