Electromyography and Velocity Analysis of Rock Climbing Fatigue

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Spring 2018

Abstract

This experiment looks into variables that potentially affect fatigue and performance for expert and inexperienced rock climbers. Trials were carried out by conducting electromyographies on subjects performing pull-ups before and after climbing a set of three routes. The subjects were tracked while climbing one of the routes and also during both sets of pull-ups. The data was then analyzed for trends between the two groups.

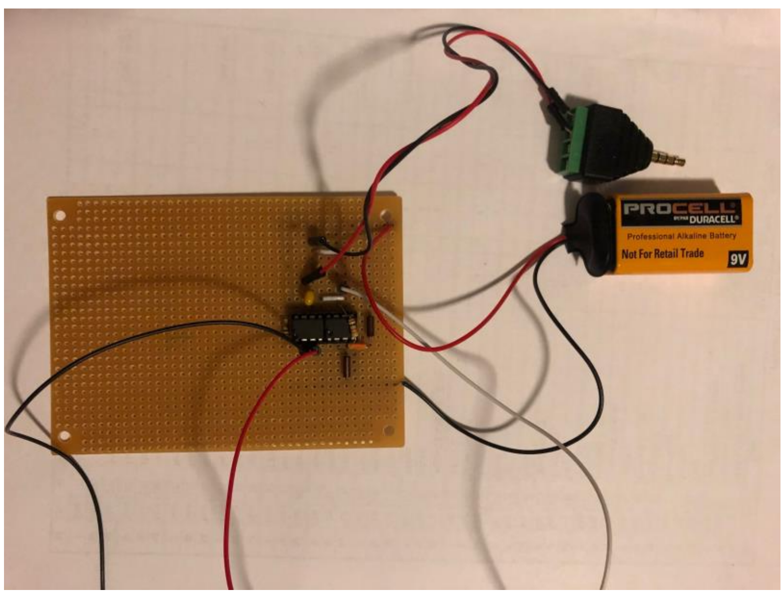
Introduction

Rock climbing is likely able to cause considerable changes to the human body due to its strenuous requirements. Through many steps of revision, our ultimate question was narrowed down to: What physiological and biomechanical changes occur when becoming an expert climber? One aspect of our experiment, which was tracking each subject as he or she climbed a boulder route, would lead us to analyze if advanced climbers adapt their hand, feet, and torso placement for the most advantageous climbing method. This would be a biomechanical change from standard human behavior, as humans have evolved away from animals that travel primarily through climbing. Our prediction was that expert climbers adjust their body placement while climbing in a way that keeps their center-of-mass the most stable.

Electromyographies measure the potential difference within a muscle. Previously, EMGs have been used to help detect neuromuscular abnormalities. In our experiment, however, we used EMGs to measure the difference in electrical activity before and after climbing. We made the assumption that fatigue was indicated by a decrease in electrical activity measured. Our hypothesis was that expert climbers would experience less fatigue after climbing than the subjects with no experience. We predicted this thinking that rock climbing experience would decrease the amount of energy required to climb.

Methods

For our preliminary trials, we gathered 5 inexperienced and 5 expert climbers and performed tests at the Campus Recreation Center at Georgia Tech. We defined an expert climber as someone who has climbed, on average, one or more times each week for more than 6 months. We built a circuit on a breadboard and used a headphone jack and our phones to take the electromyography data. We placed sticky electrode pads above and below what we estimated to be each subject's right bicep, and then we clipped the pads to our circuit. To ensure consistency, the subjects kept the same pads on their arms during their climb, so we could measure the exact same location afterwards as we did prior. An EMG was recorded during subject doing a single pull-up before climbing and then after climbing. The routes we had them climb were boulder routes subjectively rated by the staff as beginner routes. Each subject climbed the three chosen routes between the EMG tests. We had difficulty with the wires falling out of the breadboard, so prior to our real experiment, we soldered the wires to a prototype board.



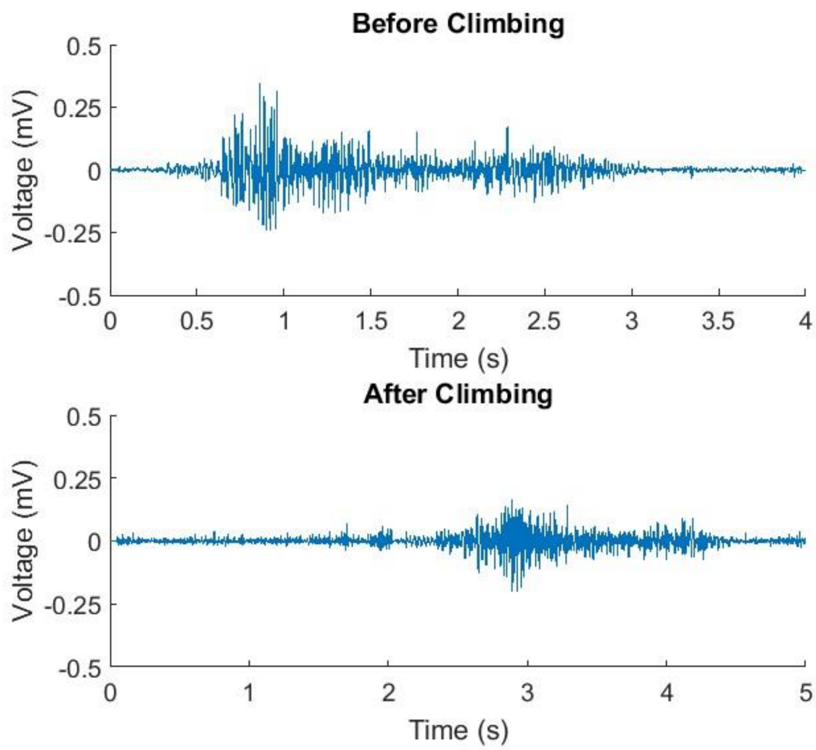
Pictured above: The circuit we used to collect data.

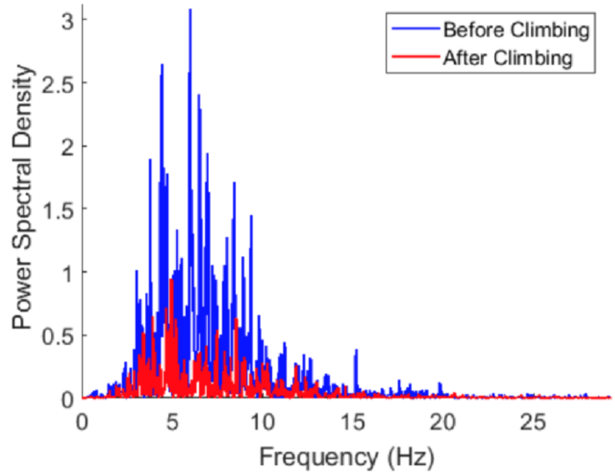
For our official trials, our test subjects were a male and female expert climber and a male and female unexperienced climber. Little changed with our method of collecting EMG data, but we took additional data besides that. We taped a piece of paper with a circle on it to the backs of each subject and video recorded their pull-ups. The paper was taped to what we would estimate their centers of mass being. We also recorded each subject climbing the first of the three boulder routes we decided to use. This was to track the changes in their centers of mass, not only while performing pull-ups, but also while climbing.

With the EMG data we collected, we then used MATLAB to calculate a Fourier analysis on each of the recordings. From that, power spectral densities were also calculated in MATLAB.

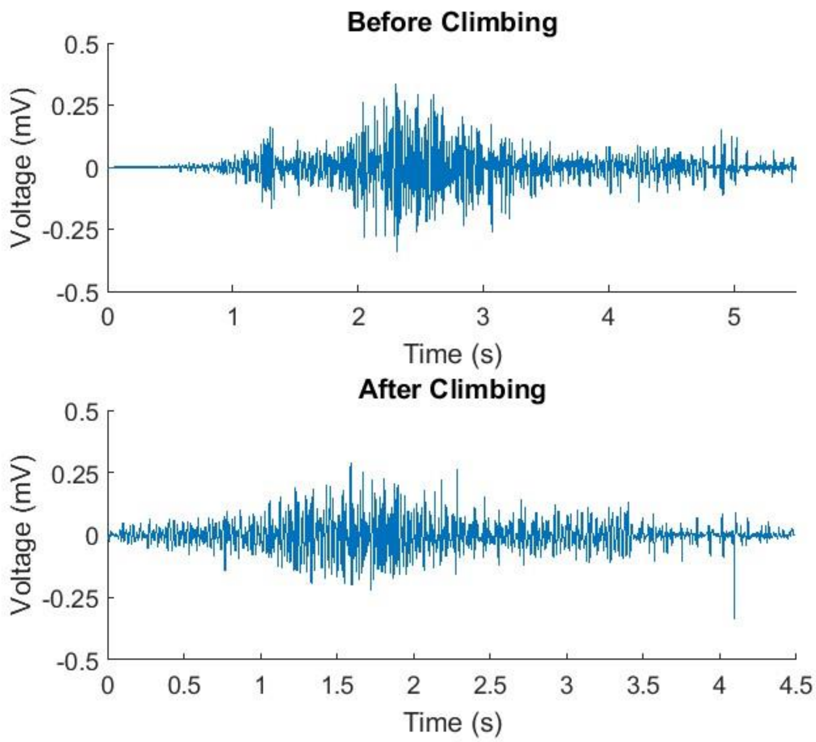
Results

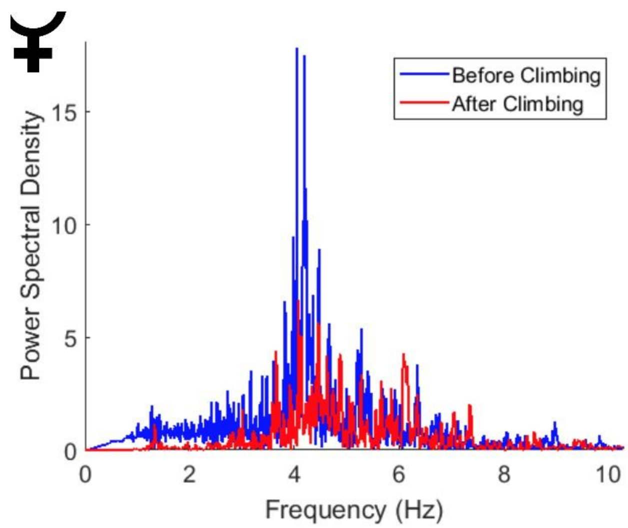
Electromyography potential graph and power spectrum of male expert climber:



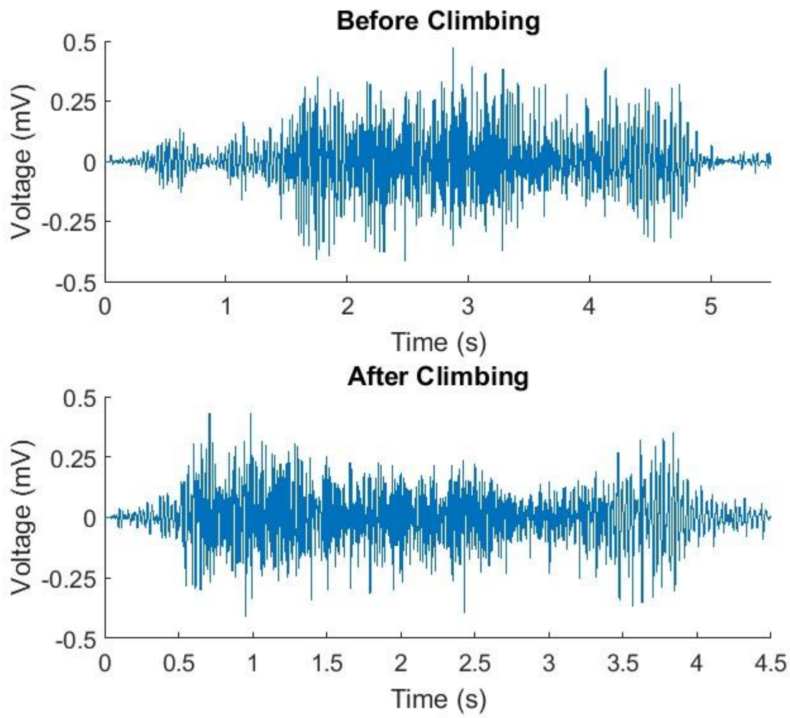


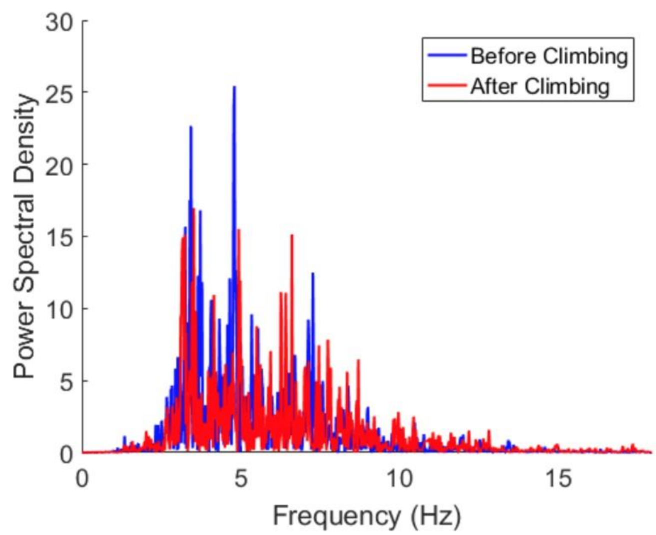
Female expert climber:



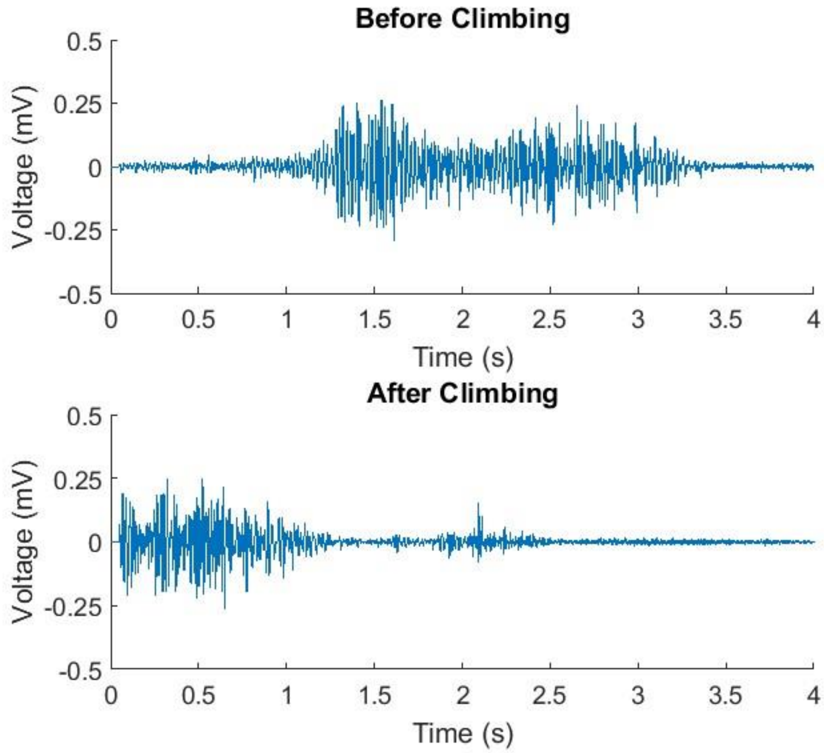


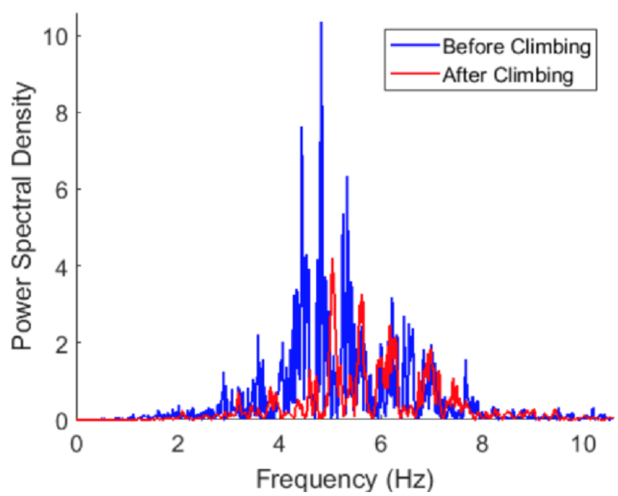
Male inexperienced:





Female inexperienced:





Percent Reduction in Muscle Activity (with Standard Deviation)

	Expert	Inexperienced
Male	67.25% (0.22)	55.08% (0.60)
Female	65.35% (0.28)	24.49% (0.61)

I was unfortunately unable to access the videos recorded of the subjects climbing. The velocities of the pull-ups were still calculated.

Velocity of Pull-up

	Before	After
Male, expert	0.507 m/s	0.763 m/s
Female, expert	0.269 m/s	0.292 m/s
Male, inexperienced	0.215 m/s	0.162 m/s
Female, inexperienced	0.019m/s	0.095 m/s

Discussion

The results we obtained from the experiment are mixed in supporting our hypothesis. Regarding the electromyography data, our results are the opposite of our hypothesis. The expert climbers had a greater reduction in electrical activity in their bicep after climbing than inexperienced climbers. This would suggest that a decrease in fatigue due to climbing is not a result of becoming an expert climber. However, a similar study using EMGs was published by Dr. Matt Parr at Saint Mary's University in June of 2017 (Parr, 2017). They gathered 17 rugby players and measured the electrical activity of their gluteus muscles before and after performing an unspecified warm-up exercise. They found that the electrical activity of their gluteus muscles actually decreased after a warm-up, which opposed their hypothesis just as our results opposed ours. Their explanation for the results was that the warm-up caused a re-potentiation of the muscle activity. The warm-up allowed the glutes to recruit the assistance of surrounding muscles like the hamstrings. Our expert climbers reported that the three beginner-ranked routes we assigned them to climb were not strenuous, but rather a warm-up for them. The decrease in their electromyographies could have been due to their bicep muscles recruiting the assistance of triceps and extensor muscles. This could mean that climbing did change their physiology when they became experienced climbers, by training their bicep muscles to redistribute electrical activity to be advantageous for climbing. However, due to our small sample size, a conclusion cannot begin to be drawn.

For the velocity data, the possibility that the expert climbers experienced a warm-up is supported because both expert subjects had an increase of pull-up velocity after climbing. The female inexperienced climber shows an increase of velocity after climbing, but it is difficult to attribute that to being a warm-up because the subject was unable to actually complete a full pullup. The center-of-mass tracking from each subject climbing a boulder route appeared to indicate that the expert climbers' center-of-mass varied less while climbing. This would support our hypothesis that climbing experienced changed the biomechanics of human movement. However, it is difficult to provide a full analysis due to not having complete access to the data.

A better method of testing our hypothesis could be to perform individual case-studies of people learning how to climb. Similar tests could be performed before any experience, and then after 6 months of experience. Then, it would be easier to compare initial and final differences. Furthermore, the data could have been taken more carefully. We did not instruct a specific way for each of the subjects to perform a pull-up, which could have affected our results. Additionally, the EMG was very sensitive, so it is difficult to get truly reliable data with a hand-built one. Overall, we discovered an interesting relationship between warming-up and climbers. It still may be suggested that the decrease in muscle activity for the expert climbers was actually an indication of their bodies' adaptations for climbing. The center-of-mass data was supportive of the climbers altering their biomechanics. Further studies could be conducted with more test subjects and more stable conditions in order to produce better results.

References

Parr M, Price PD, Cleather DJ Effect of a gluteal activation warm-up on explosive exercise performance *BMJ Open Sport & Exercise Medicine* 2017;**3:**e000245. doi: 10.1136/bmjsem-2017-000245