LOWER EXTREMITY WORK IS ASSOCIATED WITH CLUB HEAD VELOCITY DURING THE GOLF SWING IN EXPERIENCED GOLFERS

Michael P. McNally, Nicholas A. Yontz, Ajit M.W. Chaudhari, PhD

Ohio State University Wexner Medical Center, Columbus, OH, USA
Nike Inc., Beaverton, OR, USA
Email: Michael.mcnally@osumc.edu

INTRODUCTION

The golf swing is a complex whole body movement, requiring the coordination of multiple joints to achieve the maximum power while still producing an accurate shot. Despite the strong interest by players and coaches in improving the golf swing, most of the scientific literature has focused on either the role of the pelvis and trunk interaction, or the ground reaction forces which occur during the swing to generate club head energy. A significant lack of scientific evidence exists to explain how lower extremity biomechanics relate to club head velocity during the golf swing. Only one known study has investigated lower extremity biomechanics during the golf swing, using computer modeling to estimate the amount of work performed by the total body, including the lower extremities [1]. However, this study did not investigate what relationship may exist between lower extremity biomechanics and club head velocity or collect data from enough subjects to permit any generalizations in their results beyond the four individuals they measured.

For this study, we tested the hypothesis that greater lower body net work would be associated with greater club head velocity. In addition, we hypothesized that individual joints of the lower extremity would have different joint work contributions to club head velocity, and that golfers of different skill levels would show different influences of overall, side to side, and individual joint work from the lower extremities during the golf swing.

METHODS

Forty-one subjects were recruited from local country clubs and golf teams and divided into four groups (Elite, Low, Mid, High) based on their self-reported handicap or team status. A passive optical three-dimensional motion capture system (Vicon Inc., Oxford UK) was used to collect kinematics of the body while subjects used their own driver to hit golf balls into a net placed approximately 3 m down the target line. Force plates were used to capture ground reaction forces from lead and trail legs throughout the swing. A single representative trial with the most complete trajectory data from each subject was chosen for data analysis.

Standard inverse dynamics equations were used to calculate joint kinetics of the lower extremities, including the intersegmental power flow from the distal segment to proximal segment across the joint using Vicon Bodybuilder software. Total work (Work\textsubscript{Total}) was estimated by summing the integrated powers of all six primary lower extremity joints (hips, knees, ankles) throughout the downswing. Lead leg work (Work\textsubscript{Lead}) and trail leg work (Work\textsubscript{Trail}) were similarly estimated by summing the integrated powers of the hip, knee, and ankle joints on their respective sides.

Figure 1. Peak club head velocity vs. total lower extremity work for all subjects.
Correlations were calculated between peak club head velocity (Club\textsubscript{Peak}) and Work\textsubscript{Total}, Work\textsubscript{Lead}, Work\textsubscript{Trail}, and individual joint work. Comparisons of Work\textsubscript{Total}, Work\textsubscript{Lead}, Work\textsubscript{Trail}, and individual joint work between the four groups were performed using a MANOVA analysis with Tukey’s post hoc test for analysis of significant variables.

RESULTS AND DISCUSSION

There was a strong correlation (R = 0.82) observed between Work\textsubscript{Total} and peak club head velocity (Club\textsubscript{Peak}; Figure 1), which suggests the lower extremities may play a significant role in the development of club head velocity during the golf swing. A strong correlation also was observed between Work\textsubscript{Lead} and Club\textsubscript{Peak} (R = 0.72). Only a moderate correlation was seen between Work\textsubscript{Trail} and Club\textsubscript{Peak} (R = 0.54), suggesting that the lead leg might play a greater role in the development of club head velocity than the trail leg.

Comparison between groups showed that the Elite group performed significantly greater Work\textsubscript{Total} than Mid and High groups (195±28 J vs. 151±32 J and 117±30 J; p=0.05 and p<0.01), and the Low group performed significantly greater work than the High group (191±41 J vs. 117±30 J; p<0.01; Figure 2). When divided into lead and trail legs, differences were only seen in Work\textsubscript{Lead}, where both Elite and Low groups were significantly greater than both Mid and High groups (94±24 J and 92±24 J vs. 61±16 J and 48±24 J; p<0.05). Individual joint work was also different between groups at the lead knee (Elite > High; p = 0.02) and lead ankle (Elite > Mid; p = 0.05). These results provide further evidence that players of a higher skill level use their lower extremities to a greater extent during the downswing than golfers of a lesser skill level, especially the lead leg. More skilled golfers may also be utilizing more distal joints of their lead leg to generate energy in addition to the hips.

While this study provides evidence that the lower extremities play a role in the production of club head velocity during the golf swing, the exact mechanism of how they generate that energy to accelerate the club head is still unknown. The increased work by the lower extremities may be related to an upward pull generated by the body as suggested by Chu et al [2]. Increased lower extremity work may also be related to an increased magnitude of weight transfer from the trail leg to the lead leg, which has been shown by multiple studies to relate to club head velocity.

CONCLUSIONS

This study is one of the first to explore the role of the lower extremities in the development of club head velocity. In this study we show strong relationships between the work performed by the lead leg and club head velocity, though this may not be as important as the total amount of work performed by the lower extremity to generate club head velocity. Future work needs to be done to validate these results, as well as to further investigate the lower extremity mechanisms which aid in developing club head velocity.

REFERENCES