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EFFECTS OF TRYING TO GAIN DISTANCE ON GOLF DRIVING TECHNIQUE

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Previous biomechanical research of the golf swing has shown segment separation of the shoulders and hips aids ball velocity. The purpose of the current study was to examine how the swing may differ when "trying" to gain extra distance in a game specific situation and whether an increase in launch velocity was achievable. A single subject design was employed with kinematic data (200 Hz) and ball characteristics collected using Trackman Pro launch monitor (ISG A/S, Denmark). Segment separation of the shoulder and hips (X-Factor and X-Factor stretch) and maximum endpoint velocity of the left hip, shoulder and elbow showed a significant difference between conditions, although mean launch velocity did not. This finding shows although the subject was able to produce greater endpoint velocity, performance improvement did not occur.

KEY WORDS: Golf, Kinematics, X-Factor, proximal to distal sequencing.

INTRODUCTION: The aim of golf driving is to hit the ball with both distance and accuracy. Golf driving, however, is an open skill with the situation faced by the golfer varying on the constraints of the layout of the hole and situation making the degree of accuracy required variable. Biomechanical research into the golf swing conducted by Cochran & Stobbs (1968) focused on the interaction between the left shoulder, arm and wrist movements in the downswing allowing the clubhead to release at impact; allowing connection with the ball. This was termed the double pendulum model. Proximal to distal sequencing (Bunn, 1972; Putnam 1994) suggested clubhead velocity is determined by the kinetic and kinematic interaction of body segments rather than the manner in which the club is released. Greater rotation of the shoulders occurs compared to the hips with position created at top of backswing termed the 'X-Factor' (Mclean, 1992). Separation of the shoulders and hips has been shown to be more important than position alone (Myres et al., 2007). The separation achieved after the initial transition between the backswing and downswing has been termed the 'X-Factor Stretch' (Cheetham et al., 2001). With a strong relationship to the 'X-Factor' position at the top of the backswing this position should have a greater value as the hips have rotated towards the target with the shoulders remaining in the same position. The greater the value achieved, the greater the stretch shortening cycle that can be applied to the trunk muscles.
The golf swing itself has been explored and current models of performance have been validated (Chu et al., 2010). An essential component of golf is the players' ability to adapt to changes in the environment and task both within and between rounds. To the authors' knowledge there is little research in this area and as such this study represents an initial investigation into the influence of task on technique in golf driving. The aim of this study was to analyse whether different task constraints influence the biomechanics of technique in golf driving.

METHODS: A single subject design was employed for this study. One right handed county level male golfer was used (Age: 19 years; Height 1.83 m; Body mass 86 kg; Handicap 3) to hit 20 golf drives under two conditions. Condition one was a standard drive, condition two was a golf drive with the aim of outperforming the first condition's distance. Differences in the conditions were expressed, by an experienced golf instructor using diagrams of two different golf holes (figure 1). The study was granted ethical approval by the University Research

Ethics Committee. Written informed consent was gained prior to participation and subject was free from injury.

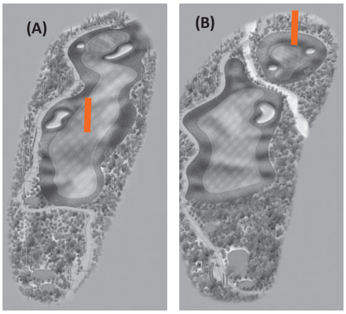

Figure 1: Diagrams of the two layouts which varied in distance were used in study. A) Condition 1 layout. Subject instructed to hit fairway with their standard drive. B) Condition 2 layout. Subject was instructed that standard drive would finish in waste area in front of green therefore extra distance was required in order to clear hazardous area and land on green. Red line on diagrams correlated to red fabric in net to give subject relationship between diagram and actual hitting area (not to scale).

Kinematic data were recorded at 200 Hz using the Codamotion automated system (Charnwood Dynamics, UK). Six active markers were placed on the joint centres (lateral side) of the left and right shoulder, left elbow and left wrist. Two markers were also placed on the iliac crest of the left and right pelvis. Initial ball velocity and take off characteristics (spin rate and launch angle) were collected using Trackman Pro Launch monitor (ISG A/S, Denmark). The subject used his own driver (Ping G2 7.5° driver with Grafalloy Red X-Stiff Shaft) and a Titleist Pro V1X golf ball.

Data analysis: Residual analysis was used to determine a suitable cut-off frequency of 8 Hz for the shoulders, hips and elbow (Winter, 2005). At the wrist a cut-off frequency of 40 Hz was used to account for the effects of the impact of club on ball. Data were filtered using a digital filter. Resultant endpoint velocity was recorded from the joint centres of the, left hip, shoulder, elbow and wrist. Linear measurement (m/s) in the y axis was used in order to gain directional perspective. Segment separation was recorded between the hip and shoulders in the longitudinal plane (shoulder vector angle subtracted from hip vector angle). Two discrete values were recorded, separation at the top of the backswing; which was defined as point of maximum shoulder rotation away from target (X Factor) and maximum separation at the beginning of the downswing (X-Factor Stretch). An independent t-test was performed to test for the significance in difference in ball characteristics, segment separation and maximum velocity of each segment between conditions. Percent root mean square difference (RMSD) was used to show differences between the end point velocity profiles of the two conditions.

RESULTS AND DISCUSSION: Mean ball launch velocity did not increase between condition one and two (Table 1). Furthermore ball spin rate and vertical launch angle were not significantly different. X-Factor and X-Factor stretch increased in the condition two trials and showed a significant difference (Table 1), achieved by increasing shoulder rotation. Hip rotation also showed an increase, but not to the extent of the shoulder. The values observed in the current study showed similarities to the high ball velocity group reported in Myres et al. (2007). Segment separation has been shown to be of importance in generating ball velocity (Chu et al., 2010; Myres et al., 2007; Cheetham et al., 2001) however due to the complex nature of the golf swing differences in X-Factor and X-Factor stretch did not correspond to a subsequent increase in ball launch velocity.

Table 1
Mean (± SD) initial ball velocity, ball launch characteristics and segment separation of the shoulders and hips

	Condition 1	Condition 2
Ball Launch Velocity [m/s]	74.4 ± 0.8	75.5 ± 2.2
X-Factor [˚/s]	63.7± 1.1	66.1 ± 1.0*
X-Factor Stretch [˚/s]	71.4 ± 0.5	73.4 ± 0.9*
Spin Rate [rev/s]	2460.8 ± 1235.4	2829.3 ± 947.2
Vertical Launch Angle [˚]	11.8 ± 2.1	11.5 ± 1.9
Horizontal Launch Angle [˚]	2.3 ± 1.8	3.1 ± 1.4

**p<0.01*

End point velocities of the body segments are presented for both conditions in Figure 2. In each condition the movement, as reported in previous research, showed proximal to distal sequencing (Putnam, 1993; Bunn, 1972) with maximal segment velocity being achieved initially by the hip, followed by the shoulder, elbow and wrist.

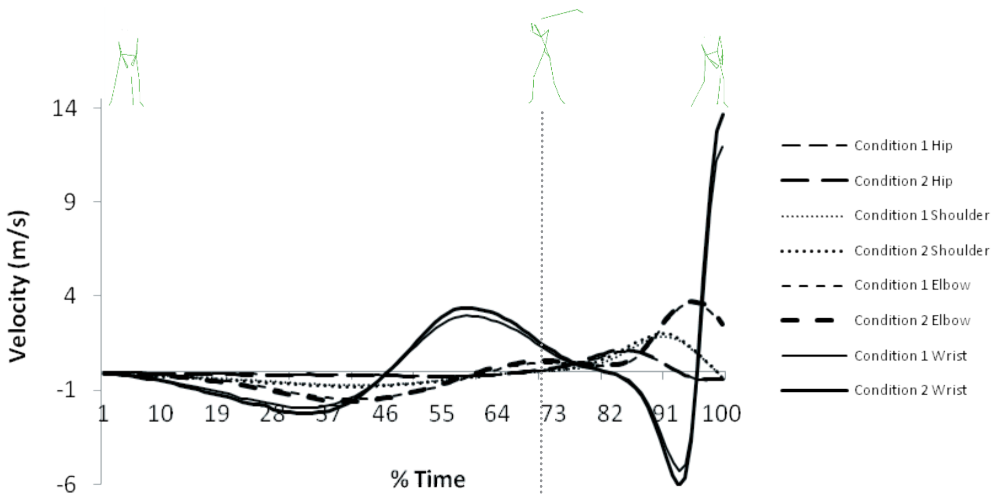

Figure 2: Mean end point velocity between takeaway and impact for condition one and two. Vertical dashed line indicates top of backswing (X Factor).

The hip changed direction before the shoulder, which would be expected due to the greater X-Factor stretch value in comparison to X-Factor (Table 1). In condition two, the change of direction between the backswing and downswing occurred earlier in the overall movement with increases in the maximum velocity obtained at each segment. %RMSD showed greater differences between the profiles of the hip and shoulder (proximal) segments with 2.97% and 3.07% differences respectively with the elbow and wrist showing smaller differences 1.77% and 1.89% respectively (distal). The maximum velocities of each segment were significantly greater in condition two (P<0.01). Greater endpoint velocity was also witnessed in the backswing for all condition two locations. Interaction between segments is non linear due to their complex nature (Putnam & Dunn, 1987) with greatest transfer occurring when segments are at right angles to each other, which is not achieved in the golf swing (Putnam, 1993). Velocities at the wrist did show a statistically significant difference between conditions, which did not result in desired increases in ball velocity. The movement of the body segments have to be converted into clubhead velocity by the “wrist release” of the club prior to impact. The timing of release has to be performed correctly in order for maximum clubhead and ball velocity to be produced. Small deviation from the optimum release can lead to loss; previous research reported a 4.6% loss in ball velocity due to late release (Sprigings & Mackenzie, 2002). This may have cancelled the extra velocity gained by the body. Wrist release was not reported in current study with further research needed to show the importance of wrist release in trying to increase situation specific distance. Technique adaptations were observed due to the influence the task constraints imposed on the player. Future research should incorporate other performance characteristics such as shot accuracy, the interaction of which with distance will be an important consideration, as well as clubhead velocity. In addition a wider range of performers and use of more detailed analyses (e.g. segmental interaction and musculoskeletal work) will develop understanding the underlying mechanisms.

CONCLUSION: Differences in the segment positioning and velocities indicated the subject was able to impart a change in technique to perform the task demands of the second condition (to gain distance). Technique differences were most evident in X-Factor and X-Factor stretch. No increases in ball velocity were observed between conditions. As such condition two was neither detrimental nor beneficial to ball velocity. Further development of the methodologies and analyses presented here will aid coaches and performed with informed shot selection.

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