# ANALYSIS OF ELITE GOLFERS' KINEMATIC SEQUENCE IN FULL-SWING AND PARTIAL SWING SHOTS

**Fredrik Tinmark, John Hellström, Kjartan Halvorsen, Alf Thorstensson**

**The Swedish School of Sport and Health Sciences (GIH), Stockholm, Sweden**

**KEY WORDS:** Motor control; Multi-joint movements; Skilled golf players

**INTRODUCTION:** Proximal-to-distal sequencing (PDS) has been observed in full-swing golf shots as in most throwing and striking skills, where the main goal is to maximize speed in the most distal segment of an open-link system (Zheng et al., 2007). Although PDS primarily is associated with mechanical advantage when the speed requirement is high, this temporal order has also been found and ascribed various merits in relatively slow multi-joint movements (Furuya & Kinoshita, 2007). However, no research to date has examined the sequencing pattern in partial golf shots to submaximal distances. The purpose here was to investigate whether PDS is a common characteristic also in partial swing shots of skilled golf players.

**METHODS:** A total of 47 golfers were investigated, 11 male tournament professionals, 23 male amateurs (HCP 0 ± 2 strokes), and 13 female amateurs (HCP -2 ± 2 strokes) performed partial shots with a wedge to targets at three discrete distances (40, 55 and 70 m), and full-swing shots with a five iron as well as a driver in the same direction for maximal distance. Pelvis, upper torso, and hand movement were recorded in 3D with an electromagnetic tracking system (Polhemus) at 240 Hz. The magnitude of the resultant angular velocity vector of each segment was used to examine the sequencing pattern and the angular speed of segment motions. Movement onset, peak amplitude and time for peak amplitude were analyzed in separate repeated-measure ANOVAs with pre-planned Bonferroni corrected pairwise comparisons. Significance level was set at $P < 0.05$.

**RESULTS:** This study showed a significant proximal-to-distal temporal relationship of movement onset and maximum angular speed at the pelvis, upper torso and hand segments in the golf swing. The same temporal structure was evident in all test conditions, as well as among different genders and levels of expertise. However, the increment in angular speed from the upper torso to hand were significantly larger for male professionals than for female amateurs at all shot conditions and significantly larger for male amateurs than for female amateurs at full-swing shots.

**DISCUSSION AND CONCLUSION:** While there exists a body of evidence in support for PDS providing mechanical advantages when the highest possible ball speed is to be achieved, merits of PDS in partial golf shots are less evident. However, it has been proposed that a given torque or force can be more accurately generated by a stronger muscle than a weaker muscle (Hamilton et al., 2004) and a potential role of the observed sequencing pattern in partial shots of skilled golf players could be to improve accuracy and minimize the speed-accuracy tradeoff.

**REFERENCES:**

Zheng N., Barrentine S.W., Fleizig G.S., Andrews J.R. (2008). Kinematic analysis of swing in pro and amateur golfers, *International Journal of Sports Medicine*, 6, 487-493.

Furuya S., Kinoshita H. (2007). Roles of proximal-to-distal sequential organization of the upper limb segments in striking the keys by expert pianists, *Neuroscience Letters*, 421, 264-269.

Hamilton A., Jones K.E., Wolpert D.M. (2004). The scaling of motor noise with muscle strength and motor unit number in humans, *Experimental Brain Research*, 157, 417-430.