INFLUENCE OF THIGH MARKER CLUSTER DESIGN ON THE ESTIMATION OF HIP AXIAL ROTATION

[1] Anthony Schache, [1] Richard Baker and [2] Larry Lamoreux
[1]Murdoch Childrens Research Institute & Hugh Williamson Gait Laboratory, Royal Children's Hospital, Australia
[2]Gait Dimension, Benicia, California; email: anthony.schache@mcri.edu.au

INTRODUCTION

Measurements of hip axial rotation are prone to considerable error [1]. Given the degree of soft tissue mass surrounding the femur, it is likely that most of this error is a consequence of soft tissue artifacts associated with markers mounted on the thigh. Therefore, the purpose of this study was to evaluate various thigh marker cluster configurations with a view to optimising the estimation of hip axial rotation.

METHODS

Five able-bodied adults (4F; 1M) participated in this study. Mean age, height and body mass were 23.7 years (SD 6.9), 164.9 cm (SD 2.9) and 58.1 kg (SD 7.4) respectively. Ethical approval was obtained prior to commencement. Reflective markers were placed over the pelvis, thigh and shank. A thigh wand fixed to a thermoplastic base plate was firmly mounted on the thigh using circumferential straps. Four different thigh clusters were then configured as defined in Figure 1 (see legend). Three were non-rigid (clusters A, C & D) and one was rigid (cluster B). Cluster A corresponded to the Helen Hayes marker set up. The HJC was estimated from the pelvic markers [2]. Clusters B, C and D were mounted distally on the thigh to optimise rigidity with the underlying femur [1].

A VICON motion analysis system (Oxford Metrics Ltd.) was used to capture 3D kinematic data (120 Hz). A static calibration trial was first captured to define the relationship between all clusters (technical frames) and the relevant anatomical frames. Subjects then performed two tasks: normal gait at a self-selected speed and isolated longitudinal rotation of the lower limb. For the latter task, the test subject stood with the test limb on a ball-bearing turntable and the knee extended. Subjects rotated the test limb about its long axis by internally and externally rotating the hip. As the knee does not permit axial rotation when extended and soft tissue movement in the shank is not expected during this task, markers on the tibia were used to represent true axial rotation of the femur.

Hip axial rotation patterns during gait, as measured from the different thigh clusters, were compared for similarity using the coefficient of multiple determination (CMD or r^2) statistic. Regression analysis was used to describe the relationship between estimated (thigh cluster) and true (tibial markers) hip axial rotation for the isolated longitudinal rotation task. Analyses were performed for the left and right side independently and results were averaged.

RESULTS AND DISCUSSION

Hip axial rotation during gait was highly sensitive to thigh marker cluster design (Figure 1). The mean CMD value was 0.34 (SD 0.29) indicating quite poor similarity between clusters. All clusters underestimated true bone movement during the isolated longitudinal rotation task (Figure 2). Mean regression coefficients were 0.46 (SD 0.06), 0.60 (SD 0.05), 0.56 (SD 0.07) and 0.56 (SD 0.07) for thigh clusters A, B, C and D respectively. This indicates that marker clusters on the distal thigh were only capable of estimating, at best, up to 60% of the true magnitude of movement. When comparing the different clusters, the Helen Hayes convention (cluster A) was associated with the greatest degree of error. Clusters C and D produced near identical results. Thus, the addition of the thigh wand in cluster C had no measurable influence. Clusters C and D tended to produce hip axial rotation patterns during gait that were more systematic across subjects when compared to clusters A and B.

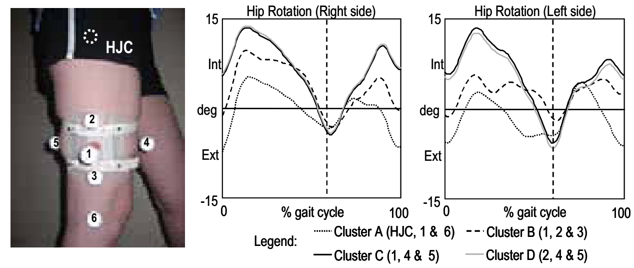

Figure 1 Hip axial rotation during gait as measured using the different thigh marker clusters for a typical subject.

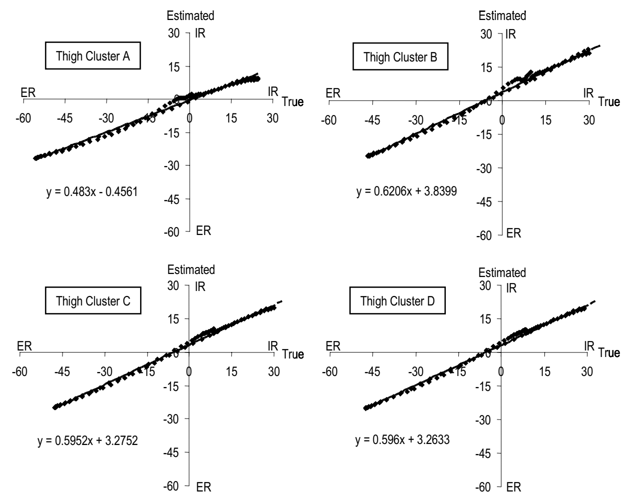

Figure 2 Estimated (thigh cluster) versus true (tibial markers) hip axial rotation during right-sided longitudinal rotation for a typical subject.

CONCLUSIONS

The estimation of hip axial rotation was highly sensitive to thigh marker cluster design. Whilst none of the clusters were capable of satisfactorily estimating true bone movement, clusters C and D appear to be better alternatives than clusters A and B. Until further work provides a definitive solution, one must remain cautious when using estimates of hip axial rotation for purposes of research or clinical interpretation.

REFERENCES

1. Lamoreux LW. *Proceedings of ISB XIII*, Perth, Australia, 1991, pp 372-373.
2. Davis RB et al. *Hum Mov Sci* 10; 1991, pp 575-587.