VALIDATION OF GOLF CLUB DELIVERY PARAMETERS FOR A FAST OPTICAL CAPTURE SYSTEM

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Introduction

Marker-based, fast optical capture and analysis systems such as the PING FOCAL system are widely used in golf research and club engineering environments for both, full-swing and impact analysis. Prominent impact parameters relate to the clubhead delivery at the time of first ball contact. However, the accuracy of these measurements is not well reported. Knowing the error of measurement is key to understand the capabilities and limitations of measurement systems. A study by Leach *et al.* [1] reported the accuracy of launch monitors. In this work, a study was conducted to validate the clubhead delivery at impact obtained by the PING FOCAL system.

Methods

A high-speed stereo-camera system capturing the clubhead-ball impact at 20000 fps was set up alongside the PING FOCAL system. The study was approved by the ethical committee at Loughborough University and subjects gave their informed consent for taking part. In total, 500 shots were recorded from 18 players hitting driver and 7-iron. The software GOM Correlate by gom GmbH (Braunschweig, Germany) was used for the analysis of the high-speed videos reconstructing clubface path and orientations in three dimensions [1,2]. Three angular parameters (delivered loft, lie, face angle), three velocity parameters (clubhead speed, path, attack angle), and horizontal and vertical impact location were considered for analysis, for which the error was calculated as difference between FOCAL and GOM. The proportion of data points falling into research grade tolerance [1] was used to assess the accuracy of the PING FOCAL system.

Results and Discussion

For angular parameters 92-99 % of all shots fell into the research grade range of ± 1° (see Table 1). For horizontal and vertical impact location, respectively, 95 % and 97 % of the shots fell into the research grade range of ± 0.15 inch. For clubhead velocity 75 % of all shots fell into the research grade range of ± 1 mph. Clubhead velocity measures outside the research grade were predominantly iron shots with ground contact before ball impact, for which clubhead velocity was overestimated. This problem will be addressed in future studies.

Significance

While launch monitors can resolve clubhead delivery parameters with research grade accuracy only in 29-66% of shots [1], the PING FOCAL system measures 75-99% of shots with research grade accuracy. The PING FOCAL system is therefore favorable over launch monitors for measuring clubhead delivery parameters.

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References

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Table 1. Impact parameter definitions, research grade tolerances [1] and proportion of datapoints falling into the research grade. All parameters are calculated at or with respect to the geometric clubface center.

Impact parameter	Definition	Research Grade	Proportion
Delivered Lie	Angle between toe-heel vector and the global, horizontal plane	± 1°	98 %
Delivered Loft	Angle between clubface normal vector and the global, horizontal plane	± 1°	95 %
Face Angle	Angle between clubface normal vector and a vertical plane through the target line	± 1°	99 %
Clubface Speed	Magnitude of clubface velocity vector	± 1 mph (± 0.45 m/s)	75 %
Path Angle	Angle between clubface velocity vector and a vertical plane through the target line	± 1°	97 %
Attack Angle	Angle between clubface velocity vector and the global, horizontal plane	± 1°	92 %
H. Impact Location	Toe-heel impact location	± 0.15 in (± 4 mm)	95 %
V. Impact Location	Sole-crown impact location	± 0.15 in (± 4 mm)	97 %