# ELECTROMYOGRAPHIC CORRELATES OF ROBOTIC LAPAROSCOPIC TRAINING

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## INTRODUCTION

Laparoscopy, a form of minimally invasive surgery (MIS), has revolutionized the treatment of abdominal pathologies. The advent of robotic surgical systems, such as the da Vinci™ Surgical System (dVSS), have further improved MIS by adding three-dimensional viewing [1] and increasing dexterity [2]. However, it is necessary to train and evaluate surgeons on the usage of the robotic system. The current means of evaluating surgical performance, while using a robotic surgical system, are limited to task completion time and number of errors [2, 3] or subjective evaluations. To our knowledge, no studies have examined physiological measures of the surgeons during performance of robotic surgical techniques. Especially, how training affects such physiological measures is unknown. This study seeks to determine how physiological measures, in the form of electromyography, change during training with dVSS.

## METHODS

Fifteen right-handed novice dVSS users performed and/or practiced three tasks: bimanual carrying (BC), needle passing (NP), and suture tying (ST). BC required simultaneously picking up two rubber pieces and placing them 50 mm away. NP required passing a 26 mm surgical needle through 6 holes in a latex tube. ST required tying three intracorporeal knots with a surgical suture. All tasks mimicked actual laparoscopic tasks that require significant bimanual coordination. Subjects were randomly assigned to either a training (T) or a control (C) group. The experiment was performed over a period of four weeks and consisted of one pre-training test (PRE), 6 training sessions, and one post-training test (POST). Surface electromyography (EMG) was recorded (1000Hz) from 4 muscles: flexor carpi radialis (FCR), extensor digitorum (ED), biceps brachii (BB), and triceps brachii (TB). Frequency power spectrums for each muscle were calculated using Fast Fourier Transforms. Median frequency and bandwidth were compared using a mixed two-factor (group by testing session) ANOVA for each muscle and for each task.

## RESULTS AND DISCUSSION

Median frequency was larger for POST for three muscles (FCR, BB, and TB) during the BC task and for one muscle (FCR) during the ST task (Figure 1). This increase was independent of group. This is not surprising considering that our previous work has found that significant decreases in task completion time are possible even after one training session. Furthermore, the increase in median frequency may be due to a reduction in muscle fatigue, since it has been shown that decreases in EMG frequency are associated with muscle fatigue [4]. It was also found that when a significant difference in median frequency or bandwidth was found, it occurred in muscles that would predominately be used for the given task.

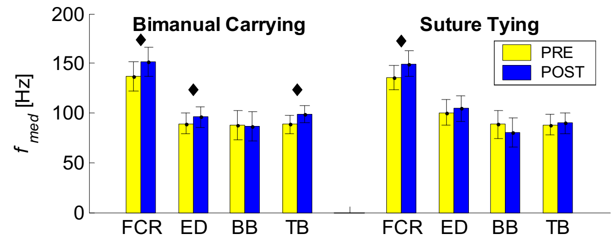


**Figure 1:** EMG Median Frequency grouped by PRE/POST training for Bimanual Carrying and Suture Tying tasks. A diamond indicates significance ($p<0.05$) between PRE and POST training.

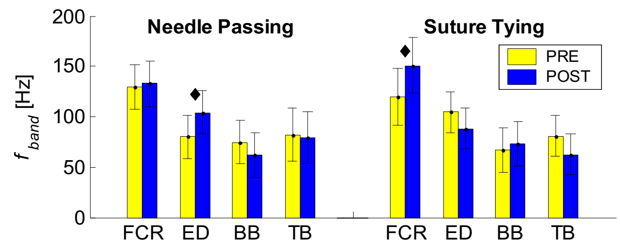


**Figure 2:** EMG Bandwidth grouped by PRE/POST training for Needle Passing and Suture Tying tasks. A diamond indicates significance ($p<0.05$) between PRE and POST training.

During the BC task, median frequency increased for the muscles used for grasping (FCR) and arm movements (BB and TB). Likewise, the median frequency for the FCR increased POST-training during the ST task, a grasping intensive task. The EMG frequency content is also directly related to the conduction velocities of recruited motor units [5], i.e., the types of motor fibers that are recruited. Therefore, frequency bandwidth may be a representation of the range of motor units that are recruited. For the more complex tasks (NP and ST), we found that POST bandwidth increased for the muscles that are required to perform the respective tasks (ED for NP, FCR and BB for ST; Figure 2). It is likely that different motor units are recruited during different phases of the task depending on the complexity of each phase. In conclusion, an evaluation of the physiological demands of robotic laparoscopic surgery can provide us with a meaningful way to quantify performance and skill acquisition.

## REFERENCES

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