

# KINEMATIC ALTERATIONS WITH CHANGES IN PUTTING DISTANCE AND INCLINE SLOPE

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## Introduction

Although the golf drive has been studied frequently using motion analysis, there has been minimal work examining putting. It is recommended that golfers make a pendular motion with the club during putting. There are kinematic changes when putting from longer distance, including increased backswing times and clubhead speed [1]. However, how the club motion changes with increasing difficulty and what joints contribute to this club pendular motion have not been studied. The objective was to compare joint kinematics and timing variables during putting at different distances and surface inclines.

## Methods

Male, amateur, right-handed golfers (n=14, mean age 22 y) completed putts on an artificial putting surface using a standard putter and ball. They completed three trials for each of the four putting conditions: 3-foot putts on flat and incline (5.7°) surfaces, and 7-foot putts on flat and incline (5.7°) surfaces. Kinematic data were collected with an eight-camera motion capture system (Vicon) and reflective markers placed on the head, trunk, right arm, pelvis, club, and ball. Reflective marker data were filtered with a low pass Butterworth filter (5 Hz). Joint angle waveforms were calculated for the head, trunk, and right arm, while the club angle with respect to the lab was also determined. Waveforms were time normalized from the beginning of backswing to the end of follow-through. The peak ball and clubhead speed, and time of each putting phase (backswing, downswing, follow-through) were also determined.

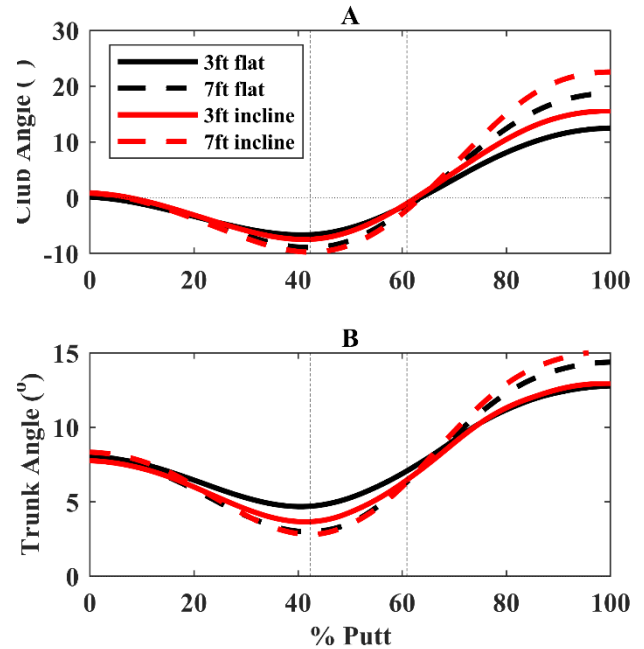
One-way repeated analysis of variance (ANOVA) compared peak ball and clubhead speed. Two-way repeated ANOVAs compared the times of each putting phase over the conditions. Statistical parameter mapping (SPM) compared the angle and club waveforms over the putting conditions [2].

## Results and Discussion

There were significant differences in peak ball and clubhead speed between conditions ( $p < 0.05$ ), with 3-foot flat and 7-foot incline conditions producing the lowest and highest speeds, respectively. There was a significant putting phase\*condition interaction ( $p = 0.03$ ) for the putting phase times. Specifically, there were longer backswing times for the 7-foot compared to the 3-foot putt on both flat (mean difference=0.05 s) and incline (mean difference=0.07 s) surfaces.

The SPM revealed significantly greater club angles away from the hole during backswing and towards the hole during follow-through for the 7-foot conditions, including both flat and incline surfaces (Figure 1A). Both 7-foot conditions resulted in greater head rotation towards the target during all phases, and greater trunk rotation away and towards the hole during backswing and follow-through, respectively (Figure 1B). There were no significant differences in the right shoulder angle waveforms between any putting conditions.

In amateur golfers, increasing the distance had a greater impact on the club angle than changing the incline. Golfers increased their backswing times and sped up their club during longer distances. Interestingly, trunk rotation seemed to contribute to increased club motion during long putts, rather than trail (right) side shoulder angles. Longer distance also resulted in the golfers “lifting” their head, by rotating it towards the hole.



**Figure 1:** A) Club angle (+ive is bringing clubhead towards the hole) and B) trunk angle (+ive is axial rotation towards the hole) during the four putting conditions. The vertical dashed lines represent the transition from backswing to downswing to follow-through.

## Significance

During putting, it is recommended the club follows a pendular motion. The trunk might have a greater impact on this pendular club motion, rather than the shoulder, during short and medium distances. However, studies need to be compared to professional golfers. Also, amateur golfers tend to lift their head at longer distances, which should be discouraged.

## Acknowledgments

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## References

- [1] Dias et al., 2014. *Motor Control* 18, 221-43.
- [2] Pataky et al., 2016. *J Biomech* 49 :1468-76.