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Weight Lifting Affects the EMG Activity of the Flexors and Extensors of the Legs

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ABSTRACT

Athletes work out to become stronger and more flexible; these are two variables that can place their skill level over that of their competitor. By lifting weights athletes tear small muscle fibers that then repair themselves later, post workout, allowing them to grow, increase muscle capacity, and become stronger. The purpose of this study was to compare the Electromyography (EMG) activity of the flexors and extensors of the legs of female collegiate softball players before and after an 8-week weightlifting program, while the athletes also participate in daily practices, cardio, and games. Nineteen players from the McPherson College softball team completed the study. EMG measurements were taken on three separate dates while each subject did a series of three body squats. EMG absolute integrals and maximum peak data from the Gluteus Maximus, Biceps Femoris, Vastus Lateralis, and Vastus Medialis were compared from the first initial squat before participating in exercise and after weight lifting on a specified program for eight weeks. After analyzing the data, a significant difference was found in overall muscle activity, maximum peaks, and strength gain over the eight week time period. EMG absolute integral was found to be significantly lower in the anterior and posterior muscles of the right leg (Anterior: p=1.20824E-09; Posterior: p=5.1024E-09) after the eight week program. Maximum peak values were found to be significantly higher in the anterior and posterior muscles of the right leg (Anterior: p=1.03608E-06; Posterior: p=5.92521E-05) after the eight week program. Strength gain in back squat was also found to be significantly higher (p=3.2852E-07) after the eight week program. With the assigned weight program, the subjects had less muscle activity while gaining leg strength by the end of the study.

Keywords: *electromyography, muscle activity, gluteus maximus, biceps femoris, vastus lateralis, vastus medialis*

INTRODUCTION

Participating in a weight lifting program can have many benefits including: prevention of injury, strength gain, increased flexibility, and many others. This is why many athletes ranging from middle school to professionals lift weights. There are also different kinds of lifts, auxiliary and Olympic. Auxiliary lifts tend to focus on one individual muscle group at a time while Olympic lifts use a combination of different muscle groups. Many coaches believe that weight lifting can be the key to making their team excel. However, they are unaware as to whether or not the lifts that they have their athletes doing is benefitting them as much as they hope it to be.

One way to look at the effectiveness of a workout is to observe muscle activity, you can do this by using an EMG, or an Electromyogram. An EMG is used to measure muscle activity of different muscles in the body and can show you what muscles are active in whatever activity you are doing. EMG amplitude is known to be used as a global measure of motor unit activity during muscle action being performed (McCarthy 2002). The amplitude can also show you characteristics of tension in a muscle which can be very valuable when comparing different exercises or different athletic positions. It has also been said that an EMG is currently the most practical way of assessing the extent to which a muscle is working (Stastny 2015). This means that the EMG can also see how hard a muscle works with a certain amount of load. The EMG will be able to show how much activation weight lifters will gain or possibly lose over the course of this experiment. Strength gain in the athletes will also have to be measured to determine strength changes as muscle activation is changing, and to see if the two are related. It has been shown in other experiments that exercises that produce large muscle activations also lead to superior muscle adaptations (Häkkinen 1998).

Multiple literature sources have shown that the most common muscles used to measure the legs are the Vastus Lateralis, Vastus Medialis, Biceps Femoris, and the Gluteus Maximus (Häkkinen 1998, Mero 1994, Roelants 2006). Studies show that when doing both strength and endurance training at the same time there are increases in thigh extensor and flexor/adductor muscle EMG activity (McCarthy 2002). In one such study, 30 year old males that underwent testing under conditions above for ten weeks showed significant EMG activity gain for muscles tested; this will help when the subjects are tested for the same duration of time while doing the same kind of workouts. High resistance training with high weight has been shown to cause greater increases in muscle strength when compared to low resistance training (Nóbrega 2016). This workout type mirrors what the McPherson Softball team does.

When testing subjects, it has been shown that when doing a normal two legged squat it is easier to see the

overall mean peaks in the quadriceps and when comparing the quadriceps and hamstring muscles EMG activity. The main focus of this study was on the EMG activity of the Gluteus Maximus and Biceps Femoris, two muscles in which I will be focusing on (McCurdy 2010). Squats are also one of the most commonly used lifts to assess overall lower body strength and are said to be one of the most effective exercises to enhance overall athletic performance (Zweifel 2015).I believe this shows that squats will allow an easy way to asses strength gain and muscle activity gains that occur from participating in the team workouts.

This research will be able to answer questions that all athletes have about their workouts. How effective are they? Are our workouts allowing us to continuously gain strength? Is every single person on the team getting results from doing the exact same workouts? Do we need to change aspects of our workouts so that they target specific muscles? What muscles are we targeting in our current workouts? Therefore in this study I will be testing the 15-20 subjects from the McPherson College softball team that have designated workouts and workout times. Subjects who consent, will lift three days a week and they will participate in cardio one day a week on top of practices and games. I will then take measurements of the leg muscles of the subjects three times, once before we start any of the workouts, once at the half way point (4 weeks later)and once after 8 weeks of workouts. After the testing is complete the strength gain and muscle activation will then be compared and analyzed to determine how affective the workouts were at increasing both strength and muscle activation.

MATERIALS AND METHODS

This study was conducted from September-December of 2018 at McPherson College. In the early weeks of September of 2018 the McPherson College softball team coaches made three workouts that consisted of 3 major Olympic lifts: squat, bench, and cleans, along with many different auxiliary lifts. These three workouts were each done once per week. The same workouts were done for eight consecutive weeks as the players increased their weight lifted while decreasing their reps lifted. The amount of weight lifted varied from player to player but the percentage of weight remained the same. The subjects recorded the amount of weight lifted for each lift that they performed every week.

Before the softball team began their workouts; they underwent individual tests on the Electromyogram. The Electromyogram was set up on the IWX/214 platform using accepted protocols and the software LabScribe was used on the computer to record the muscle activity. After setting up the software the Electromyogram cable setup was the next step to preparing the Electromyogram, which consisted of inserting the cables into the proper channels of the IWX machine. Then, the muscles of the right leg in which activity was examined, were located on the subject. These muscles were the Vastus Lateralis, Vastus Medialis, Biceps Femoris, and Gluteus Maximus, and an electrode was placed on each. A fifth electrode was then used as the ground and centered between the positions of the four recording electrodes. An alcohol swab was used to clean and scrub the areas where the electrodes were placed, the areas then air dried before the electrodes were attached. Next, the plastic disk from disposable electrodes were removed and applied to each of the scrubbed areas. Then, the recording lead wires were snapped onto the electrodes so that: the red “+1” lead is attached to the electrode on the Vastus Lateralis, the black “-1” lead is attached to the electrode on the Vastus Medialis, the white “+2” lead is attached to the electrode on the Gluteus Maximus, the brown “-2” lead is attached to the electrode on the Biceps Femoris, and the green “C” lead (the ground) is attached to the electrode in the center of all electrodes.

The Subject to be tested was then asked to stand shoulder width apart and instructed on what she would be doing during the test. During the recording the subject performed a controlled squat while exploding upward after hitting a 90 degree angle. They performed this five times in a row with a three second rest in between each squat. During the recordings a Mark Box was used to mark when the subject was standing neutral, flexing, and extending their legs. These marks then made it easier when going back and observing the muscle activity peaks. All recordings were then saved to a computer file labeled with the subjects name and the date they were tested.

The team then underwent a weights training program for eight weeks, doing their set weights program three days a week and conditioning once a week. After four weeks of training the team was tested a second time on the EMG and then they were tested one more time after the eight week program was complete.

Data was collected for the absolute integral, minimum peak, maximum peak, and weight lifted for back squat. This data was collected at each four week period. Statistical analysis focused on the before and after results, the mid study results were ignored to see an overall change from start to finish. A paired t-test was ran on the absolute integral and maximum peaks for the anterior and posterior muscles and then a paired t-test was also ran for the weight lifted during back squats. The significance was set at p= .05.

RESULTS

EMG activity showed similar results for both the

anterior and posterior muscles in the legs of the subjects. EMG absolute integral was found to be significantly lower in the anterior and posterior muscles of the right leg (Anterior: t= 1.734063592, df= 18, p= 1.20824E-09; Posterior: t= 1.734063592, df= 18, p= 5.1024E-09) after the eight week program. Maximum peak values were found to be significantly higher in the anterior and posterior muscles of the right leg (Anterior: t=1.734063592, df=18, p=1.03608E-06; Posterior: t=1.734063592, df=18, p=5.92521E-05) after the eight week program. Strength gain in back squat was also found to be significantly higher (t=1.734063592, df=18, p=3.2852E-07) after the eight week program.

DISCUSSION

The combination of auxiliary lifts and Olympic lifts in a weight training program that consists of lifting 3 days a week while also participating in conditioning and practices led to strength gain but also led to a decrease in the absolute integral of the flexors and extensors of the legs in a collegiate women's softball team. Gains in strength were seen through the amount of weight the subjects could lift during back squat on the first day of lifting weights compared to the amount of weight that the subjects were lifting on back squat on the last day of weight lifting, at the end of eight weeks. After being tested on the EMG after the eighth week of lifting the absolute integral, which is the overall muscle activity seen during the squat, decreased from week one. However, the highest peak that was achieved during the squat, the max peak, increased from week one.

It has been shown in previous studies that when doing both strength and endurance training at the same time there are increases in thigh extensor and flexor/adductor muscle EMG activity (McCarthy 2002). However, on this study that was not seen. I do believe that even though the absolute integral decreased over time that this is could still be an effective weight lifting program for this set of subjects. All subjects gained strength over the eight weeks and were able to back squat heavier amounts of weight. I believe that if some changes are made to this same experiment that we could see a difference in the change in absolute integral.

Due to space and equipment the testing was done in a lab. If the testing had been done in a weight room, the subjects could have been doing a back squat while being connected to the EMG instead of simply doing a body weight squat. An EMG shows how hard a given muscle is working at a given time, doing a weighted squat could have made the muscles work harder, causing them to use more force and possibly showing higher activity on the EMG. With that being said, I think that doing a body weight squat may have become easier after the weight lifting program and the muscles did not have to work as hard during the squat, leading to lower muscle activity on the EMG. The other possibility is that the weight workout did not help the subjects reach their full potential, and could have actually decreased the subjects' muscle activity. This could have been a case in which the subjects were worked too hard in which their muscles were unable to recover correctly and resulted in decreased muscle activity at the end of the study.

The test also showed an increase in the maximum peaks of the EMG activity even though the absolute integral was decreasing. Muscle tension is formed by the force at which a muscle is contracting during a specific movement. I believe that these maximum peaks could be when the maximum tension was built up in the muscle while it was contracting during the squat. This would show that the athletes were able to create more force after the eight week lifting program. However, more research would need to be done in order to conclude if this was the true reason as to why the peaks increased.

Overall, this study was unable to prove that strength and endurance training increases EMG activity in the flexors and extensors of the legs in female collegiate softball players while using their current weight lifting program.

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