INTRODUCTION

The concept of a ‘swing plane’ in golf was popularized by Cochran and Stobbs (1968) based upon their qualitative observation that the clubhead moves in a single inclined plane for much of the downswing. The assumption of planar arm and club motions has been central to most modeling of the swing, though its validity has been questioned (see, for example, Coleman and Anderson, 2007).

The planarity of the field hockey hit has not been investigated. The purpose of this study was to initiate such an analysis by developing a quantitative version of Cochran and Stobbs’ approach and applying it to the path followed by the stickface during the downswing.

METHODS AND PROCEDURES

Thirteen experienced female field hockey players were asked to hit a stationary ball after a single approach step. They were filmed with two cameras at 200 fps, and the DLT method was used to calculate the positions of three stick markers at 0.005 s intervals between the start of the downswing and impact. These data were used to reconstruct the 3D motion of the center of the stickface during the downswing.

The positional data for the center of the stickface were then resampled to give equal weight to all parts of its curved path. For this, quintic spline interpolation was used to calculate points at even 0.1 m intervals from the position at impact back along the path followed by the stickface. The planarity of the stickface motion was investigated by determining planes of best fit for the points defining progressively longer sections of the downswing path, each of which ended at the impact position. The first section included the final 0.2 m of the stickface path, to provide the minimum of three points required for plane fitting. Each subsequent section included a further 0.1 m along the path until the start of the downswing was reached. The planes were calculated using Total Least Squares (Orthogonal) Regression, since this allows for error in each of the three coordinate directions (Nievergelt, 1994). The closeness of fit of each plane to the data points was measured using the mean absolute residual, expressed as a percentage of the distance traveled by the stickface in that section.

RESULTS

A mean absolute residual of 1% of the distance traveled by the stickface was selected as the cutoff defining planar motion. Using this criterion, the entire downswing was planar in 10 of the 13 subjects. Figure 1 shows a typical subject within that group. For the remaining three subjects the stickface motion was planar during the final 83, 91 and 92% of the downswing path.

Figure 2 illustrates the close fit of the stickface path to a plane for mean absolute residuals of 1% or less.
In the 10 subjects whose entire downswing was planar, the stickface traveled between 2.1 and 2.8 m during this phase. In the three remaining subjects, the range of the downswing was longer, between 3.0 and 3.4 m, and the length of the planar portion was between 2.7 and 2.9 m.

Figure 3 shows the stick motion, viewed perpendicular to the stickface plane, for the subject with the median downswing path length (2.6 m).

**DISCUSSION**

The results indicate that the curved path followed by the center of the stickface is remarkably planar for all, or almost all, of the downswing of a field hockey hit.

Future work should investigate the motions of the stick shaft and of the arms, and how they relate to the plane fitted to the path followed by the center of the stickface.

**SUMMARY**

A method has been developed for quantifying the planarity of the motion of a selected landmark. The application of this approach to the field hockey hit indicates that the curved path followed by the center of the stickface is very close to planar for all, or almost all, of the downswing.

**REFERENCES**

