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Short communication

Use of wand markers on the pelvis in three dimensional gait analysis

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ABSTRACT

During clinical gait analysis, surface markers are placed over the anterior superior iliac spines (ASIS) of the pelvis. However, this can be problematic in overweight or obese subjects, where excessive adipose tissue can obscure the markers and prevent accurate tracking. A novel solution to this problem has previously been proposed and tested on a limited sample of healthy, adult subjects. This involves use of wand markers on the pelvis, to virtually recreate the ASIS markers. The method was tested here on 20 typical subjects presenting for clinical gait analysis (adults and children, including overweight subjects). The method was found to accurately reproduce ASIS markers, and allow calculation of pelvic angles to within one degree of angles produced by ASIS markers.

1. Introduction

The standard lower body model [1] employed in three dimensional gait analysis uses markers attached at particular bony landmarks. At the pelvis, these are located over the anterior-superior iliac spines (ASIS) and the sacrum. A common problem encountered during clinical gait analysis is when excessive abdominal tissue obscures the ASIS markers, causing difficulty with tracking. One solution involves the application of extra markers to the iliac crests, which are then used to recreate the missing markers using virtual points. These extra tracking markers necessitate a static trial where the true ASIS markers are visible – a requirement which is not always possible. In addition, the rigid body assumption employed to re-create the virtual ASIS points is violated in the presence of excessive adipose tissue around the pelvis.

An alternative suggestion for dealing with obscured ASIS markers was suggested by Curtis et al. [2]. This involved the use of wand markers applied to the ASIS. The wands consist of two markers each on a stem positioned at known distances from the base of the wand. The vector connecting these markers, and distances between the markers and the base were used to virtually reconstruct the ASIS position. The initial testing involved five healthy subjects who were assessed with both skin mounted and wand type ASIS markers, which were located at a marked position for assessing repeatability between tests. Initial results demonstrated promising reliability.

However, it remains to be seen whether this technique is applicable to a typical patient population seen within a clinical gait laboratory. Therefore, the aim of this study was to (a) identify the accuracy of reproducing pelvis kinematic data obtained using pelvic wand markers on clinically relevant subjects compared to conventional surface mounted markers, and (b) to establish whether kinematic data obtained from pelvic wand markers is more accurate than data generated using iliac crest markers. It was hypothesised that pelvic wand markers would offer a means of reconstructing pelvic landmarks that result in kinematic angles at the pelvis to within $\pm 1^{\circ}$ of those generated using conventional surface mounted ASIS markers.

2. Method

The pelvic wand markers were constructed based on the original description [2] with a clear silicone base and plastic tube, and retro-reflective markers (Fig. 1a). In order to compare surface mounted markers with pelvic wand markers, the wands were modified to incorporate the surface ASIS marker (Fig. 1b). This eliminated differences associated with marker placement, allowing the same trials to be directly compared. The base was also altered to facilitate ease of accurate placement on overweight subjects. Data collection was approved by the local ethics committee (09/H1102/88) and subjects provided informed consent.

Subjects presenting for routine clinical gait analysis at the Oxford Gait Laboratory, with a range of pathologies including cerebral palsy and orthopaedic deformity, were selected according to their body mass index (BMI). Subjects included five adults

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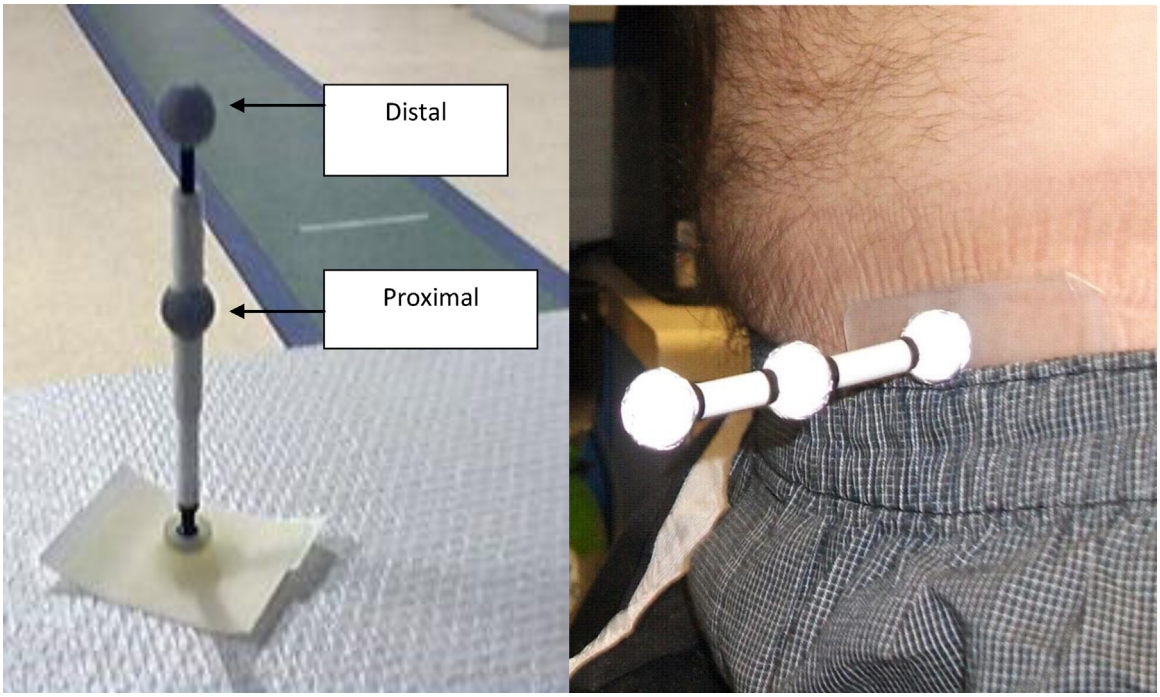

Fig. 1. (a) – Pelvic wand markers as designed in Hvidovre. (b) – Modified pelvic wand markers as used in Oxford.

within normal range according to their BMI with values between 18.5 and 25, five adults classified as overweight, with values between 25 and 30, five children (5–16 years) within normal range with a BMI between the 5th and 85th percentile, and five children classified as being overweight with a BMI of between the 85th and 95th percentile.

Passive retro-reflective markers were placed on the subjects according to the standard lower body model gait model [1]. Modified pelvic wands were used in place of conventional surface mounted ASIS markers. In addition, skin mounted markers were placed on the right and left iliac crests. Data from three trials of level walking at self-selected speed were collected, along with a static, standing trial. Pelvic kinematics, including tilt, obliquity and rotation were calculated. In addition, the absolute positions of both the real and virtual ASIS markers were recorded.

The average of three walking trials was calculated (point by point over 100 data points). The root mean square difference across the entire gait cycle for all pelvic angles (tilt, obliquity, and rotation) was calculated between surface markers and pelvic wand markers. This was repeated to find the difference in pelvic angles using surface markers, and extra markers placed on the iliac crest. Finally, the absolute difference in marker position between real and virtual ASIS points was calculated and compared using paired *t*-tests.

3. Results

Subjects 1–10 were children with 1–5 being of normal BMI and the remainder classified as overweight. Subjects 11–20 were adults with 11–15 being of normal BMI and the rest classified as overweight.

Results indicate that pelvic angles can be reproduced accurately using pelvic wand markers to within one degree of data obtained from surface mounted ASIS markers (with the exception of one angle for one subject, which reached 1.2° difference) (Fig. 2).

When comparing the data obtained from pelvic wand markers to those obtained from extra markers placed on the iliac crest, it is clear that in the majority of cases the use of extra pelvic markers on the iliac crest results in greater differences compared to the actual ASIS markers and more inconsistency in reconstruction of pelvic rotation angles (Fig. 3).

The absolute difference in positions between real and virtual ASIS points was found to significantly decrease when pelvic wand markers were employed compared to the use of extra markers on

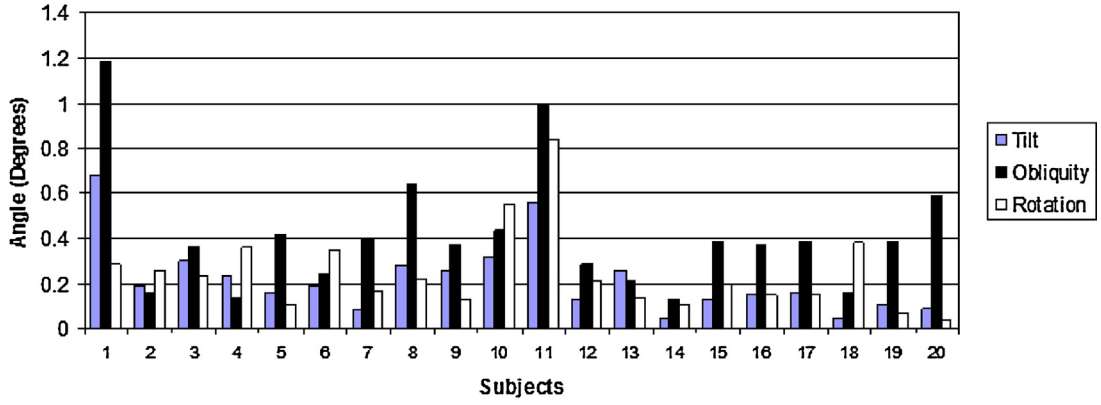

Fig. 2. Average RMS difference between pelvic angles calculated using surface and wand ASIS markers for all subjects.