

## KINEMATIC AND KINETIC ANALYSIS OF THE ELITE GOLF SWING

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**INTRODUCTION:** The purpose of this study was to determine the association between select biomechanical variables and clubhead speed at impact (CSI) in a sample of elite golfers. Power generation is thought to arise from a number of factors including body rotation and weight shift. CSI is often used to indicate power generation (Fradkin, et al., 2004). We hypothesized that CSI would be highly related to torque, relative hip-shoulder rotation (X-factor) and weight shift during the golf swing.

**METHOD:** The relations between select biomechanical variables and CSI were analyzed during 2 easy, 2 medium and 2 hard golf swings of 6 elite right handed golfers (4 men, 2 women) using a 5-iron. 3D kinematic and kinetic data were recorded at 240Hz with a high-speed motion capture system and a forceplate imbedded in the floor. Biomechanical variables included peak stance torque and torque at the top of backswing (moment about the vertical axis with both feet on the forceplate), peak clubhead speed, peak and average weight shift velocities (center-of-pressure in the medio-lateral direction) as well as peak X-factor and X-factor at impact. The X-factor was calculated as the angle between the line through the right and left anterior superior iliac spines and the line through the right and left acromion processes in the axial plane (McLean and Andrisani, 1997). These variables were recorded relative to five phases of the golf swing: backswing (BkS), initial downswing (IDS), mid-downswing (MDS), late downswing (LDS) and follow-through (FT) as determined by clubhead position. Biomechanical data were pooled across subjects and swings, and correlated with CSI using a non-parametric Spearman correlation.

**RESULTS:** Peak torque occurred consistently in IDS and MDS and was strongly correlated to CSI ( $\rho=.84$ ,  $p<.001$ ) between subjects. Torque at the top of backswing also correlated to CSI ( $\rho=.49$ ,  $p<.01$ ) between subjects. As expected, peak clubhead speed occurred consistently in LDS and FT and was strongly correlated to CSI ( $\rho=.94$ ,  $p<.001$ ) between subjects. There was no correlation between X-factor at impact or peak X-factor and CSI between subjects. However, within individuals, four of the six golfers exhibited strong correlations between X-factor at impact and CSI ( $\rho\geq.90$ ,  $p<.05$ ) and between peak X-factor and CSI ( $\rho\geq.89$ ,  $p<.05$ ). Peak X-factor occurred in IDS shortly before peak torque in all swings. Within individuals, there was a strong correlation between peak torque and CSI ( $\rho\geq.89$ ,  $p\leq.05$ ), between torque at the top of backswing and CSI ( $\rho\geq.83$ ,  $p\leq.05$ ) and between peak clubhead speed and CSI ( $\rho\geq.90$ ,  $p<.05$ ) in five of the six subjects. Weight shift velocity was not correlated to CSI between or within individuals.

**DISCUSSION AND CONCLUSION:** These data suggest that peak stance torque occurs in IDS and MDS and is most highly correlated to CSI between and within subjects. Torque at the top of backswing, peak X-factor and X-factor at impact were also correlated to CSI within subjects. While weight shift is thought to be important in generating clubhead speed, in this initial study they were not found to be correlated with CSI. It is important to note that the sample size was small and the data was pooled. These variables are likely to be intercorrelated, thus, future studies will use partial correlations to identify variables that are uniquely correlated with CSI.

**REFERENCES:**

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