EXPLORING THE RELATIONSHIP BETWEEN HIP KINEMATICS AND DRIVER CLUB PATH

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Introduction

The golf swing is a complex sport-specific movement that requires the coordinated motion of multiple body segments to transfer energy from the body and club to the ball in a consistent manner. Two important aspects of golf swing performance are shot distance and accuracy. While there are many swing and biomechanical factors (e.g. club head velocity, kinematic sequencing, and ground reaction force production) that affect these golf performance outcomes, one understudied factor is club path. Club path is defined as the direction that the club head's geometric center is moving relative to the target line at impact (TrackMan Blog 2017). A positive club path indicates the club is moving to the right of the target line at impact (in-to-out swing); whereas a negative club path indicates the club is moving to the left of the target line at impact (out-to-in swing). Previous research has identified club path as a main determinant of the initial direction of ball flight (Sweeney et al. 2013) and that club path differs significantly with medial-lateral ball position at address (SE Kim et al. 2018). Determining the biomechanical factors related to golf swing metrics like club path may help coaches and trainers identify modifiable swing characteristics related to shot shape and accuracy. However, few studies have investigated the biomechanics of the golf swing in relation to club path. Hip mobility and pelvis motion in the swing have been shown to influence golf swing mechanics and be related to performance, but hip kinematics have not been studied in relation to club path (SB Kim et al. 2015, Lynn et al. 2014). Therefore, the purpose of this study was to investigate the relationship between hip kinematics and driver club path in the golf swing.

Methods

Fifty-two healthy golfers (27.5 ± 13.7 yrs, 1.75 ± 0.10 m, 76.1 ± 17.7 kg, 26 males/26 females, 49 right-handed/3 left-handed) ranging in skill level from recreational to professional completed 5 driver swings for assessment in a biomechanics laboratory. 3-D kinematic data was collected from 10 optical motion capture cameras recording at 300 Hz (Qualisys AB, Gothenburg, Sweden) with the Qualisys Golf Performance markerset. A TrackMan 4 launch monitor (TrackMan, Vedbæk, Denmark) was set up according to manufacturer specifications and used to collect club path data. The Sanford Health Institutional Review Board approved this study and all golfers consented to their participation in the study. Hip kinematic variables chosen for assessment were peak and minimum lead and trail hip angles, the lead and trail hip range of motion (ROM), and the lead and trail hip angles at discrete time points of address and top of backswing (TOP). All angles and ROM were assessed in three planes, for a total of 30 hip kinematic variables. Kinematic and club data from each participant was averaged across all 5 driver swings. A stepwise linear regression model was used to determine which kinematic variables were significantly related to club path. Significance was set *a priori* at $p < 0.05$.

Results and Discussion

The final regression model included three kinematic variables. Lead hip rotation at TOP, trail hip rotation at TOP, and trail hip adduction at TOP were significantly related to club path ($p < 0.05$, Table 1). The mean and standard deviation of club path was -0.93° ± 4.12°. For the golfers in our dataset, less lead hip external rotation and less trail hip internal rotation at TOP was associated with a greater out-to-in club path, while more lead hip external rotation and more trail hip internal rotation at TOP was associated with a more in-to-out club path. Additionally, more trail hip adduction at TOP was associated with a greater out-to-in club path. Therefore, increasing the amount of transverse plane hip mobility and decreasing the amount of trail hip adduction at TOP may help golfers that are struggling to achieve an in-to-out club path. However, it is important to note that the three kinematic variables chosen by the regression only explained 26.8% of the variance surrounding club path, indicating that there are many other factors that influence club path outside of a golfer's hip kinematics.

Significance

The findings of this study provide some basis for the role that hip kinematics play in determining a golfer's club path at impact. While there are likely a number of factors that affect club path, increasing hip rotation and decreasing trail hip adduction at TOP may be beneficial for improving golf performance, especially for golfer's with a greater out-to-in club path looking to have a more neutral or in-to-out club path. Future investigations should determine the effects that other biomechanical variables have on club path in an effort to identify modifiable swing characteristics that can help a golfer achieve their desired shot shape.

Table 1. Descriptive Statistics and Stepwise Linear Regression Model Results for Significant Hip Kinematic Variables

Variable	Value (Mean ± SD)	Model Estimate	P-value
Intercept		-1.6730	0.200
Lead Hip External Rotation °	24.03 ± 14.00	-0.0900	0.025*
Trail Hip Internal Rotation °	9.66 ± 9.61	0.1390	0.018*
Trail Hip Adduction °	14.43 ± 7.40	-0.1916	0.011*

Note: All variables are at top of backswing.