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Children with cerebral palsy with increased femoral anteversion present with a variety of hip and pelvic gait patterns

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Summary and Conclusions: Unsupervised learning techniques (factor and cluster analysis) were used to recognize typical gait patterns and to search for underlying pathological mechanisms which might explain the large inter-subject variability in gait

of children with cerebral palsy (CP) with increased femoral anteversion (FA). Six typical patterns were described, ranging from normal hip rotation with increased pelvic anterior tilt to a crouched mal-rotation pattern. Differences for gait parameters, age, diagnosis, FA and strength and spasiticity measures were seen between the six clusters.

Introduction: Internal hip rotation and intoeing gait is usually associated with an increased FA in children with CP. However, several studies indicated that FA and kinematic measures correlate weakly. The purpose of the study was to evaluate whether different gait patterns could be statistically recognized for children with increased FA.

Patients/Materials and Methods: 239 patients with CP (diplegia: 131, hemiplegia: 108) were selected based on following criteria: (1) ambulation, without walking aids, (2) full gait analysis, including 3D kinematics, kinetics and EMG and full clinical examination (ROM, spasticity, strength and selectivity) at 4 to 19 years of age, (3) FA of 40º (according to Ruwe et al. [1]) or more and clear indications for accurate marker placement during gait analysis (range of coronal knee motion <15º). 42 gait parameters and 32 clinical examination parameters (ROM, spasticity, strength, selectivity) were originally defined for each subject. 20 kinematic and kinetic parameters, typically related to the pelvis and hip, and to rotational deformities, were then selected to develop the classification. The remaining parameters were used post-hoc for the description of the gait patterns. Due to the high dimensionality of the gait data and the correlations between parameters, factor analysis (three factors extracted) on standardised variables, was used as input for non-hierarchical k-means clustering. The number of clusters was selected based on the observed overall R-squared and the Cubic Clustering criterion for repeated cluster analyses. Six clusters were defined. Pathological data were compared to control data of a group of 65 age-related healthy children. Mean and SD of all parameters were calculated for each of the 6 clusters. Analysis of variance (ANOVA, post-hoc Tuckey) was used to detect differences between groups.

Results: Study of the three factors extracted from factor analysis indicated that pelvic anterior tilt, sagittal hip kinematics, and hip rotation at terminal stance were the most discriminating parameters between the 6 gait patterns. Two patterns were close to normal gait with one cluster (N = 55) characterized by normal hip rotation with increased pelvic anterior tilt, and a second group (N = 59) with normal hip rotation at initial contact, quickly increasing into internal hip rotation during loading response, but no pelvic anterior tilt. Three clusters were characterised by crouch, with or without mal-rotation. One crouch gait group (N = 15) was combined with internal hip rotation at initial contact, gradually increasing in stance, combined with external foot alignment (mal-rotation). Two other crouch patterns were characterised by internal hip rotation, gradually increasing in stance, resulting in intoeing gait, with one group more severely involved and more fixed (N = 14) compared the other group (N = 54). A final cluster (N = 42) could be described as coupled pelvis-hip rotation. Significant between-groups differences were also seen for age, diagnosis, FA angles and strength and spasticity measures. Discriminating clinical examination parameters between groups were strength and selectivity of hip extension and abduction and spasticity of hip adductors.

Discussion: In this large cohort of children with increased FA, continuous internal hip rotation was only recognized in one of the six clusters (6.3% of the total group). Four other groups (70.8% of the total group) were characterized by dynamic internal hip (normal hip rotation at initial contact, gradually increasing in stance). One group showed normal hip rotation throughout the gait cycle (22.9% of the total group).

References

[1] Ruwe et al. (1992), J. Bone Joint Surg, 74A: 821–830.

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Torsional MRI pre and post femoral derotation osteotomy in spastic diplegia – do the changes in anteversion correlate with the dynamic findings?

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Summary: Total derotation amount resulted in adequate change of anteversion (measured by MRI) over all patients. However, no significant correlation between the change of femoral anteversion (FA) after femoral derotation osteotomy (FDO) and the change of mean hip rotation during stance (3D gait analysis) was found. The femoral anteversion is not suitable as a predictor for mean hip rotation in stance.

Conclusions: The study supports the hypothesis, that internal rotation gait is not an isolated problem of increased FA, but a dynamic multi-dimensional problem [1]. These dynamic factors are not addressed by an isolated FDO, which only corrects the static aspect. This explains the incidence of over- and under-corrections, reported in recent studies [1,2]. As long as all pathogenic components of internal rotation gait are not understood, isolated FDO for the correction of internal rotation gait should be questioned.

Introduction: The internal rotation gait, frequently seen in spastic diplegia, is commonly treated by a FDO which may be carried out either proximally or distally. Older studies report satisfactory results [3], whereas recent follow-up studies report high occurrence of over- and under-correction [1] and recurrence [2] of internal rotation gait following FDO. With the femoral derotation osteotomy, only increased anteversion can be treated. It is still unclear, if femoral anteversion is the main factor leading to internal rotation gait. The clinical determination of anteversion (TPAT) is afflicted for measuring errors. The torsional MRI enables a much more accurate determination of the anteversion angle, without radiation exposure for the children. The purpose of this study was to correlate the femoral anteversion (measured by MRI) with the intra-operative derotation amount and the dynamic parameters from the 3D gait analysis. Is increased FA the most important factor for internal rotation gait?

Patients/Materials and Methods: 15 children with diplegic CP (n = 29 legs, age: 9.6±2.9 y) were prospectively examined pre- (E0) and postoperatively (E1) after FDO (mean follow-up: 13 m±2 m). The patients underwent standardized torsional MRI of the lower extremity (calculation of femoral anteversion), clinical exam and 3D-gait-analysis (Helen-Hayes-Set) at E0 and E1. The intra-operative derotation angle was measured in a standardized way with derotation K-wires and a Moeltgen® goniometer. 20 osteotomies were carried out distally and 9 proximally. The