MUSCLE ACTIVATION PATTERNS OF UPPER EXTREMITY DURING DIFFERENT STROKES OF BADMINTON: A SINGLE SUBJECT PILOT STUDY

Gyeongeun Lee[1] and Hoon Kim[1]

[1]Department of Sports Medicine, Soonchunhyang University, Asan, South Korea

The purpose of this study was to quantify muscle activation patterns during different stroke techniques in badminton. We hypothesized that muscle activation patterns in upper extremity would be different depending on stroke techniques. We recruited a recreational badminton player. The participant performed five stroke techniques such as forehand and backhand drive, high clear, smash, and drop with electromyography sensors on wrist flexor, wrist extensor, elbow flexor, elbow extensor, middle deltoid, upper trapezius, and pectoralis major. We compared muscle activations within muscle and between stroke techniques. We found that muscle activation patterns were different depending on strokes. Our results provide background knowledge about muscle activation patterns and suggest that trainers should target different muscles depending on stroke techniques.

KEYWORDS: badminton, electromyography, EMG

INTRODUCTION: Badminton is one of the most popular sports among recreationally active people due to easy access (e.g., minimal equipment requirement: racquet) and a simple rule. Indeed, badminton is one of the Olympic games and a lot of competitions are held for recreational badminton players (Steels et al., 2020). To develop players' performances, it is very important to target muscles to be trained for each badminton stroke technique. Accordingly, it is also important to study muscle activation patterns depending on different strokes and provide a guide based on the research.

A few studies have been conducted to investigate muscle activation patterns in the upper extremities in badminton. For example, Barnamehei et al (2018) showed that non-elite players did not show different muscle synergies of muscle activations in the upper extremity during overhead forehand smash compared to elite players (Barnamehei et al., 2018). Also, Barnamehei et al (2018) examined the effect of kinesiotape on muscle activations of shoulder muscles during various stroke techniques in badminton players with impingement syndrome and revealed that kinesiotape did not influence the muscle activations of shoulder muscles in badminton players with impingement syndrome (Fong et al., 2019).

Although these previous studies revealed important information about neuromuscular control of the upper extremities during badminton stroke techniques, muscle activation patterns of the upper extremity during different badminton strokes in healthy players have not been thoroughly studied. Therefore, the purpose of this study was to quantify the muscle activation patterns of the upper extremities during different badminton stroke techniques in a healthy person.

METHODS: One healthy female recreational badminton player (21 years, 165cm, 55kg) was recruited for this study. The participant performed three swings of five different stroke techniques (e.g., forehand drive, backhand drive, high clear, smash, and drop) while muscle activations were recorded on upper extremity muscles using 7 sensors of electromyography (EMG) (Noraxon, USA) with a sampling frequency of 1500 Hz. Specifically, the EMGs were attached to wrist flexor (flexor carpi ulnaris), wrist extensor (flexor carpi radialis), elbow flexor (biceps brachii), elbow extensor (triceps brachii), middle deltoid, upper trapezius, and pectoralis major. We also recorded 3-dimensional kinematics of the upper extremities (i.e., head, trunk, upper arms, lower arms, hands) using 16 motion capture cameras (Optitrack, USA). However, we did not analyze motion capture data for this study.

We filtered the muscle activation data using the 4^{th}-order Butterworth band-pass filter with cutoff frequencies of 20 and 450 Hz. Then, we fully rectified and smoothed data with 4^{th} order

Butterworth low-pass filter with a cutoff frequency of 10 Hz (Kim et al., 2021). Lastly, we extracted the peak muscle activation of each muscle during three swings of each stroke technique. These EMG processing steps are presented in Figure 1. The peak value of muscle activations during different stroke techniques was extracted and normalized by the peak value of each muscle activation across all stroke techniques.
Because we analyze the muscle activations from a single participant, we did not use statistical analysis, but the peak muscle activations were presented in a spider plot for each stroke technique (Figure 2) and a bar plot for each muscle (Figure 3).

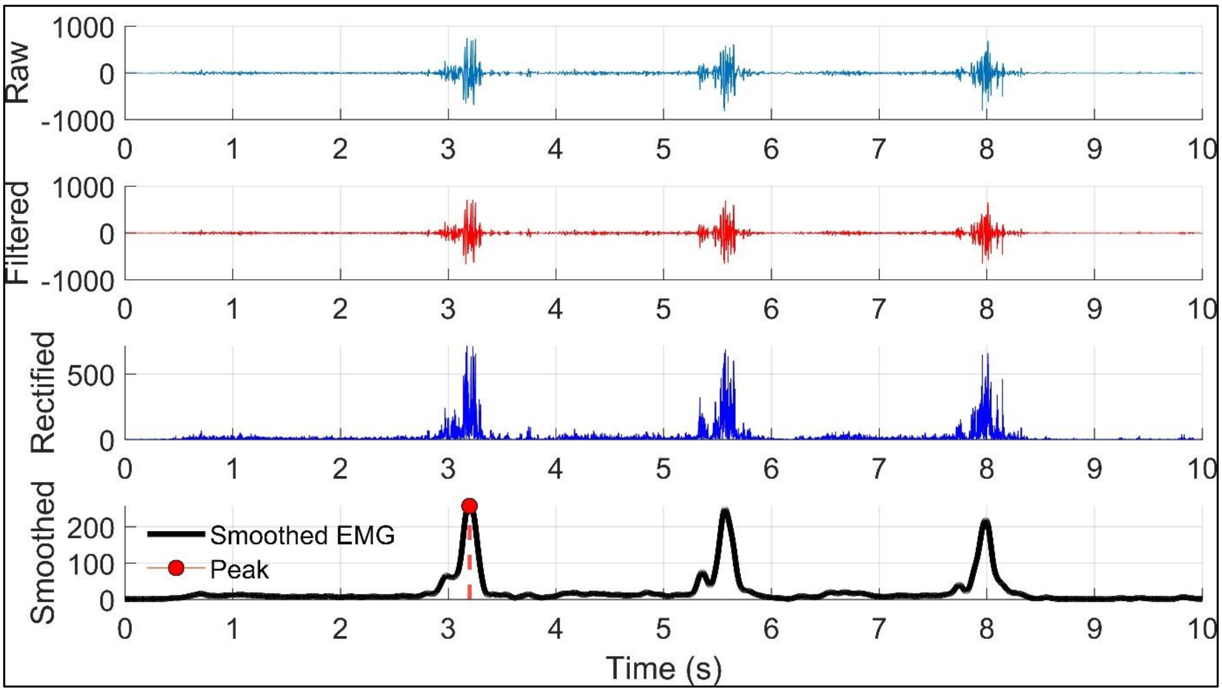

Figure 1: EMG Processing Steps. The raw, filtered, rectified, and smoothed EMG data during three strokes drop from the pectoralis major of a participant are shown. Peak EMG value was also extracted.

RESULTS: We found that the muscle activation patterns were different depending on stroke techniques. Spider plots show the patterns of muscle activation in an upper extremity during each stroke technique (Figure 2). For example, a spider plot of the forehand drive shows that the dark area spreads to the wrist extensor and elbow flexor, which indicates that the participant activated the wrist extensor and elbow flexor more than other muscles during the forehand drive. In addition, the participant used the wrist extensor and elbow extensor more during the backhand drive, the upper trapezius more during high clear, and all most all muscles except for the upper trapezius and elbow flexor during the smash. Whereas the participant used all muscles with small activations.
Bar plots show a stroke technique during which the participant shows peak muscle activation of each muscle (Figure 3). Specifically, muscle activation in the elbow flexor was greatest in forehand drive, muscle activation in the elbow extensor and wrist extensor was greatest in backhand drive, muscle activation in upper trapezius was greatest in high clear, muscle activation in wrist flexor and pectoralis major was greatest in smash, and muscle activation in all muscles was smallest in drop, compared to other stroke techniques.

DISCUSSION: Our results supported our hypothesis that muscle activation patterns would be different among five different stroke techniques.
We found that the participant activated the wrist extensor and elbow flexor more than other muscles during the forehand drive. This may indicate that the participant decelerated elbow extension with strong activation of elbow flexor followed by accelerating wrist extension. On the other hand, the participant accelerated elbow extension and wrist extension with strong

elbow extensor and wrist extensor activations to push the arm backward. High clear is a stroke to push the shuttlecock far away (Steels et al., 2020). Our result that the upper trapezius and middle deltoid muscles were mainly activated during high clear shows that the participant may elevate the shoulder joint and contract back muscles to hit the shuttlecock in an upward direction. Smash and drop show the opposite patterns of upper extremity muscle activations. Because smash is the most powerful stroke in badminton (Steels et al., 2020), the participant may recruit almost all muscles in their maximum activation. However, the participant may use all muscles minimally because drop is a stroke that should be a weak hitting to locate the shuttlecock around the net (Steels et al., 2020).

To our knowledge, this is the first study that shows patterns of muscle activation in an upper extremity during five different badminton stroke techniques, although this is a single-participant pilot study. We believe that this study can be used as background information for researchers to design an experiment to better understand human movement in badminton and for coaches to train specific muscles for better performance depending on stroke techniques.

This study has limitations. First, as a pilot study, we present results from a single participant without statistical analysis. However, we believe that this study will provide background information about upper limb muscle activations during different stroke techniques in badminton. Second, we did not acquire activation during maximum voluntary isometric contraction (MVIC) to normalize EMG data because this study was designed to quantify muscle activations across different stroke techniques relatively. Future studies should quantify muscle activation during MVIC. Fourth, we did not present upper extremity kinematics. To better understand, the analysis of kinematics should be combined with EMG analysis. To provide overall information, we will continue to analyze the kinematic data that was collected in this experiment.

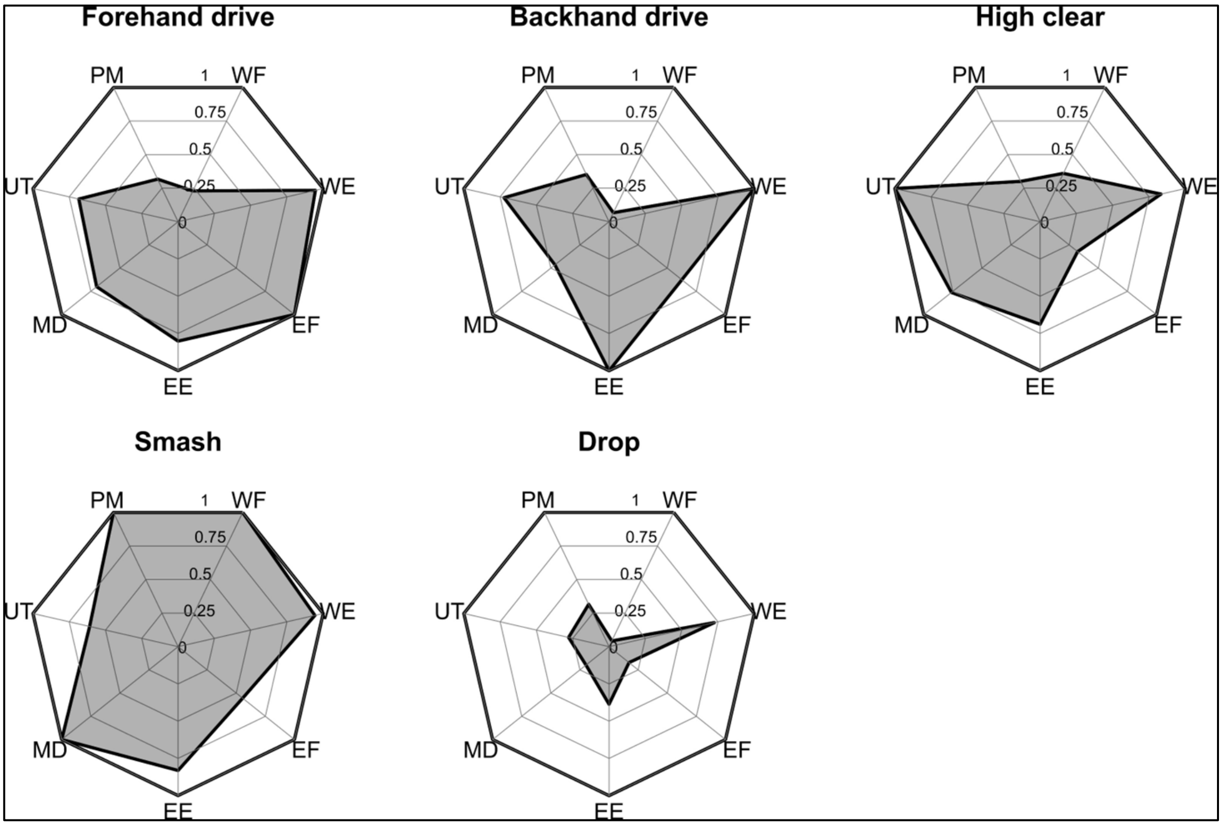

Figure 2: Spyder plot. Normalized peak muscle activations from wrist flexor (WF), wrist extensor (WE), elbow flexor (EF), elbow extensor (EE), middle deltoid (MD), upper trapezoid (UT), pectoralis major (PM) during each stroke techniques are presented.

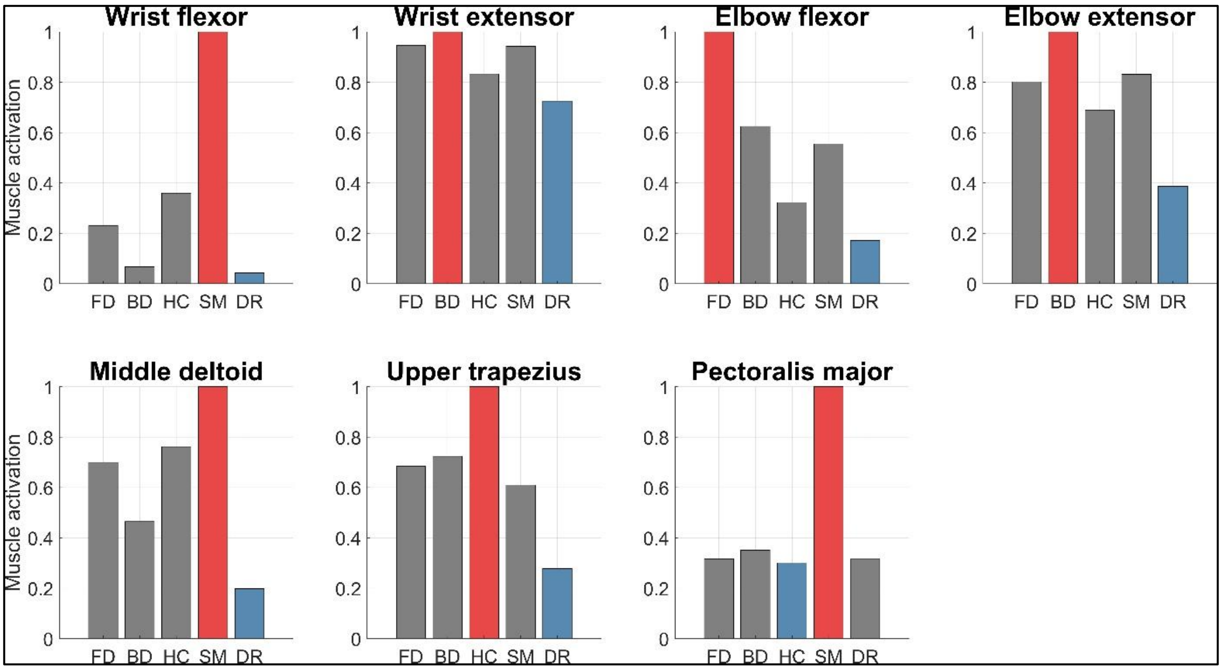

Figure 3: Bar figure. Normalized peak muscle activations from each muscle during different stroke techniques such as forehand drive (FD), backhand drive (BD), high clear (HC), smash (SM), and drop (DR) are shown. The red and blue bars are represented stroke techniques that show the biggest and smallest EMG values, respectively.

CONCLUSION: This study quantified the muscle activations of the upper extremity during different badminton stroke techniques in a female participant and shows that muscle activation patterns in the upper extremity are different depending on stroke techniques. Although this study is a pilot study, our results will provide background information about muscle activation patterns in the upper extremity in badminton.

REFERENCES

Barnamehei, H., Tabatabai Ghomsheh, F., Safar Cherati, A., & Pouladian, M. (2018). Upper Limb Neuromuscular Activities and Synergies Comparison between Elite and Nonelite Athletics in Badminton Overhead Forehand Smash. Appl Bionics Biomech, 2018, 6067807. https://doi.org/10.1155/2018/6067807

Fong, S. M., Ng, L. K., Ma, W. W., Wang, H. K., Bae, Y. H., Yam, T. T., Kam, W. K., & Chung, W. Y. (2019). Effects of kinesiology taping on shoulder girdle muscle activity and sports performance during badminton forehand overhead strokes in amateur badminton players with shoulder impingement syndrome. J Sports Med Phys Fitness, 59(6), 994-1000. https://doi.org/10.23736/S0022-4707.18.09125-9

Kim, H., Palmieri-Smith, R., & Kipp, K. (2021). Muscle Synergies in People With Chronic Ankle Instability During Anticipated and Unanticipated Cutting Tasks. J Athl Train. https://doi.org/10.4085/1062-6050-74-21

Steels, T., Van Herbruggen, B., Fontaine, J., De Pessemier, T., Plets, D., & De Poorter, E. (2020). Badminton Activity Recognition Using Accelerometer Data. Sensors (Basel), 20(17). https://doi.org/10.3390/s20174685

ACKNOWLEDGEMENTS: This work was supported by the Soonchunhyang University Research Fund.