DO DIFFERENT METHODS OF HIP JOINT CENTRE LOCATION IMPACT ON KINETICS AND KINEMATICS IN OBESE ADULTS?

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INTRODUCTION
In many developed countries substantial proportions of populations are obese; in the UK this includes up to a quarter of adults [1]. Movement strategies in obese adults may compensate for additional loads and there is some concern that some exercise regimens such as brisk walking [2], may promote osteoarthritis in load bearing joints.

The biomechanical assessment of activity restrictions in obese populations may provide important insights into the aetiology of OA and into appropriate exercise strategies [3]. Recent interest in the study of biomechanics of obese cohorts has increased [4, 5], though the variation and lack of reporting of methods used raises questions about the true comparability of data sets. Such assessments need to comprehensively measure kinetics and kinematics at all weight-bearing joints to fully understand quality of movement and the impact of activity restriction in obesity. However, the reliability of methods used to capture data may be compromised in obese subjects because of increased difficulty in identifying anatomical landmarks, particularly at the pelvis and thigh. This would particularly affect the determination of the hip joint centre (HJC) location, accurate estimation of which is important not only in the measurement of hip moments and adduction and abduction angles of the hip [6], but because it determines varus and valgus alignment of the femur and knee angles.

The reliability and accurate estimation of the HJC has been extensively discussed and has resulted in International Society of Biomechanics (ISB) recommending that the functional approaches to HJC location are favourable above predictive methods [7]. It is suggested for participants likely to have a restricted range of movement (ROM), predictive methods may be more preferable [7]. Whilst the recommendations may account for pathology, anatomical variations and movement restrictions [8], there is no evidence to support which technique is best supported for use in obese cohorts.

This study compares the relative bias in determining the HJC between different methods [9-11] in obese and non-obese groups, to assess the effect of these on hip and knee angles as well as hip moments.

METHODS
8 obese subjects (BMI=30) and 8 healthy age matched subjects (BMI= 20-24.9) were recruited to this study. The kinematics and kinetics of the lower limbs, pelvis and thorax were recorded using a ten-camera ProReflex movement analysis system at 100 Hz (Qualisys Medical, AB) with four AMTI force plates at 200 Hz (Advanced Mechanical Testing Inc). Each participant was asked to walk at their normal speed down a 12 metre walkway five times. The segments of the lower limbs were modelled in six-degrees of freedom using the calibrated anatomical system technique (CAST).

Four models: one functional and three predictive were defined based on the different methods used to estimate the hip joint centre. These were: the functional method [9], the predictive model described by Bell [10] and two predictive methods derived from the conventional gait model (CGM) Davis [11] (Helen Hayes and the Plug-in-Gait). All models were applied to the same dynamic walking trials for both subject groups within Visual3D software (C-Motion inc. USA).

RESULTS AND DISCUSSION
Significant differences in HJC location were found between the functional method and the three predictive methods for normal weight subjects in the sagittal and transverse planes and in the sagittal, coronal and transverse planes in the obese subjects (Figure 1), with the exception of the functional versus Bell’s method.

Figure 1: Differences in HJC location [Functional (Blue), Bells’ (Yellow), CGMI (Green), CGMII (Pink)], for an Obese (left) and Non-Obese (right) participant.

Bell’s [10] method also differed significantly from the CGM (Plug-in-Gait), in all planes for both groups of subjects (p<0.005). The two CGM models [11] showed significant
differences in the sagittal and transverse planes in both obese and non-obese groups, primarily resulting from differences in anthropometrics used within the calculations.

Analysis of the hip angle during the gait cycle showed significant differences in minimum and maximum hip angles in the sagittal, coronal and transverse planes were seen (P<0.05) for both participant groups. However, when considering the hip ROM there was no significant difference (data not presented) between the different HJC location methods (P>0.05) in any plane (mean difference < 2.0°). This indicates a shift occurs to alter the maximum and minimum values, leaving the hip ROM unaffected by the HJC location method.

Analysis of the knee angle during the gait cycle showed significant differences in minimum and maximum knee angles in the sagittal, transverse planes (P<0.005) between methods, for both groups. In obese participants, a significant effect was seen only in the coronal plane (P=0.026); whereas in the non-obese group significant effects were noted in the sagittal (P=0.009) and coronal (P<0.001) planes. Pairwise comparisons revealed that for knee flexion/extension some similarities may be seen between the functional and predictive models in both groups of participants (mean difference < 2°).

The largest differential effect of the HJC location methods was seen in the knee abduction/adduction ROM in both subject groups, with the largest mean differences being 4.6° (P<0.001) in non-obese and 3.5° (P=0.026) in obese participants respectively. The largest difference occurs between the functional and CGM methods and between Bell’s and CGM-II methods. Pairwise comparisons show significant mean differences (>1°), except between Bell’s and CGM-I in the non-obese and between functional and Bell’s in the obese group. In all participants, knee ROM in the transverse plane appears to be similar between HJC location methods (mean difference ≈ 0.0 to 0.6°), indicative of comparable knee rotations. However, an offset in maximum and minimum angles occurs. Notably, similarities may be seen between the CGM methods in both the sagittal and transverse planes (mean difference <0.2°).

Pairwise comparisons between HJC location methods indicate clear differences in both obese and non-obese peak hip moments. No significant effect was noted on internal rotation moments. However, significant differences between methods were seen in peak flexion and extension moments in the obese group (P<0.001) with some pairwise differences. In the non-obese subjects however a significant difference is only noted in the peak extension moments of the hip. The mean peak hip abduction moments significantly differ between measurement methods within the obese (P=0.001) and non-obese (P=0.004) groups, directly relating to the differences in the medial-lateral position of the HJC. While a significant pairwise difference was seen in obese subjects between all methods, differences in mean peak abduction moments were small (<0.5Nm/kg).

CONCLUSIONS

In obesity, movement range may be restricted and hence make it difficult to perform the movement required to calculate the recommended functional HJC [7]. The alternative then lies in a predictive model that is unable to account for asymmetry and shows significant differences in both obese and non-obese groups. It is therefore vital to report the exact method used to allow data-sets to be comparable.

Different methods of calculating the HJC, can cause changes in the reported of hip moments and adduction/adduction angles as well as varus/valgus deformity of the knee angle. Such measurements are of particular importance when reporting treatment of knee pathologies (i.e. medial compartment osteoarthritis) in both obese and non-obese groups.

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