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MODIFICATION IN NEUROMUSCULAR CONTROL OF GOLF SWINGS WITH DIFFERENT CLUBS

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SUMMARY
A within-player design was used to test the hypothesis that between-club differences in reaction forces were regulated by scaling muscle activation. Comparison of lower extremity muscle activation patterns during the swing indicated that all players amplified muscle activation of target and rear leg muscles when using the driver as compared to the 6-iron. Four of the 12 players also selectively recruited additional muscles when using the driver versus the 6-iron. An increase in muscle activity, either through amplification of all muscles or selective recruitment and amplification of additional muscles, assists the player in creating greater peak horizontal reaction forces when using a driver as compared to a 6-iron.

INTRODUCTION
Performance of well-practiced goal-directed tasks involves simultaneous control of reaction forces (RF) relative to the total body center of mass trajectory (CM) during contact with the environment [1]. During the golf swing, the golfer generates reaction forces at the foot/ground interface to accelerate rotation of the body-club system toward the target. During competition, a player can choose which club to hit depending on the circumstances of the shot (distance, wind, elevation, etc.). Modifications in the club facilitate regulation of shot distances. For example, lower numbered irons and woods tend to have longer shafts and lower loft angles than higher numbered irons and wedges. Our working hypothesis is that an experienced player will maintain control preferences across clubs by selectively scaling their muscle activation. In a previous study, within-subject differences in reaction force magnitudes were observed between the long (driver) and medium length (6-iron) clubs [2]. A within-club analysis also revealed that regulation of shot distance was achieved in part by increasing the magnitude of the resultant horizontal reaction force without modification in the resultant horizontal reaction force-angle relationships within leg [2]. Temporal relationships between target and rear legs during the swing were also consistent within player and across shot conditions. How these reaction force magnitudes are regulated by technique or muscle activation patterns remain unknown. In this study, we used a within-player design to test the hypothesis that between-club differences in reaction forces were regulated by scaling muscle activation.

METHODS
Skilled golfers (n=12; handicap < 5, right handed) performed five swings using a driver and a 6-iron (Taylor Made adidas golf) under normal swing conditions. Placement of the force plates allowed players to use their preferred address position to hit the golf ball toward the target. Subjects were on average 28.1 (12.4) years old, 1.77 (0.12) m in height, and 78.7 (18.7) kg in body mass. Reaction forces at the artificial turf-plate interface were quantified during each swing using dual force plates (Kistler, 1200 Hz) [3]. Kinematics of the body and club during the golf swing were captured at 110 Hz using reflective markers (MATT, Motion Reality, Inc.). Ball contact was synchronized at the time of club/ball contact using a microphone signal collected simultaneously with the reaction force-time data (t = 0s at ball contact). Activation of lower extremity muscles were monitored using electromyography using surface electrodes (1x1cm^2 Konigsberg, Pasadena, CA). Muscle activation (RMS filtered zero-lag fourth-order recursive Butterworth filter at 10-350 Hz, full wave rectified, and integrated in 20 ms bins) quantified and compared within player (normalized by manual muscle tests). The magnitude and direction of the peak resultant horizontal reaction forces were computed for each foot using reaction forces measured by each force plate during the swing. The interval of interest began at late backswing and ended at the time of ball contact [4]. The player-preferred swing for each club was identified by using the player's numerical rating of the swing immediately following the swing (10 being an ideal representation of their performance of the swing).

RESULTS AND DISCUSSION
Comparison of lower extremity muscle activation patterns indicated that all players amplified muscle activation of target and rear leg muscles when using the driver (+) as compared to the 6-iron (-) (Figure 1-4). EMG muscle activation patterns fell into one of two categories: Amplify only or Amplify and Recruit groups. The Amplify group (n = 8) amplified muscle activation of target and rear leg muscles when using the driver versus the 6-iron (Figures 1-2). While the Amplify and Recruit group (n = 4) amplified muscle activation while also selectively recruiting additional muscles (target and rear legs) to complete the swing. Although subjects had different muscle recruitment strategies, the muscles activated at similar times within subject during the downswing indicating that swing mechanics remain relatively unchanged. This is substantiated by the fact that within a player (regardless of muscle recruitment group), it was found that greater peak resultant horizontal force with the driver occurs at approximately the same angle as with the 6-iron [2].

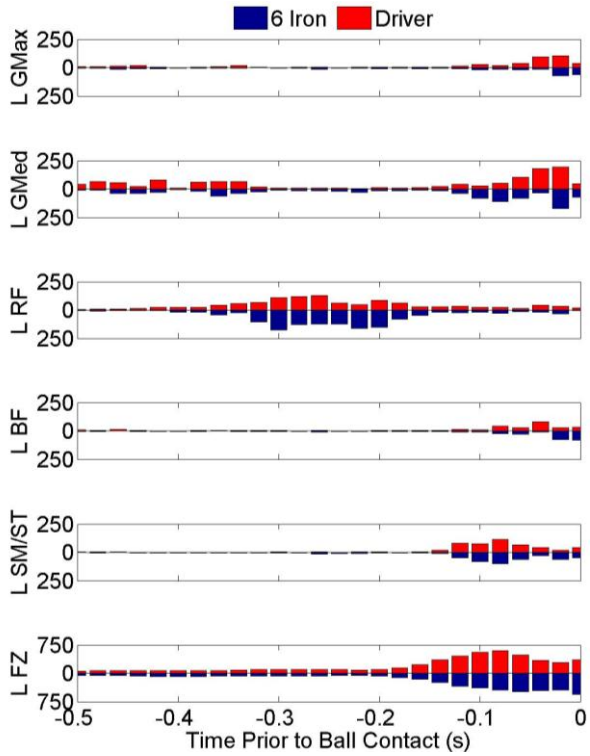

Figure 1: EMG and vertical forces for target leg of an exemplar subject in the Amplify group. Driver (+), 6-iron (-)

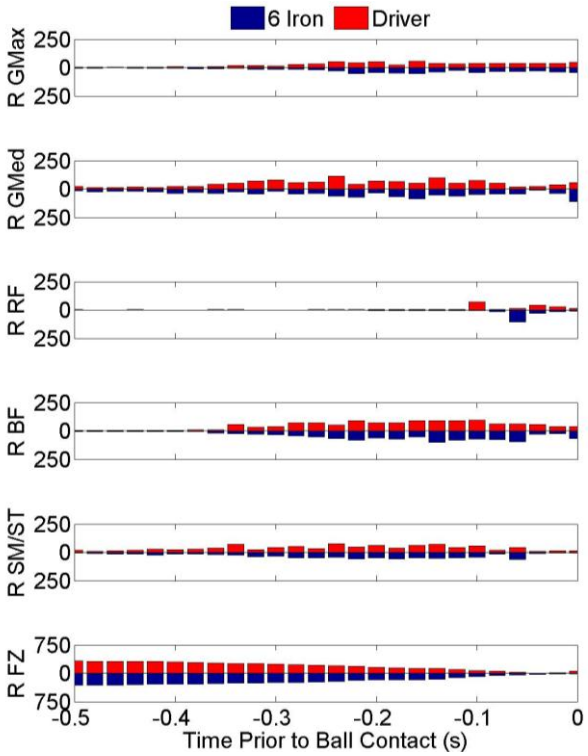

Figure 2: EMG and vertical reaction forces for rear leg of an exemplar subject in the Amplify group.

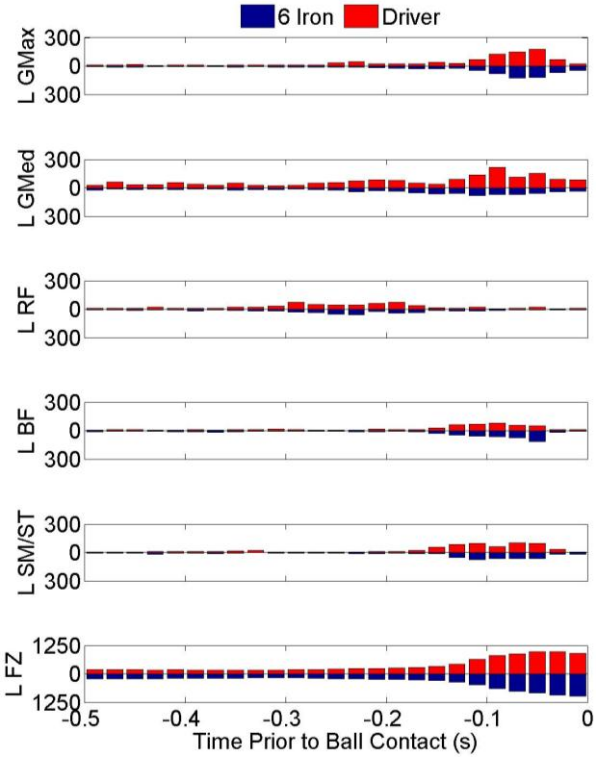

Figure 3: EMG and vertical reaction forces for target leg of an exemplar subject in the Amplify and Recruit group.

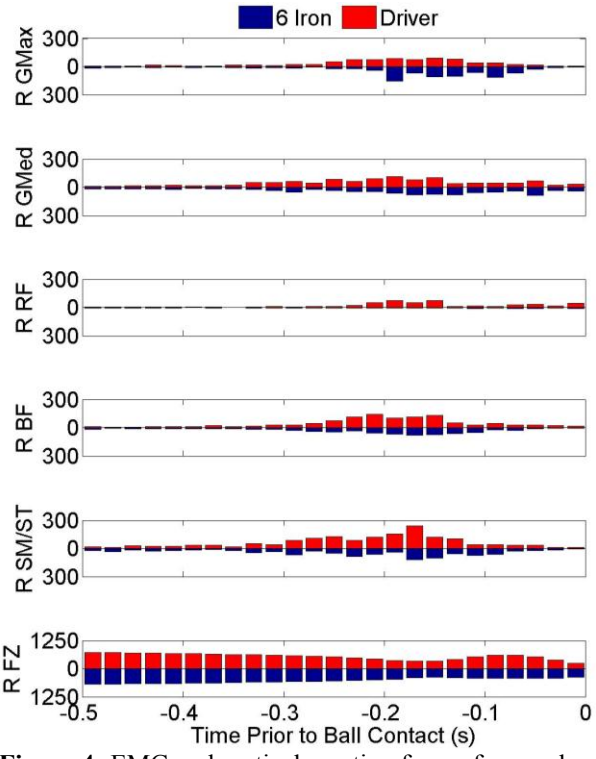

Figure 4: EMG and vertical reaction forces for rear leg of an exemplar subject of the Amplify and Recruit group.

CONCLUSIONS

Subtle, yet consistent amplification of muscle activation was observed within subjects across clubs. An increase in muscle activity, either through amplification of all muscles, or selective recruitment and amplification of muscles assists the subject in creating greater peak horizontal reaction forces observed when swinging the driver than the 6-iron and maintaining control preferences between clubs.

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