Motion Characteristics of the Innominate-hip complex under increasing passive loads

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INTRODUCTION

The human pelvis provides the bony link between the spinal column and the lower limbs, acting as an intermediary in the load transfer mechanism from the trunk to the legs and *vice versa*. A problem encountered in modelling research is the representation of the pelvis as a solid or rigid body, thus pelvic joint motion is ignored. To increase our understanding of the mechanisms involved in loading injury to the lumbar spine there is a need for research combining lower limb and spine kinematics with pelvic joint kinematics to identify the extent and nature of motion in the lumbar-pelvic-hip complex.
The aim of the present research was to examine the motion characteristics of the innominate-hip complex under normal passive loading conditions and specifically, to determine the contribution of relative innominate bone motion within the complex.

METHODS

Thirty healthy subjects (16 females and 14 males) between the ages of 20 and 40 gave their informed consent to participate in this study. A magnetic tracking device (Fastrack, Polhemus Incorporated, Colchester, VT, USA) was used to track the motion of the pelvis, innominate bones and femurs as the hip was passively loaded in 10° increments. A standardization frame was used to standardize the passive loading of the hip in two separate constraint conditions up to maximum lateral flexion (AB) and external rotation (ER). The frame constrained the hip so that only motions in the frontal and transverse planes were allowed (i.e., the femur was constrained in the directions of flexion and extension). Thus, the hip orientation was described relative to the pelvis as a y x y sequence of Euler angles. In each load position the transverse (I_{NSy}) and sagittal plane ($I_{NSz,}$) angles of the innominate bones were calculated from digitized pelvic landmarks. Finally, the innominate motion was described as absolute angular displacement between the neutral and loaded positions.

To determine whether there was an effect of Hip Condition or Load Position on the ROM of the innominate and hip, means and standard deviations for motion measured in the final positions of each hip condition were calculated. The dependant variables $H_{ABx,}$ $H_{ERy,}$ $I_{NSz,}$ and I_{NSy} were each tested in a GLM univariate analysis, F-ratios and alpha levels derived for each source of variance (Hip Condition, Load Position and Load Position x Hip Condition). Where significant differences between Positions were found a Tukey *post-hoc* test was used to determine which Positions were significantly different.

RESULTS

Firstly, as expected the femur motion increased significantly with each successive Position. So, H_{ERy} increased significantly (p<0.001) with increasing external rotation stress and H_{ABx}, also increased significantly (p<0.001) with increasing lateral flexion stress. Secondly, the only significant Position effect in innominate bone displacement was about the y-axis (I_{NSy}) in the ER condition where there was there a significant change (p=0.001) in innominate motion with increasing stress. The evidence from the Tukey *post-hoc* test showed that the increase in ROM from Position 1 to Positions 3, 4 and 5 was significant, the mean difference between Positions 1 and 3 was -0.84° (95% CI = -1.37 to -0.32°). There was a very low ability to adequately predict I_{NSy} innominate from H_{ERy} of the femur as determined through regression plots (R^2 = 0.10 right, Figure 8 and R^2 = 0.13 left, Figure 7). The combination of small ROM and large individual variability make such across-subject comparisons difficult.

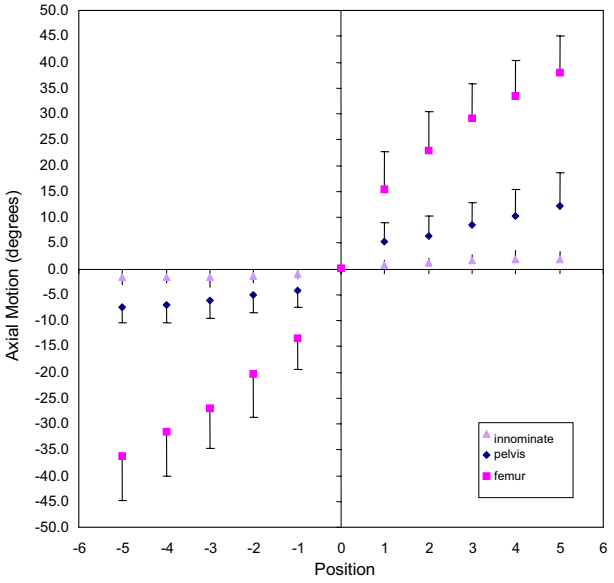

Figure 1: Means and standard deviations for the left (-) and right (+) hip, pelvis and innominate bones in each of the loaded positions of the ER hip condition.

DISCUSSION AND SUMMARY

The present study demonstrated that the greatest change in innominate bone ROM occurs within the first 15-20° of hip motion and that increased load on the innominate from the hip does not significantly increase the displacement of the innominate bones. Although the ranges of innominate bone motion were significantly smaller compared to pelvic or femur motion, the innominate bone motion accounted for 3 to 5% of the total x and y femur rotations. The results of this study support the theory that the main functional role of the pelvic joints (apart from aiding in childbirth) is to reduce the injurious torque from the hip to the lumbar spine.