# UPPER LIMB MUSCLE ACTIVATION BETWEEN TWO DIFFERENT STANCES IN A TENNIS FOREHAND DRIVE: A PRELIMINARY STUDY

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The purpose of this study was to compare the electromyography (EMG) activity and ball velocity between one forehand drive performed in quasi-static stance (QSS) in the cross-court direction (CC) and one forehand drive performed with a dynamic frontal weight transfer stance (DS) in the inside-out direction and the ball velocity between both stances. The EMG activity was recorded in five muscles of the upper limb in one high-performance tennis player. Six forehand drives in QSS in the CC direction and six in the IO direction were selected for analysis. Results demonstrate a higher activation of most of the selected muscles in the QSS except for the triceps brachii (TB), moreover, the QSS presented higher ball velocity. This study could present a deeper comprehension of the muscle activation intensity, thus, helping coaches and health professionals.

**KEYWORDS:** racket sports, muscle activation level, tennis forehand, electromyography, ball velocity.

**INTRODUCTION:** Electromyography studies in the tennis forehand drive have investigated mostly the flat (Rota et al., 2012) and top spin (Rouffet et al., 2009) forehand drives (Rogowski et al., 2011). These studies have focused on the relationship between muscle coordination and forehand drive velocity pointing out that the EMG burst timing and the amplitude of muscle activity was adjusted to the velocity of the stroke (Rota et al., 2012). A proximal-to-distal sequence was described for the agonist muscles while the antagonist muscles were recruited at the end of the acceleration phase in young tennis players (Rouffet et al., 2009). More skilled players were able to differentiate clearly the flat and topspin forehand drives and, presented a significant decrease in the flexor carpi radialis (FCR) and in the extensor carpi radialis (ECR) muscle activity and a similar middle deltoid (MD) muscle activity from the flat to topspin forehand drives (Rogowski et al., 2011). While the above-mentioned studies provide valuable insight into muscle activity during the forehand, variations in technique such as jumping with a dynamic frontal weight transfer (DS) have not been studied. Even most of the kinematic studies describes the forehead drives with the feet on the ground, and there are no studies describing these different techniques used by tennis players. To the best of our knowledge, no study has compared the EMG during these different forehand drive stances to understand what differentiates a QSS when the player hits the ball with their feet on the ground with a more DS with frontal weight transfer when the players contact the ball with their feet off the ground. Thus, the aim of this work is to compare the EMG activity of selected muscles of the upper limb between the tennis forehand drive performed in a QSS and a DS with frontal weight transfer and the ball velocity of one high-performance tennis player.

**METHODS:** One male expert tennis player (age: 26 years old; height: 176 cm; mass: 75 kg), provided written informed consent to participate in this study, which was approved by the Institution’s Ethics Committee. The participant was free from injuries, practiced regularly 12h hours per week and competed at national competitions. Before testing, the participant had 15 min for an individual warm-up and to become familiar with the test environment. Before data collection, the experimental procedure was explained. The participant used his own tennis racket, and he was instructed to hit the ball as in a real situation during both stances. Six forehand drives performed with the feet on the ground at ball impact in the CC direction and six forehand drives with the feet off the ground at ball impact in the IO direction were selected for analysis. A ball machine projected new tennis ball with controlled velocity (24.5m/s) to a target area (yellow box) (Figure 1). Starting at the basely, participants were instructed to hit three series of ten forehands. A forehand stroke was valid when the ball landed inside the target area (Figure 1) (Landlinger et al., 2012).

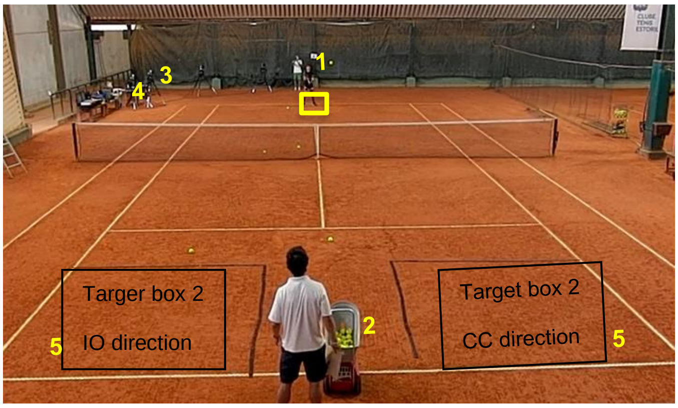
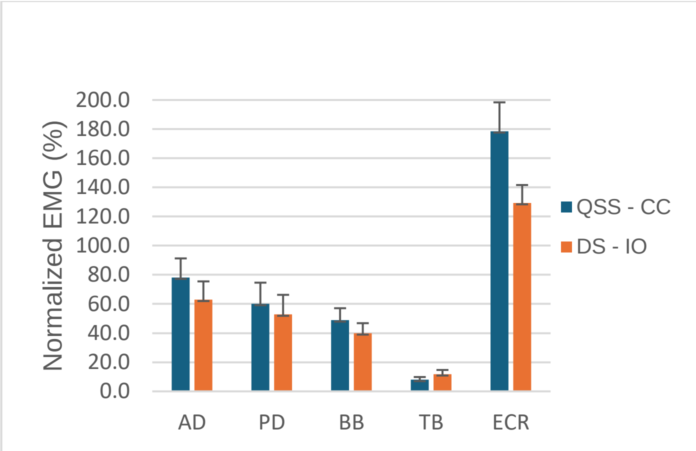



**Figure 1 - Set up with the (1) participant ready to data collection, (2) ball machine, (3) one video camera Oquos 210c, (4) the EMG Delsys System and the Qualisys software (5) target boxes in the cross-court and the inside-out direction.**

After 15 minutes of warm up, participants performed isometric maximal voluntary contractions (IMVC) of 3s duration, repeated three trials with a rest interval of one minute. This process allows to transform the muscular activity expressed in microvolts as a percentage of muscle activity after calibration, through an isometric voluntary contraction (MVC) or a reference voluntary contraction (RVC) (submaximal) (Lehman & Mcgill, 1999). Also, allows to compare absolute values of muscular activity, making possible the comparison between muscles of the same subject, between subjects, between different days (Burden, 2010; Soderberg & Knutson, 2000). It is also considered the most powerful way to physiologic interpretation in healthy people (Lehman & Mcgill, 1999). The protocol used to EMG normalization for muscles biceps brachii (BB), triceps brachii (TB), Extensor carpi radialis (ECR) was performed as Chow et al. (1999) and for anterior and posterior deltoid as Rota et al., (2013). For Muscle coordination in five selected muscles of the dominant upper arm the muscle activity was monitored using surface electrodes (TrignoTM Wireless System, Delsys, Inc. 2048Hz; interelectrode distance = 1cm; Silver. The muscle activity was recorded in the 5 above-mentioned muscles. The electrode placement follow the SENIAM recommendation procedures to avoid EMG limitations (Hermens et al., 2000). Skin surface was shaved and clean with cotton alcohol. Participants were placed in the starting posture to determine and mark the proper location of the sensors on the muscle before placing EMG surface electrodes. EMG sensors were placed on the muscle belly aligned with the muscle fibres direction and fixed to the skin with double-sided tape and reinforced with tape around the sensor. A connection test was performed to verify if the EMG signal is reliable and if the electrodes have been placed properly, these procedures were followed by the EMG normalization in amplitude. The EMG signals were recorded using the Qualisys Track Manager software and exported to CSV format. The raw signal were processed in the Delsys EMGworks Analysis software throughout an Amplitude Analysis performing a RMS and a normalization against a isometric maximal voluntary contractions (IMVC).

**RESULTS:** Figure 2 and 3 displays the mean and standard deviation of the EMG amplitude between a forehand drive performed in a quasi-static stance (with both feet on the ground at the impact) and with a dynamic stance (with both feet in the air at the impact) and the ball velocity between both techniques. The EMG normalized muscle activity was higher in most of the selected muscles when the participant performed the forehand drive with both feet on the ground except for the TB. The higher velocity was present when the participant performed the forehand drive with the feet on the ground in the CC direction.



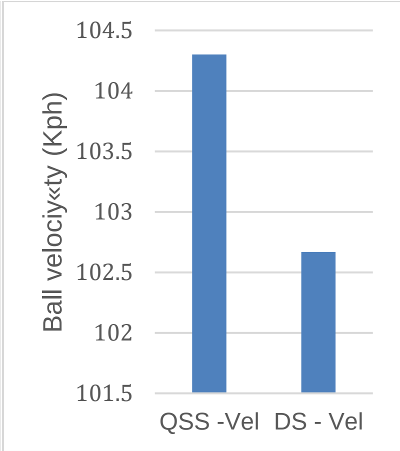




**Figure 2: Mean ± SD values for anterior deltoid (AD), posterior deltoid (PD), biceps brachii (BB), triceps brachii (TB), extensor carpi radialis (ECR) normalized activities for a forehand drive performed with both feet on the ground at impact (QSS) played at the cross-court direction and a forehand drive with the feet off the ground at the impact (DS) played at the inside-out direction. Figure 3 - Ball velocity between both stances.**

**DISCUSSION:** The purpose of this study was to compare the EMG activity of five selected muscles of the upper limb between two different forehand drives stances, one in a quasi-static stance and one in dynamic stance and ball velocity to identify which of the stances present higher muscle activity. Our preliminary results show that the QSS presented slightly higher ball velocity compared with the DS forehand drive 104.2 (5.1) vs 102.5 (6.5) kph). The EMG normalized activities for most of the selected muscles (AD, PD, BB, TB and ECR) presented higher activity in the QSS with exception of the TB. The muscles with higher activity during the acceleration phase were the ECR and the one with lower activation were the TB.
Similar results were presented in a previous study comparing a forehand drive in young tennis players between a flat and a top spin forehand drive, presenting similar values of EMG normalized activity for the BB (30-40%) and TB (10-12%) muscles. We can consider that the muscles AD and PD muscles present an important role in this technique, showing an activity between 60 to 80% of the IMVC. These activities present a lower value for the PD, BB and TB, showing that tennis coaches and all tennis professionals should be aware to develop proper injury prevention programs to the shoulder complex. The proximal-to-distal sequential muscle activity described by Rouffet et al., (2009) was not analysed in this preliminary study, although we can consider the higher EMG muscle activity in the more proximal muscles of the body as a key role to for injury prevention and higher performance.
The understanding of this phenomenon of muscle activity in tennis forehand drive could be also complemented with the study of the moments of force in these techniques as the study of Bahamonde & Knudson, (2003) that compared the moments of forces of the upper limb between the close and the open stance.

**CONCLUSION:** This study compared two stance technique used by one experienced tennis player in a tennis forehand drive. Our results suggest that the participant present a high muscle activation of the upper limb when perform this technique with their feet on the ground. It was also demonstrated a higher ball velocity with both feet on the ground at the impact. The results may suggest a smaller use of the kinetic chain when the players stand with the feet on the ground, specially in attack situations, thus, showing the need of a higher muscle activation. These results present value information for tennis professionals to a better understand of these techniques and to make a better decision during the coaching programs.

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