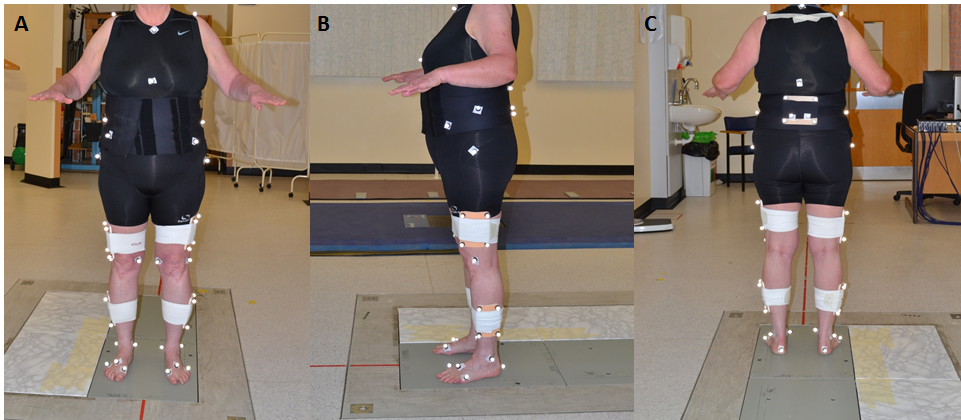
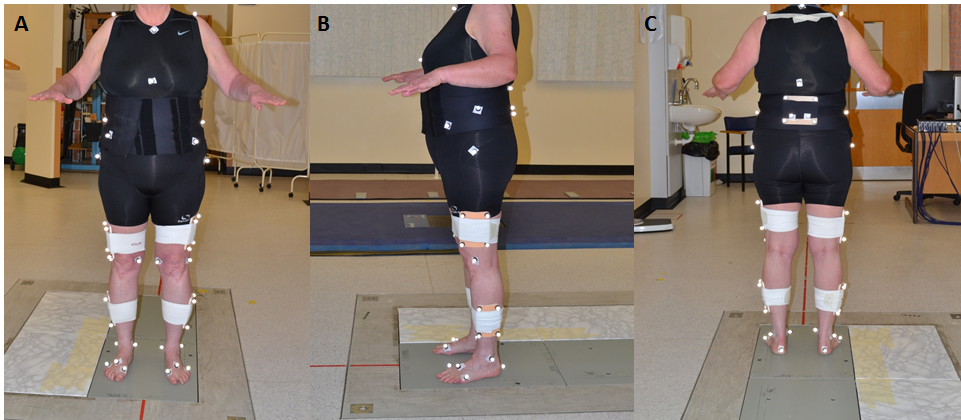
## Method

## Patients

THR patients were recruited into the study through a clinical database of surgical cases, and 27 healthy control patients were recruited from local community groups. Inclusion criteria for the hip replacement group were; between 1-5 years THR post-surgery, older than 18 years of age, no lower limb joint replaced other than hip joint(s), fully pain free and not suffering from any other orthopaedic or neurological problem which may compromise gait. The same inclusion criteria were applied to the healthy control group except no participants had a joint replacement. Ethical approval was obtained via the UK national NHS ethics (IRAS) system and all participants provided informed, written consent.

## Data Capture and Marker Protocol

Each patient undertook one session of motion. Lower limb kinematics and kinetics were collected using a ten camera Vicon system (Vicon MX, Oxford Metrics, UK) sampling at 100Hz, integrated with two force plates (AMTI, Watertown, MA, USA) capturing at 1000Hz. The CAST marker set was used (Figure 1)to track lower limb segments kinematics in six degrees of freedom, with four non-orthogonal marker clusters positioned over the lateral thighs, lateral shanks and sacrum as described comprehensively elsewhere20, 21. With six retroflective markers positioned on the first, second and fifth metatarsophalangeal joints as well as the malleoli and calcanei. Ankle and knee joint centres were defined as midpoints of the malleoli and femoral epicondyles, respectively. Participants wore a pair of tight fitting shorts and vest onto which reflective markers were affixed at bony anatomical landmarks using double-sided tape.



### Figure 1. Marker protocol.

### Data Capture

### Activities of daily living

The Activities of daily living are grouped into two categories: locomotor tasks (walk, fast walk, stair ascent and stair descent) and non-locomotor tasks (sit to stand, stand to sit, squat and lunge). Information regarding the protocol of each task are detailed below.

### Walking tasks

Patients undertook two walking conditions i) at a self-selected walking speed (hereafter referred to as a normal walk) and ii) a fast walk, where patients were instructed to walk “as fast as possible without running” along a 10m walkway. A successful trial was defined as a clean foot strike within the boundary of the force plate. Heel strike and toe-off were determined using thresholds (>20N for heel strike and <20N for toe off) from the GRF. All trials were time-normalized from heel-strike (0%), to heel strike (100%) and interpolated to 1% steps (101 points).

### Stair Negotiation

Subjects were asked to ascend and descend three steps at self-selected comfortable speed, without the use of a handrail. The stair case was mounted and bolted to the force plates (Della Croce and Bonato) to collect ground reaction force data. Heel strike and toe-off were determined through the same method in the walking tasks. All trials were time-normalized from foot-strike (0%), to footstrike (100%) and interpolated to 1% steps (101 points).

### Standing and Sitting

During the sitting and standing trials patients sat on a platform with the feet shoulder-width apart, each foot positioned on a separate force plate in a fixed position. The seat height was matched to the level the patient’s tibial plateau. Patients were then asked to stand and return to a seated position without use of the arms which were held out straight ahead, to avoid any occlusion of the markers. This was performed In STS trials initiation of movement was defined by acromion marker velocity in the sagittal plane at a threshold of 0.1m/s-1 and the stood up position was defined as the maximum coordinate value of the acromion marker in the transverse plane. Initiation of sitting was defined by the acronium marker dropping below the maximum value and end of the sitting.

### Lunge

Patients were asked to stand with both feet one force plate and lunge, leading with the study limb, onto the adjacent force plate return to standing. The lunge action was split into two phases lunge descend and lunge ascend. Lunge initiation was identified when the first metatarsal marker of the operated limb left the force plate and end of lunge descend was defined when knee flexion was at the maximum value. This event also identified the start of the lunge ascend and the end of the lunge ascent was defined at the frame before the metatarsal made contact with the force plate. Data was normalised to 101 datapoints from lunge initiation to lunge end.

### Squat

Patients were positioned with one foot on each force plate shoulder width apart, and were asked to perform a squat with arms out in front of them to avoid marker occlusion. Squat was split into two phases squat descend and squat ascend. Start of the squat was defined by a change in the knee angular velocity (>10 degrees/second) and end of squat was defined at maximum knee flexion angle, and end of the squat was defined at maximum knee extension angle.

## Data Analysis

All markers were labelled and gap-filled using the spline fill function in Vicon Nexus 2.5 (Vicon MX, Oxford Metrics, UK), before the labelled marker coordinates and kinetic data were exported to Visual 3D modelling software (C-motion, USA) for further analysis. Kinematic data were filtered using a low-pass (6Hz) Butterworth filter. Ground reaction force (GRF) data were filtered using a low-pass Butterworth filter (25Hz).