

HOW PRECISE IS THE HIP JOINT CENTRE POSITION FOUND USING FUNCTIONAL METHODS?

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INTRODUCTION

The location of the hip joint centre (HJC) plays an essential role in the calculation of hip kinematics and kinetics in motion analysis studies. Mislocation of the HJC can lead to errors in hip joint moments and in hip flexion-to-extension timing (Stagni et al., 2000).

The most common way of estimating the position of the HJC is to use regression equations derived from anthropometric data (for example, Davis et al., 1991, Harrington et al., 2007). The accuracy of such equations depends on the size and variability of the data set and on the independent parameters chosen for the regression.

So-called functional methods for finding the HJC (Cappozzo, 1984) should be superior to regression equations since they are subject-specific. Functional methods involve a movement of the thigh relative to the pelvis and calculation of HJC position from the positions of skin-mounted markers. For functional methods to be useful, they must be not only accurate, but precise. In theory, they should give the same HJC position regardless of the leg movement undertaken or the calculation method used.

The aim of this study was to assess the precision of the HJC position found using functional methods.

METHODS

One healthy adult male subject (age 23, height 183 cm, weight 67 kg) performed six repeats each of four functional motions (right leg only): hip flexion-extension-abduction, hip circumduction, forward walking, and sideways walking. Four retro-reflective markers (14 mm dia) were placed on the pelvis (ASIS and PSIS, left and right), and five similar markers were placed on the thigh (two on the anterior side, two on the lateral side, and one on the lateral femoral epicondyle). Motion data were collected at 100 Hz using a twelve-camera Vicon 612 (Vicon, Oxford, UK). Marker trajectory data was neither filtered nor smoothed. Data are reported in *mm*.

For each trial, the HJC position in a pelvis-based coordinate system (Wu, 2002) was calculated from the marker trajectories using several mathematical methods: Reuleaux method (Halvorsen et al., 1999), sphere-fitting methods (1-Piazza et al., 2001; 2-Halvorsen, 2003) and symmetrical estimation (SCoRE, Ehrig et al. 2006). A first estimate of the HJC position was calculated using the single-variable regression equations in Harrington et al. (2007). All calculations were implemented in Matlab (The Math Works, MA, USA).

Tests on a mechanical ball-and-socket joint gave a joint centre position accurate to just over 1 mm and repeatable to within 0.3 mm for the sphere-fit and SCoRE methods. The

Reuleaux method was accurate to 1.6 mm and repeatable to 0.6 mm.

RESULTS AND DISCUSSION

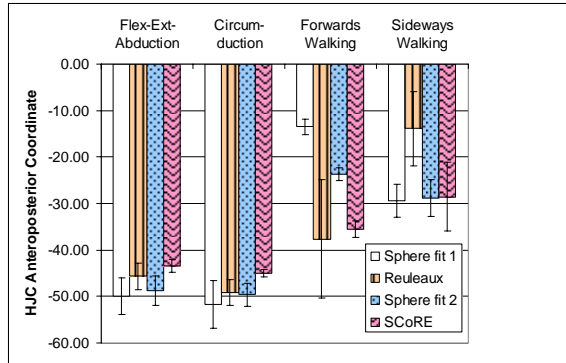


Figure 1: Anteroposterior (x) coordinate.

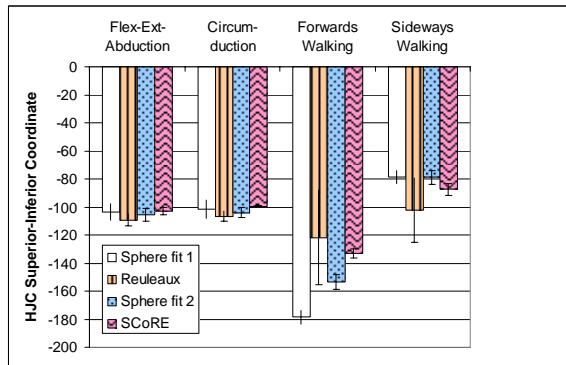


Figure 2: Superior-inferior (y) coordinate.

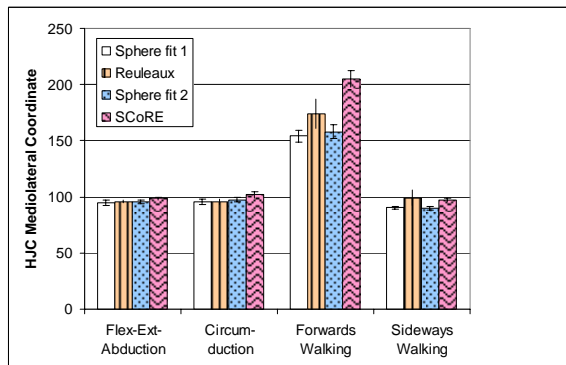


Figure 3: Mediolateral (z) coordinate.

Regression equations gave the HJC antero-posterior, superior-inferior, and mediolateral position coordinates (x , y , z) as $(-50, -88, 92)$. Functional HJC position varied both with motion type and calculation method

(Figs. 1-3). HJC position calculated from all motion trials and all calculation methods ($n=94$) was $(-37\pm 13, -110\pm 27, 115\pm 35)$.

The standard deviations (stdevs) of the calculations were used to indicate the precision, or repeatability, of functional HJC position. Overall, the SCoRE method gave the smallest stdevs in x and y (8 and 17), whilst the Sphere fit 1 method was most consistent in z (27). Flex-ext-abduction and circumduction had the smallest stdevs in x , y , and z (range 2-5). Sideways walking was similarly consistent in z (6). See Figs. 1-3.

SUMMARY/CONCLUSIONS

This study quantifies the precision of functional HJC methods. It does not give the accuracy of the methods (how close the calculations are to the true HJC) or indicate any bias in the HJC coordinate directions.

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