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Electromyographic Analysis of Golfer's Elbow in Tennis Players in Serve

Ondrej Labik*, Min Pun-Kayat, Vamsi Pusapati, David Imuetinyan, and Fereydoun Aghazadeh

Department of Mechanical and Industrial Engineering, Louisiana State University, Baton Rouge, LA, USA,70803.

*Corresponding Author's Email: olabik1@lsu.edu

Author Note: Ondrej Labik is a master's student in the Department of Mechanical and Industrial Engineering. **Min Pun-Kayat** is a master's student in the Department of Mechanical and Industrial Engineering. **Vamsi Pusapati** is a Ph.D. candidate in the Department of Mechanical and Industrial Engineering, Louisiana State University. **David Imuetinyan** is a Ph.D. student in the Department of Mechanical and Industrial Engineering, Louisiana State University. **Fereydoun Aghazadeh** is a Professor in the Department of Mechanical and Industrial Engineering, Louisiana State University.

Abstract: Background/Objective: Injuries associated with epicondylitis are one most prominent and common cases in tennis players. They are usually caused by the repetitive motion and overuse of forearm muscles, as during serving. Medial epicondylitis or Golfer's Elbow (GE) is one of such injuries around the elbow's medial side. Previous electromyography (EMG) studies for tennis players are mostly centered around lateral epicondylitis (Tennis Elbow), but no EMG studies were conducted in the case of GE. This study focuses on EMG analysis of elbow muscles, and Triceps Brachii of a tennis player suffering from GE and aims to determine the most prominent and active muscles in the elbow of a tennis player having GE while performing the three different types of serves – kick, slice, and flat. Furthermore, this study also compares muscle activity of the elbow among the players with GE and non-GE while performing those different types of serve.

Methods: An EMG analysis was done for this study where the wired electrodes were attached to four different muscles (Flexor Carpi Radialis, Palmaris Longus, Triceps Brachii, and Flexor Carpi Ulnaris). The players were instructed to perform seven serves of all three types of serves with 90 seconds between the sets.

Results: The study found out the Flexor Carpi Ulnaris is active the most during all types of serve for both GE and non-GE, with a peak of 325% of MVC of EMG during kick serve, and for non-GE with a peak of 280% of MV of EMG during kick serve. Similarly, all muscles of GE have 1.0 to 1.26 times higher muscle activity than that of non-GE.

Conclusion: The findings from this study provide an opportunity for players with GE to focus on the rehabilitation of those muscles that are being impacted. The study also shows how the same muscles work in GE and non-GE during the three types of serves differently.

Keywords: Tennis players, Golfers Elbow, Medial epicondylitis

1. Background and Objective

Upper extremity injuries in tennis are mostly due to overuse of elbow, shoulder, or wrist. One of the common injuries is the tennis elbow, which mostly affects backhand topspin and slice, volleys, and even forehand topspin. The golfer's elbow can occur on the medial side of the elbow. It mainly involves four different muscles: Flexor Carpi Radialis (FCR), Palmaris Longus (PL), Flexor Carpi Ulnaris (FCU), and Triceps Brachii (T) (Remaley et al., 2015). It has always been a significant concern for athletes, especially tennis players who use mostly elbow muscles for different strokes. The golfer's elbow is mostly affected by the serve. Serve is the most energy-demanding and with a constant motion. During an average tennis match, serve accounts for about 45%-60% of all shots (Chung & Lark, 2017). On average professional male tennis players attempt 150-200 serves during a match with a speed of 183 km/h and 156 km/h for the first and second serve, respectively (Myers et al., 2016). There are three types of serve in tennis – flat serve, slice serve, kick serve – where all of those differ in the arm, elbow, and wrist motion. Each serve, having a different motion, will have different effects on the golfer's elbow.

Golfer's elbow, also known as medial epicondylitis, occurs due to repetitive movements and hand-arm vibration, resulting in tearing of Pronator Teres muscle and Flexor Carpi Radialis muscle (Pradana & Rossa, 2015). Prior electromyographic (EMG) research by Alizadehkhaiyat & Frostick, (2015); Giangarra et al., (1993); Morris et al., (1989); Kelley at al., (1994), were centered around lateral epicondylitis, but not much significant research was conducted on medial epicondylitis in tennis players. Another EMG analysis conducted on the forearm muscles of amateur and professional golfer found that professional has more muscle activity in Pronator Teres (Farber, Smith, Kvitne, Mohr, & Shin, 2009). However, this study is limited since subjects with no prior golf elbow conditions were selected. According to interviewed one NCAA D1

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tennis team's trainer, in collegiate tennis, 10% of tennis players either have a golfer's elbow or are inclined to have a golfer's elbow without everyday treatment. With a golfer's elbow, players lose the advantage of serving, which plays a crucial role in collegiate men's tennis. The purpose of this study is to identify the most active forearm muscles causing medial epicondylitis (Golfer's elbow) in competitive tennis players during three types of serve – flat serve, kick serve, slice serve. Furthermore, this study also compares the muscle activity of golfer's elbow sufferers and non-golfers elbow sufferers to see similarities and differences in the muscle activity.

2. Materials and Methods

Five different tennis players (one female and four male) participated in this experiment. Out of all, one participant had a golfers' elbow, whereas all other players did not have any arm-related problems. The subjects' characteristics are shown in Table 1. Participants were asked to do their usual warmup, as they do before any match. Electromyographic electrodes were placed on the Triceps Brachii (T) and muscles of the wrist flexor group – Flexor Carpi Radialis (FCR), Palmaris Longus (PL), and Flexor Carpi Ulnaris (FCU) (Figure 1), with a reference electrode placed at their forehead. The wires from electrodes were connected to a channel box placed at the participant's waist. In this study, a Bagnoli -2 EMG system is used for EMG signal data acquisition where each channel of the electrodes is operated at the rate of 1000Hz. An EMG of Maximum Voluntary Contraction (MVC) data of each participant was collected by instructing the participant to hold the tennis racquet firm and tight with the flexion of wrist and Triceps Brachii five times for three seconds with an interval of five seconds rest period. This data was used to determine the reference reading of participants for overall muscle activity while serving.

Each participant was instructed to do several trials of serves to feel comfortable with wired attached electrodes while serving. After several trials, the participants started to serve the three different types of serve (flat serve, slice serve, kick serve). Each participant did the seven serves of each type of serve with 90 seconds between three serve types. The 90 second rest period was chosen to have the same length as between games replicate match conditions. Seven servers per serve type were chosen to replicate an average serving game in college tennis. The order of the serve types was randomized to eliminate bias. The study was conducted in a laboratory with a high ceiling, where participants served into a wall covered with blankets, which was three meters from the serving spot. The EMG signals of each participant's muscles while performing these serves were then recorded and analyzed through EMG acquisition software. For each muscle, the EMG signals of the seven serves were averaged and compared to the MVC signals of the same muscles (MVC was set to be 100% of muscle activity) during different types of serve. Then the muscle activity of each muscle during each serve is compared between players with golfers and non-golfers elbow.

Table 1: Experimental subject characteristics

	GE	**non-GE**	
Sex	male	male	female
Number of subjects	1	3	1
Mean age	24	25	22
Mean weight (kg)	72	77.667	57
Mean height (cm)	183	185.33	168

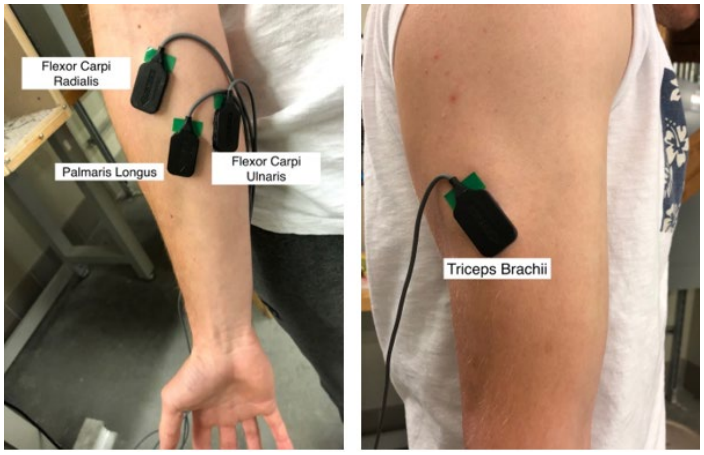

Figure 1: EMG electrode placement on the muscle of interest

3. Results

In both golfer's elbow (GE) and the non-golfers elbow (NGE), the muscles activity ranking based on peak EMG (in % of MVC) during serving was the same in all three types of serves, as stated in Table 2. During the flat serve, muscle activity was ranked: 1) FCU, 2) T, 3) FCR, 4) PL. During kick serve, the muscle activity was ranked: 1) FCU, 2) T, 3) PL, 4) FCR. During slice serve, the muscle activity was ranked: 1) FCU, 2) T, 3) PL, 4) FCR.

Table 2: Average peak muscle activity during three types of serve (% of MVC)

	Flat Serve		**Kick Serve**		**Slice Serve**	
Muscle	*Golfer's Elbow*	*Non-Golfer's elbow*	*Golfer's Elbow*	*Non-Golfer's elbow*	*Golfer's Elbow*	*Non-Golfer's elbow*
FCR	91.37	92.83	58.38	53.45	49.53	43.22
PL	85.98	85.76	95.21	80.56	58.79	48.19
FCU	272.32	215.84	325.89	280.28	146.02	123.24
T	184.11	152.41	167.81	143.34	91.47	81.27

In all types of serve, Flexor Carpi Urnalis (FCU) worked the most with the lowest of 123.24% of MVC in NGE, 146% of MVC in GE, and the peak of 280% of MVC and 325% of MVC in NGE and GE respectively. Triceps Brachii had the second-highest activity in all serves. The highest Triceps Brachii activity was during flat serve with 184% of MVC in GE and 152% of MVC in NGE. From all the muscles, only FCU and Triceps Brachii exceeded the 100% of MVC, but FCR had 93% of MVC during flat serve in both NGE and GE, and PL had 95% of MVC and 81% of MVC during kick serve in GE and NGE respectively. On average, FCR had the lowest average peak activity from all the muscles. The highest muscle activity for both golfer's and non-golfers elbow was during kick serve, where the peak activity in FCU exceeded 280% of MVC in NGE and 325% in GE.

Comparing GE to NGE, all muscles of GE have on average from 1.0 to 1.26 times higher activity than muscles of NGE during all serves. The highest difference is during a flat serve, where the peak activity of FCU of GE is 1.262 times higher than of FCU of NGE. Comparing GE and NGE activity of FCR, FCR has very close values, on average just 1.07 times higher in GE than in NGE, which suggests there is no difference in activity of FCR between GE and NGE. In GE, PL activity is 1.13 times higher than in NGE, the activity of Triceps Brachii is 1.17 times higher in GE than in NGE, and the activity of FCU is on average 1.21 times higher than in NGE.

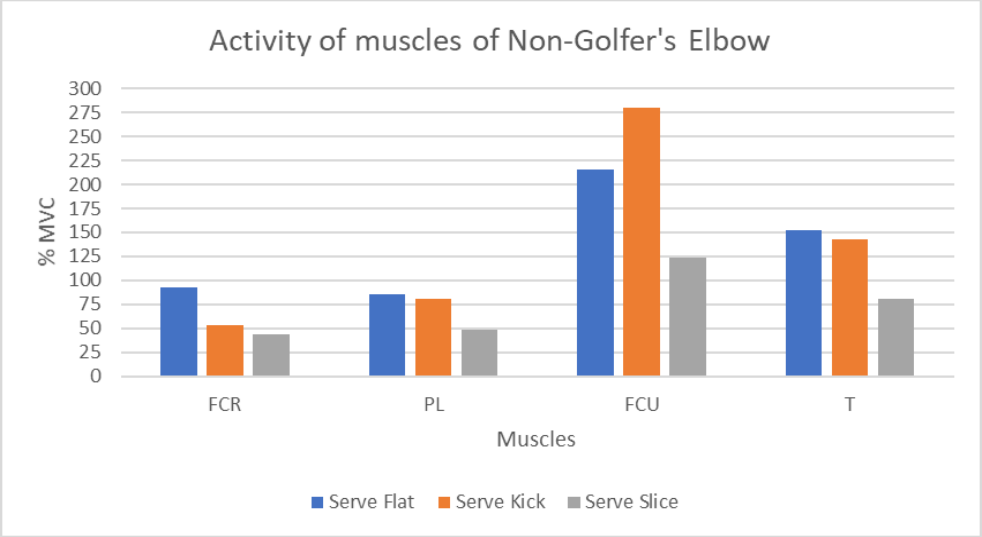

Figure 2. Muscle Activity of Non-golfer's Elbow

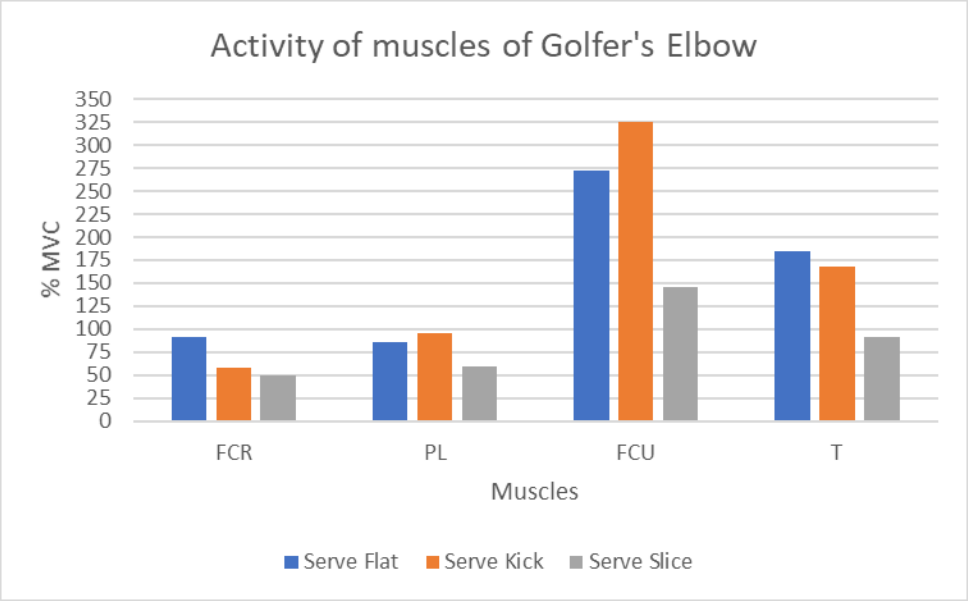

Figure 3. Muscle Activity of Golfer's Elbow

When the signal strength was averaged across all individual muscles, kick serve had the highest strength of 162% and 139% of MVC for GE and NGE, respectively, followed by flat serve to have 158% and 137% of MVC for GE and NGE, respectively, whereas during slice serve the averages were only 86% and 74% of MVC for GE and NGE respectively.

4. Discussion

The data from this study revealed that all four muscles exhibit higher muscles activities in the case of GE than NGE players while performing different types of serves. In the case of GE, muscles activity was from 1.0 to 1.26 higher than in NGE muscle activity. FCU muscle works the most in all serves for both GE, with the peak of 325% of MVC during kick serve and NGE with 280% of MVC during kick serve. The lowest FCU activity for GE is 146% of MVC during slice serve. The second

highest working muscle is the Triceps Brachii, with a peak of 184% of MVC in GE during the flat serve and 151% of MVC in NGE during the flat serve.

Similarly, after comparing different muscles between GE and NGE for different individual serve, it is found that FCU of GE exhibits more muscle activity (lowest 146% MVC, highest 325% MVC) compared to any other muscle of NGE. Furthermore, the FCU of GE shows the highest muscle activity (325% MVC) while performing the kick serve compared to the other two serves. FCU of NGE shows the highest muscle activity (280% MVC) during kick serve. These findings are beneficial for a player with GE and provide a basis of recommendation to focus on the rehabilitation of their FCU. High muscle activities were also seen on the Triceps Brachii muscle, especially during the flat serve, where the peak activity was 184% MVC for GE and 152% MVC for NGE, so players with GE should also pay attention to it too. FCR showed the lowest muscle activity among all muscles in the case of two out of three serves (slice and kick), and PL showed the least muscle activity during flat serve for both GE and NGE players.

This study was conducted in a laboratory setting with a higher ceiling where players were serving the ball into a construction covered with a blanket placed 3 meters from them. As a result, the players were not in their classic serving setting. Due to constrained space, the vision of the players and the full motion was affected. More accurate data of the serve would have been achieved if this experiment had been conducted on an actual tennis court. In this study, wired-adhesive electrodes were used to detect the EMG signals. Due to the size of the sensors, it was not possible to correctly measure the activity of Pronator Teres. Also, during the data collection, the adhesive electrodes detached from muscles in some trials due to the movement of wires, and the signal got deteriorated. In such a case, electrodes were reconnected to the muscles, and the whole set of serves was performed from the start.

Similarly, the wired connection created a sense of discomfort among the players, which affected the intensity of serve in some capacity. A wireless EMG sensor would be a better option since it will not detach, provide a more accurate reading, and be more comfortable for players to perform different serves. Finally, the number of players with GE is just one in this study. That is mainly because there were no other players with the golfer's elbow. We contacted the athletic department for more subjects, but they were reluctant to provide any subjects because it was the middle of the NCAA season, and with a packed schedule, it could be a violation of the NCAA rules. More detailed and accurate results would have been achieved if a greater number of subjects were involved.

5. Conclusion

This study focuses on identifying the most active forearm muscle for a tennis player having a GE while performing three different serves used in tennis (Kick, Flat, and Slice). Flexor Carpi Urnalis works the most out of all muscles in both GE and NGE, with peak activity of 325% MVC, for GE, during kick serve and the lowest activity of 146% MVC, for GE, during slice serve. The findings of this study help physicians and players to focus on rehabilitation of those muscles and different serve types.

6. References

Alizadehkhaiyat, O., & Frostick, S. P. (2015). Electromyographic assessment of forearm muscle function in tennis players with and without Lateral Epicondylitis. *Journal of Electromyography and Kinesiology*, *25*(6), 876-886.

Chung, K. C., & Lark, M. E. (2017). Upper extremity injuries in tennis players: diagnosis, treatment, and management. *Hand clinics, 33*(1), 175-186.

Farber, A. J., Smith, J. S., Kvitne, R. S., Mohr, K. J., & Shin, S. S. (2009). Electromyographic analysis of forearm muscles in professional and amateur golfers. American Journal of Sports Medicine, 37(2), 396-401.

Giangarra, C. E., Conroy, B., Jobe, F. W., Pink, M., & Perry, J. (1993). Electromyographic and cinematographic analysis of elbow function in tennis players using single- and double-handed backhand strokes. *American Journal of Sports Med, 21*(3), 394-399.

Kelley, J. D., Lombardo, S. J., Pink, M., Perry, J., & Giangarra, C. E. (1994). Electromyographic and cinematographic analysis of elbow function in tennis players with lateral epicondylitis. *American Journal of Sports Medicine, 22*(3), 359-363.

Morris, M., Jobe, F. W., Perry, J., Pink, M., & Healy, B. S. (1989). Electromyographic analysis of elbow function in tennis players. *American Journal of Sports Medicine, 17*(2), 241-247.

Myers, N. L., Sciascia, A. D., Kibler, W. B., & Uhl, T. L. (2016). Volume-based interval training program for elite tennis players. *Sports Health, 8*(6), 536-540.

Pradana, T. D., & Rossa, I. (2015). Factors that Related to Incident Medial Epicondylitis (Golfer Elbow) on Workers Springbad Furniture Maker. *JURNAL BORNEO AKCAYA, 2*(2), 106-113.

Remaley, D. T., Fincham, B., McCullough, B., Davis, K., Nofsinger, C., Armstrong, C., & Stausmire, J. M. (2015). Surface Electromyography of the Forearm Musculature During the Windmill Softball Pitch. *Orthopedic journal of sports medicine, 3*(1), 2325967114566796.