University of Worcester
Motion Analysis Research & Rehabilitation Centre

The Validity of Marker Reconstruction Modelling For Biomechanical Analysis in Sport

Sarah M Churchill[1], Derek M Peters[2] and Joseph W Bevins[1]
[1]Motion Analysis Research and Rehabilitation Centre (MARRC), University of Worcester, UK www.marrc.co.uk
[2]School of Sport and Exercise Sciences, University of Worcester, UK. www.worcester.ac.uk

Introduction

Biomechanical analysis is a valuable tool for injury prediction and prevention, and technique refinement in sport. Three-dimensional (3D) motion capture allows kinematic and kinetic analysis by measuring segment movement from placed anatomical markers. 3D systems require at least three cameras to track each marker; however during activities, such as cycling, key anatomical markers may be obscured due to body position. A software model may be used to reconstruct missing markers based upon their position relative to other markers. The aim of this study was to assess the validity of reconstructing missing markers using modelling software.

Method

A healthy male (age 29 years, height 176cm, mass 86kg) undertook 25 sessions cycling on a Kingcycle rig (Kingcycle, High Wycombe, UK). Data was collected at 60Hz using a 16 camera Vicon 624 system (Vicon Motion Systems Ltd, Oxford, UK). The standard Vicon Plug-in-Gait marker set was used with additional LHIP, RHIP, LCLAV and RCLAV (figure 1). The participant was re-markered for each separate session, and a standing static and three cycling trials captured on each of the 25 occasions. Data was filtered using a Butterworth filter (Winter, 1990). A model was developed in Vicon BodyLanguage to reconstruct LASI and RASI, from the following markers: LHIP, RHIP, LPSI and RPSI; and CLAV and STRN from T10, C7, LSHO, RSHO, LCLAV and RCLAV. Reconstructed markers were given numerical suffixes.

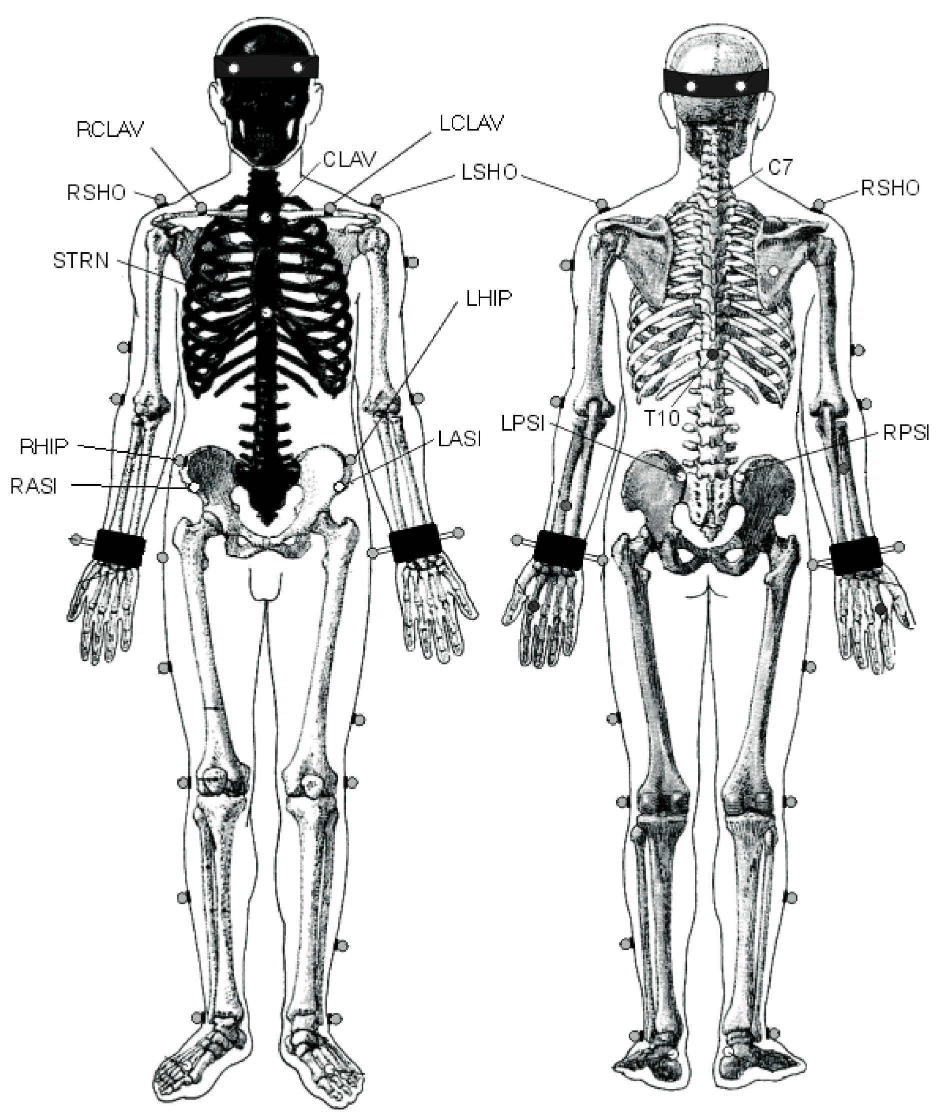

Figure 1. Marker placement of standard Vicon Plug-in-Gait marker set plus additional LHIP, RHIP, LCLAV and RCLAV markers. Adapted with permission from Vicon Motion Systems Ltd.

Results

The mean distance of the reconstructed markers from the actual markers was calculated. The most accurate reconstructed markers for LASI, RASI, CLAV and STRN were LASI 3, RASI 3, CLAV 14 and STRN 4 with mean (±SD) distances (in mm) from the actual markers of 9.10 (±2.42), 10.22 (±3.03), 11.78 (±4.38) and 10.78 (±3.88) respectively (Figure 2).

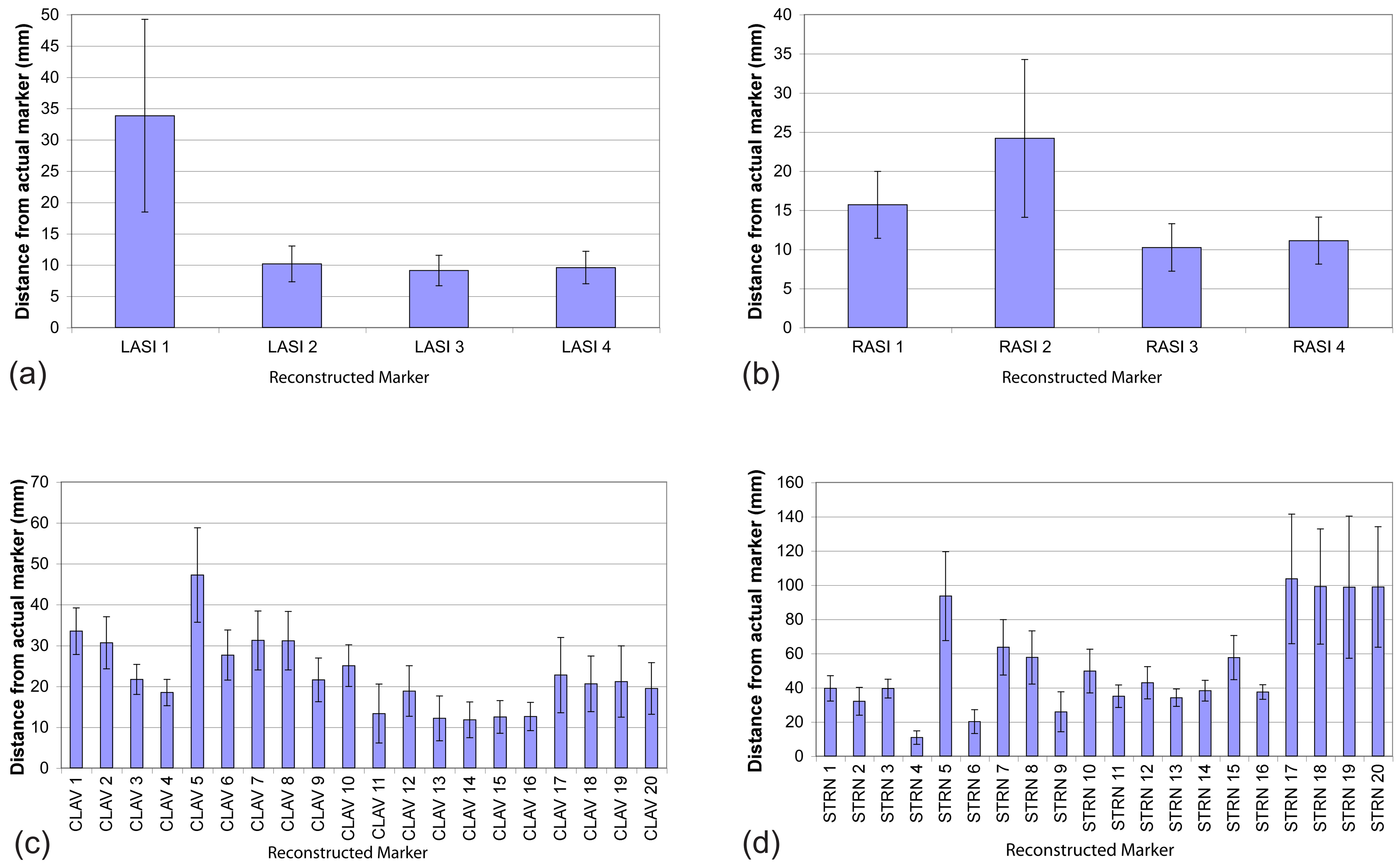

Figure 2. Mean (± SD) distance (from actual marker) of reconstructed (a) LASI, (b) RASI, (c) CLAV and (d) STRN markers over 25 cycling sessions.

Discussion

There was a large variation in the accuracy of reconstruction and the choice of markers clearly affected how accurately the missing marker was reconstructed. The most accurate reconstruction occurred when a marker close to the missing marker was used, e.g. the most accurate for LASI used RHIP, LHIP and LPSI. A possible explanation is that the proximity of the LHIP marker to LASI allows it to better represent the movement at LASI. In the most accurate reconstruction, depending on the anatomical plane in which deviation occurs, the segment size was affected by up to ±4% and the segment angle affected by up to ±2.3°. For the least accurate the values were up to ±52% and up to ±27.48° respectively.

Skin markers were applied and static trials conducted with the participant in the standard upright position. As markers are displaced relative to the landmarks they are placed upon due to skin movement (Lu & O'Connor, 1999) the resulting change in trunk angle from standing to the cycling position (approx. 45°) may have had a large effect on the marker positions relative to the underlying bone position (Chockalingham et al., 2002).

Conclusion

If reconstructed markers are to be used for output modelling, errors in their calculated position will affect derived values. The results of this study suggest that caution needs to be exercised when using models to reconstruct missing markers. Further research is needed to investigate the effect, of marker application and capturing of static trials, in a position that is representative of the activity being analysed, e.g. in the cycling position, compared to the traditional standing position.

References Chockalingham, et al. (2002). *Studies in Health Technology and Informatics*, **88**, 105-109. Lu & O'Connor (1999). *Journal of Biomechanics*, **32**, 129-134. Winter (1990). *The Biomechanics and Motor Control of Human Movement.* New York: John Wiley & Sons.

www.marrc.co.uk
s.churchill@marrc.co.uk