THE EFFECT OF BODY MARKERS ON GOLF DRIVING PERFORMANCE

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INTRODUCTION: No study to date has reported if and how the use of body markers used in three dimensional optical tracking methods to study swing kinematics in golf affect movement performance. Egret *et al.* (2004) studied the use of wired electromyographic equipment during the golf swing and concluded that the equipment significantly influenced the kinematic pattern of the golf swing. Researchers have previously concentrated their methodological analyses on such factors as the type of marker used, either wand or skin marker (Kirtley, 2002) or skin movement artefact during movement (Holden *et al*., 2007). The golf swing is a movement that is closed-chain, non-impact and does not cause excessive unwanted movement of skin and wand markers. It is therefore concluded that the golf swing lends itself well to kinematic analysis using body markers. The aim of the present study was to evaluate the effect of body markers on golf driving performance for tests carried out in a laboratory setting.

METHOD: Seven category 1 (<5 handicap) golfers (22.1 $\pm$ 2.3 yrs, 77.4 $\pm$ 9.7 kg, 1.80 $\pm$ 0.09 m and 0.2 $\pm$ 2.4 handicap) took part. All golfers were male and right-handed. Performance for each shot was determined through analysis of club head and ball impact characteristics measured using a commercially available launch monitor (GolfTek^{TM} Pro V). Subjects were positioned on an artificial grass surface wearing golf spikes as they normally would on a golf course and selected their own tee height. Thirty four body markers were attached to the subject: acromion, lateral epicondyle of the elbow, wrist centre, C4, anterior superior iliac spine, sacrum, greater trochanter, lateral epicondyle of the knee, anterior epicondyle of the knee, medial malleolus, lateral malleolus, 2nd metatarsal head, heel, and the geometric centre of mass (COM) of the upper and lower arms, and upper and lower legs. Humeral and radial markers were positioned on 63.5 mm (2½″) wands and femoral and tibial markers were positioned on 101.6 mm (4″) wands. Additional club markers were placed on the golf club shaft 254 mm (10″) from the club butt and on the toe of the club head.
A 240 Hz 5-camera Motion Analysis Corporation™ Falcon Analogue system tracked all body and club markers during the subjects' swings when body markers were attached, and only the club markers for shots performed without body markers. Subjects warmed up as they normally would before playing golf. Using their own driver subjects were instructed to hit eight shots for each randomly assigned set-up along a target line marked on the floor into netting 4.5m away.

RESULTS AND DISCUSSION: Significant differences ($z = -2.521$, $p < 0.05$) were noted for ball velocity when shots were hit with and without markers (Table 1).

Table 1. Launch monitor data for the golf swing with and without body markers

Measure	With Body Markers	Without Body Markers
Club Head Velocity (ms^{-1})	49.96 ± 0.67	49.40 ± 1.07
Ball Velocity (ms^{-1})*	69.62 ± 0.85	66.70 ± 0.93
Club Head Orientation (˚)	1.25 ± 3.24	3.00 ± 0.93
Tempo (s)	0.82 ± 0.01	0.81 ± 0.02
Backspin (rev/min)*	2676.5 ± 312.2	3263.6 ± 672.1
Sidespin (rev/min)*	-493.1 ± 423.1	189.0 ± 701.5
Ball launch angle (˚)	11.13 ± 2.12	10.63 ± 1.88

**p< 0.05*

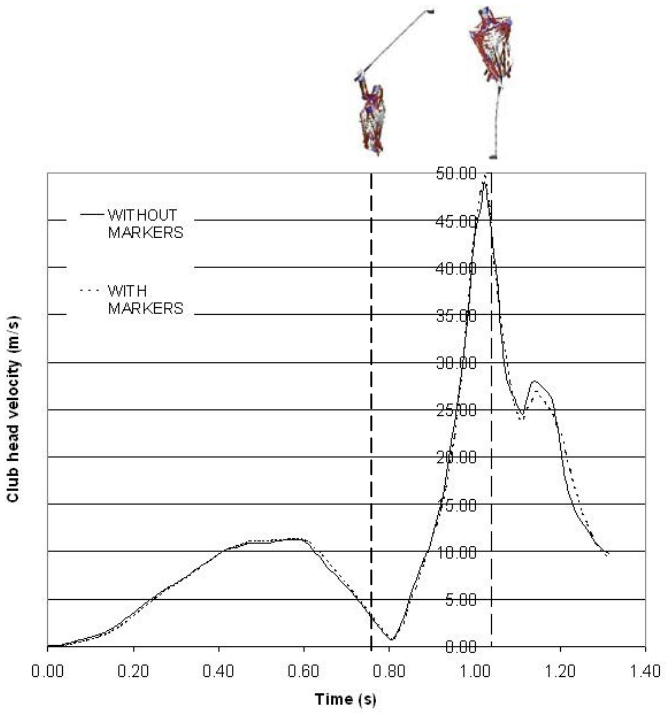

Figure 1. Club head velocity with and without markers

Shots taken without body markers averaged 2.92 ms^{-1} reduced ball velocity (-4.19%). Club head velocity did not prove significant with only 0.56 ms^{-1} difference (Figure 1). Both ball backspin and sidespin component showed significant differences ($z = -2.38$, $p < 0.05$). Swing tempo did not show differences between the two conditions. The present study illustrates that attachment of body markers that would normally be used to study the kinematics of the golf swing via passive marker based optical three dimensional systems, induces minor changes in the swing as inferred by a change in ball launch velocity and spin rates. Ball velocity normally indirectly correlates with carry distance, and sidespin component of flight normally directly correlates with shot accuracy. Sidespin, or non-horizontal component of the ball was shown to orientate left, or anti-clockwise for shots performed with markers attached. This would indicate that those shots performed with markers attached may have been less accurate, producing a more excessive right-to-left 'hook' shape. Subjects seemed to overcompensate when markers were attached, potentially sacrificing accuracy for power. Thus, important components of club head – ball impact which affect ball launch characteristics were altered.

CONCLUSION: Body markers significantly affect key shot performance measures, and field testing is required to ascertain accuracy and carry in a future study to support these findings. A number of the measures recorded, including club head velocity at impact, club head orientation, swing tempo, and ball launch angle, were relatively unaffected by the presence of body markers. Ecological validity is a concern during lab based experimentation and further investigation of the effect of experimental testing equipment on outcome performance, and shot accuracy on the golf course, is warranted for greater subject numbers.

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