UNIVERSITY OF WISCONSIN-LA CROSSE

Graduate Studies

ELECTROMYOGRAPHICAL ANALYSIS OF THE PECTORALIS MAJOR MUSCLE DURING VARIOUS CHEST EXERCISES

A Manuscript Style Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of Master of Science in Clinical Exercise Physiology

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College of Science and Health
Clinical Exercise Physiology

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ELECTROMYOGRAPHICAL ANYALYSIS OF THE PECTORALIS MAJOR

MUSCLE DURING VARIOUS CHEST EXERCISES

By Whitnee Schanke

We recommend acceptance of this thesis in partial fulfillment of the candidate's requirements for the degree of Master of Science in Clinical Exercise Physiology

The candidate has completed the oral defense of the thesis.

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ABSTRACT

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The purpose of this study was to use electromyography to determine which chest exercise(s) elicited the most muscle activation of the pectoralis major muscle. Subjects for this study were 14 males, 19-30 years of age. The first day of testing a 1RM was determined for the exercises: barbell bench press, bent-forward cable crossovers, seated chest press, incline dumbbell flys, and peck deck machine. Parallel dips, push-ups, suspended push-ups, and Swiss ball push-ups were omitted, because body weight was used for resistance. On the second day of testing, subjects performed five repetitions of each exercise, using 80% of their 1 RM. After each exercise, the subjects were asked their RPE. When analyzing the EMG data, each exercise was compared to the barbell bench press. The analysis showed no significant difference between the peck deck machine, bent-forward cable crossovers, and the barbell bench press. This correlated with the results of the subjects' RPE, except for the inclined dumbbell flys. The remaining exercises elicited significantly lower muscle activation and RPE values. Therefore, it was concluded that the barbell bench press, the peck deck, and bent-forward cable crossovers could be used interchangeably to elicit the greatest muscle activation of the pectoralis major muscle.

ACKNOWLEDGEMENTS

I would like to begin by thanking my family for being my number one support system. You guys have been there through the best and worst times for me. I certainly wouldn't be where I am today without you. I hope you all know how much I love and appreciate each of you.

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INTRODUCTION

The American College of Sport Medicine recommends that in addition to aerobic exercise, individuals should perform resistance training 2-3 days per week (2009). There are numerous health benefits of resistance training. Some of these benefits include: increased blood glucose utilization, reduced resting blood pressure, improved lipids, increased bone mineral density, improved body composition, and reduced risk of metabolic syndrome, cardiovascular disease, and all-cause mortality (Westcott, 2009). Despite the benefits, only 10% of people currently lift weights on a regular basis (Leepson, 1992). One of the most commonly used excuses for not making physical activity and resistance training a part of a person's day is a lack of time (Cantwell, 2004). By determining which exercises are the most effective for achieving benefits, it may be possible to minimize the amount of time needed to do resistance training. This, in turn, may improve exercise adherence to resistance training.

One of the body parts that weight lifters (especially men) often focus on while lifting is the chest. The most common lift performed to work on the chest is the standard barbell bench press (Welsch et al., 2005). However, that does not necessarily mean this lift is the most effective for the pectoralis major muscle. One way to determine the effectiveness of any exercise is through the use of electromyography (EMG). EMG is a technique used for evaluating muscle activation. Specifically, EMG amplitude is reflective of motor unit recruitment, firing rate, and synchronization (Basmajian and DeLuca, 1985).

There have been past studies using EMG during chest exercises, but none have focused solely on the pectoralis major muscle. For example, Welsch et al. (2005) compared three different upper-body lifts, while measuring the EMG activity of the pectoralis major and anterior deltoid. The three lifts they compared were the barbell bench press, dumbbell bench press, and dumbbell flys. For the pectoralis major, there were no significant differences in EMG activity between the three exercises. It was found, however, that the pectoralis major did have a longer activation time during the barbell bench press. Another study, performed by Cogley et al. (2005), used EMG measurements to test the pectoralis major and triceps brachii activity during push-ups, while using three different base positions for the hands: shoulder width base, wide base, and narrow base. The narrow base recruited the greatest muscle activity for the pectoralis major.

Personal training currently uses a wide variety of chest exercises. There is no consensus or scientific data to support which chest exercise is the best. Therefore, the purpose of this study was to use EMG analysis to determine which chest exercise results in the highest level of muscle activation.

METHODS

Subjects

Fourteen male volunteers were recruited for this study. The subjects were apparently healthy University of Wisconsin-La Crosse students, between the ages of 19-30 years of age. Each subject had a background in resistance training. This was to help ensure that subjects had proper lifting techniques, which reduced the risk for potential injuries. This was important because a great number of chest injuries are due to poor lifting technique (Schwarzenegger, 1985). The University of Wisconsin-La Crosse Institutional Review Board for the Protection of Human Subjects approved this study prior to testing. Also, before the subjects began the study, each provided written informed consent.

Exercises

Nine different chest exercises were performed during this study. The goal was to determine which exercise(s) activates the pectoralis major muscle most effectively. The most common lift performed to work the chest is the standard barbell bench press (Welsch et. al, 2005). Previous studies have shown this exercise to be the most effective in activating the pectoralis major (Welsch et al., 2005 & Saeterbakken et al., 2011). EMG analysis was used to compare the muscle activation between the barbell bench press and the other eight exercises. Respectively, are explanations of each lift that was performed during this study (Schwarzenegger, 1985).

1. Barbell Bench Press: This exercise was done with the subject laying flat on a bench in the supine position. He positioned his hands slightly wider than shoulder width apart on the bar. Once the bar was lifted off the rack, he held the bar directly above the center of the chest, with arms fully extended. This was be the starting position. He then slowly lowered the bar down until it touched his chest. When the bar touched the chest, the subject lifted the bar off his chest at a slow rate and returned to the starting position. The subject was instructed to keep his feet flat on the floor and his back flat on the bench throughout the exercise (See Figure 1).

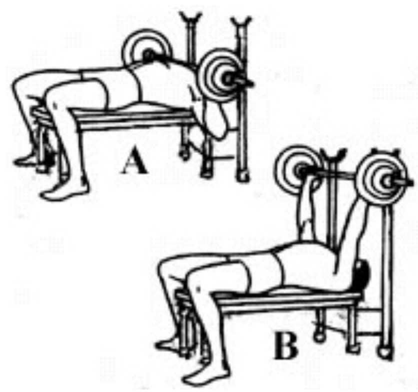

Figure 1. Barbell Bench Press

2. Bent-Forward Cable Crossovers: Using a double pulley system, the subject stood between two cable pulleys. He gripped each handle, slightly bent forward at the waist, and brought the handles to their corresponding sides. At this point, his arms were fully extended at chest height and parallel to the floor. This was the starting position. Next, he brought his hands together at chest height while his arms remained almost fully extended. When the hands met in the center, they slightly crossed one another. Then, he slowly returned his hands back to the starting position, making sure the arms remain extended and his body slightly leaned forward (See Figure 2).

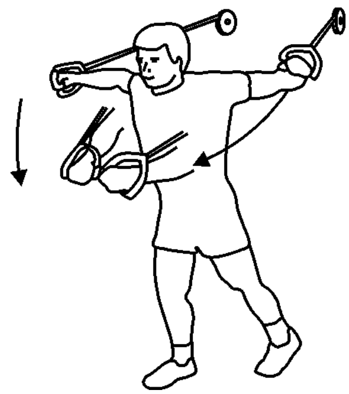

Figure 2. Bent-Forward Cable Crossovers

3. Seated Chest Press Machine: Before beginning this exercise, the seat was adjusted so that when the subject sat down, the handles were at the same level as the center of subject's chest. The subject gripped each handle with his palms facing away and elbows pointed outward. This was the starting position. Next, he pushed the handles forward, extending the arms. The subject was instructed to make sure his elbows did not lock when extended. He then brought the handles towards him until he reached the starting position. Throughout the exercise, the subject sat with his back flat against the back pad of the seat and his feet remained flat on the floor (See Figure 3).

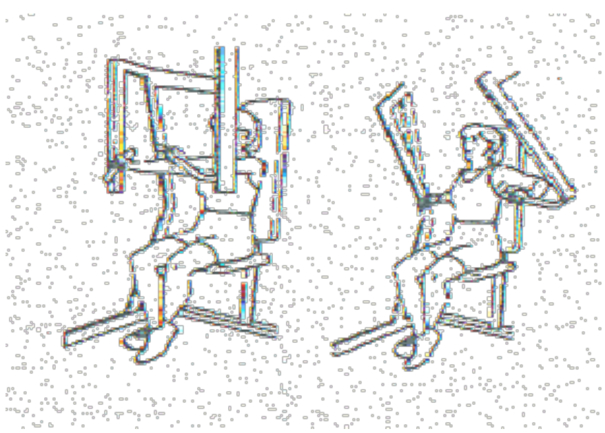

Figure 3. Seated Chest Press Machine

4. Incline Dumbbell Flys: The subject began by lying on a bench inclined to 30 degrees, while holding a dumbbell in each hand. The dumbbells were held directly above him so they lined up with the top of the chest. His palms were facing each other and his arms were extended, with only a slight bend at the elbow. This was the starting position. Next, he slowly lowered his arms until the weights were just below the level of the bench; at this point, his palms were facing upward. He then slowly began to bring his arms back up to the starting position, in the reverse motion previously performed. Throughout the exercise, the subject's feet were flat on the floor and his back remained flat against the bench (See Figure 4).

Figure 4. Incline Dumbbell Flys

5. Parallel Dips: The subject was positioned between two parallel bars on a hanging dip machine. He gripped the bars with the palms facing downward. He lifted his legs, bent at the knees, and crossed his feet, which allowed his arms to support his body weight. The arms were almost fully extended, but the elbows were not locked. Next, he leaned forward and pushed his hips forward. This was the starting position. He began to slowly lower himself, until his elbows were at 90 degrees. He then slowly pushed himself back up, until he reached the starting position again (See Figure 5).

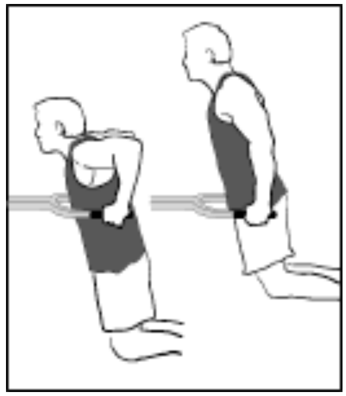

Figure 5. Parallel Dips

6. Peck Deck Machine: The seat was adjusted so the subject's feet were flat on the floor and his elbows were at shoulder level. The subject then placed his forearms on the pads located on the levers. This was the starting position. Then he slowly brought the levers towards one another until they were just about to touch. At this point, he reversed the motion and returned to the starting position (See Figure 6).

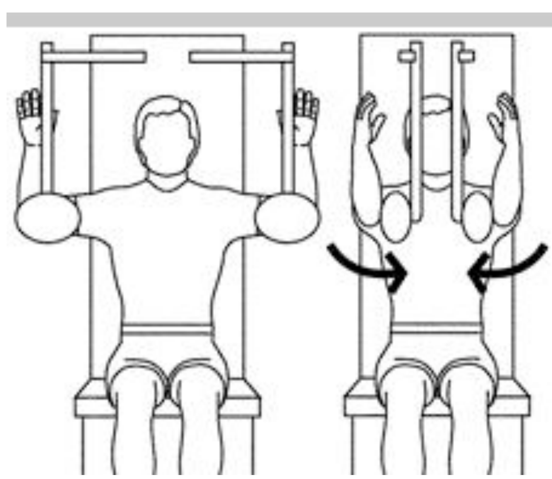

Figure 6. Peck Deck Machine

7. Standard Push-ups: The subject started by lying on the floor, face down. His hands were flat on the ground directly underneath his shoulders. He then lifted the rest of

his body off the ground. A two-inch ball was placed under the subject's chest to standardize the test. He was now in the starting position. He then slowly lowered himself downward until his chest touched the 2-inch ball. Once he touched the ball, he returned to the starting position by extending his arms. The subject was asked to keep his back flat and parallel to the floor throughout the exercise (See Figure 7).

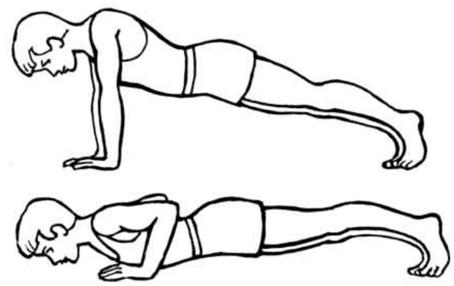

Figure 7. Standard Push-ups

8. Suspended Push-ups: The motion for this exercise was be the same method as a standard push-up, except the subject's starting position was different. There were two straps tied to a crossbar with handles on the end. Instead of having his hands placed on the floor, they were gripping the handles, which was approximately 12-inches from the ground (See Figure 8).

Figure 8. Suspended Push-ups

9. Swiss Ball Push-ups: The motion for this exercise was the same as for the standard push-up, except the subject starting position was different. The subject had his body

elevated by placing his feet on top of a 65-centimeter Swiss ball, rather than on the floor (See Figure 9).

Figure 9. Swiss Ball Push-ups

Testing

Subjects participated in two days of testing, with a minimum of 3 days of rest between each day. They were asked to not do any weight training for 48 hours prior to each test day. On the first day of testing, a one-repetition maximum (1 RM) was determined for the following exercises: barbell bench press, bent-forward cable crossovers, seated chest press, incline dumbbell flys, and peck deck. A 1 RM was not performed for parallel dips, push-ups, suspended push-ups, and Swiss ball push-ups because they used body weight for resistance. For the 1 RM testing, subjects warmed up by performing 10 repetitions using 50% of what they generally use during their workouts. Next, the weight was incrementally increased until a 1 RM was achieved for each exercise within 4-5 repetitions.

For the second day of testing, EMG electrodes were placed on the pectoralis major muscle per the recommendations of Cram and Kasman (1998). Specifically, a bipolar surface (1.0 cm center-to-center) electrode (BIOPAC Systems Inc., Santa Barbara, CA; 4mm silver/silver chloride) arrangement was placed horizontally approximately 2.5 cm medial from the right anterior axillary fold. The reference electrode was placed over the right clavicle (Figure 10). Interelectrode impedance was kept below 2000 Ω by shaving the area and by careful skin abrasion. The EMG signal was preamplified (gain 1000x) using a differential amplifier (BIOPAC Systems Inc., Santa Barbara, CA; bandwidth 10–500 Hz).

After the noise file was successfully completed, the subject performed a warm-up using the immovable bar. They did 5 repetitions at what was perceived as 50%, held each for 6 seconds, with 30 seconds of rest in between each repetition

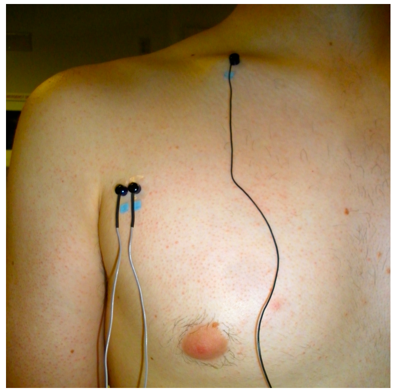

Figure 10. Electrode Placement

The subjects then performed five repetitions of each exercise. The exercises were performed in random order. For the lifts that did not use body weight, the subjects used 80% of their 1 RM as resistance. EMG was collected during the five repetitions of each exercise at 80% 1RM. After each exercise, a rating of perceived exertion (RPE) was taken, using a 0-10 Borg Scale (Figure 11). Five minutes of rest was given between each exercise to allow full recovery.

1 - 10 Borg Rating of Perceived Exertion Scale	
0	Rest
1	Really Easy
2	Easy
3	Moderate
4	Sort of Hard
5	Hard
6	
7	Really Hard
8	
9	Really, Really, Hard
10	Maximal: Just like my hardest race

Figure 11. Borg RPE Scale

Instrumentation and Data Collection

The raw EMG signals were digitized at 1000 Hz and stored in a personal computer for subsequent analyses. Muscle activation was analyzed using the second, third and forth bursts of the EMG. That is, the first and last of the five repetitions were not used. All signal processing was performed using custom programs written with Lab VIEW programming software (Version 2009, National Instruments, Austin, TX). The EMG signals were digitally band-pass filtered (fourth-order Butterworth) at 10–500 Hz. The EMG amplitude (microvolts root mean square [μVrms]) values were calculated for each trial. The EMG values (μVrms) were normalized to the standard barbell bench press for each exercise and reported as percents.

Statistical Analysis

A one-way repeated measures ANOVA was used to compare the mean values for normalized EMG (%). An alpha of $p \leq 0.05$ was considered statistically significant for all analyses. The data were analyzed using the IBM Statistical Package for the Social Sciences software (version 19.0; SPSS Inc., Chicago, IL).

RESULTS

Subjects for this study were 14 apparently healthy male students recruited from the University of Wisconsin-La Crosse. Each subject had previous experience in resistance training.

Table 1. Descriptive characteristics of subjects (N = 14).

	Mean ± SD	Range
Age (yrs)	23 ± 2.8	19-30
Height (in)	71 ± 3.2	67-78
Weight (lbs)	184 ± 20	148-225

Electromyography was used to measure total muscle activation from the pectoralis major muscle during both the concentric and eccentric phases of each exercise. Subjects performed five repetitions of each exercise. Data from the second, third and fourth repetitions were averaged to yield a value for each exercise. All data was represented as a percentage of the barbell bench press EMG value. Results of the analysis are presented in Table 2 and Figure 1, respectively.

This analysis shows that there was not a significant difference when comparing the peck deck machine or bent-forward cable crossovers to the muscle activation of the pectoralis major elicited during the barbell bench press. This correlates with the results of the subjects' rating of perceived exertion (RPE), with the exception of the inclined dumbbell flys. All of the other exercises elicited significantly lower muscle activation and RPE values than the barbell bench press.

Table 2. Average EMG and RPE for each exercise compared to the barbell bench press

Exercise	Average EMG	RPE
Barbell Bench Press	100	6.5 ± 1.98
Peck Deck Machine	98 ± 26.4	5.4 ± 2.13
Bent-Forward Cable Crossovers	93 ± 22.0	5.1 ± 1.60
Chest Press Machine	79 ± 22.4*	4.3 ± 2.30*
Inclined Dumbbell Flys	69 ± 30.5*	5.0 ± 1.50
Dips	69 ± 15.8*	2.9 ± 2.06*
Suspended Push-ups	63 ± 18.5*	3.6 ± 2.22*
Swissball Push-ups	61 ± 20.7*	2.3 ± 1.72*
Standard Push-ups	61 ± 20.6*	1.5 ± 1.15*

*Significantly lower than barbell bench press ($p < .05$)

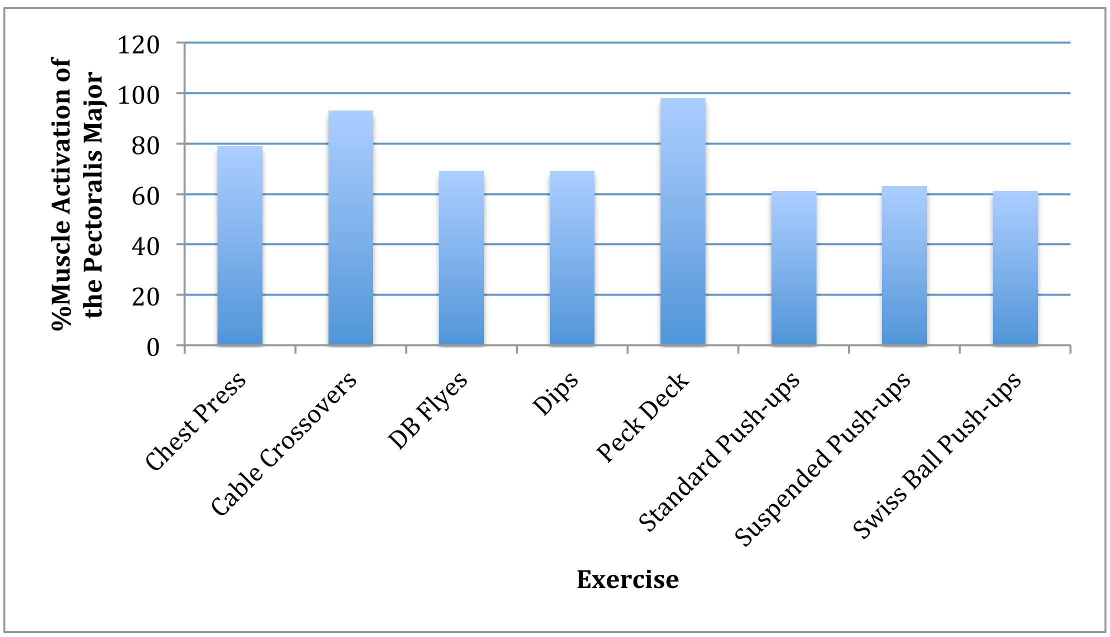

Figure 12. Muscle activation of the pectoralis major for eight different exercises in comparison to the standard barbell bench press, 100% represents muscle activation for the barbell bench press.

DISCUSSION

This purpose of this study was to use EMG to determine which chest exercise activates the pectoralis major muscle to the greatest degree. Therefore, this study compared nine different exercises that are generally used to strengthen the pectoralis major. This study found the pectoralis major to be activated the greatest during the barbell bench press. There was not a significant difference between the barbell bench press when compared to the peck deck machine or the bent-forward cable crossovers. It was therefore concluded that these chest exercises could be used interchangeably to train the pectoralis major.

For each lift, the subjects used approximately 80% of their 1RM, except for the three variations of push-ups and dips, as body weight was used for these exercises. The RPE data agreed with the muscle activation data, except for the inclined dumbbell flys, as this exercise had significantly lower muscle activation in comparison to the barbell bench press, but the RPE was not significantly different.

There have been various studies conducted comparing muscle activation with the use of EMG during various chest exercises. In 2005, Welsch and colleagues compared muscle activation of the pectoralis major during the barbell bench press, dumbbell bench press, and dumbbell flys. They found no significant differences in EMG levels between the three exercises. The barbell bench press did have a slightly greater activation of the pectoralis major muscles, however the difference was not statistically significant.

Also in 2005, Cogley et al. compared muscle activation of the pectoralis major and triceps brachii muscles during a push-up. They compared three base positions for the hands: shoulder width, wide, and narrow. They found that the narrow base push-up elicited the most muscle activation of the pectoralis major. In the current study, three variations of push-ups were investigated: standard, swiss ball, and suspended push-ups. During each of these exercises, a shoulder width base was used, and each exercise elicited similar muscle activation of the pectoralis major muscle. Yet, when compared to the barbell bench press, each of these variations had significantly lower muscle activation of the pectoralis major. It is possible that because only body weight is used during the push-up exercises, it is significantly lower because the body weight is not equivalent to 80% of the subjects' 1RM. Further investigating could be done taking this into account, and potentially adding weight to the subject while performing the different variations of push-ups.

More recently, Saeterbakken et al. (2011) compared muscle activation of the pectoralis major during a 1RM for the barbell bench press, dumbbell bench press, and the Smith Machine chest press. This study found that the barbell bench press and dumbbell bench press elicited more muscle activation of the pectoralis major than the Smith Machine chest press. Interestingly, Ristvedt (2005) conducted a study using EMG to determine which exercises activate the gluteal and hamstring muscles the greatest. Traditional squats had significantly greater muscle activation of the gluteus maximus muscle than horizontal leg press and vertical leg press machines. When comparing the results of these to studies to the current study, one may be able to conclude that when using machines, such as the chest press and leg press machines, there is going to be less muscle activation than when using free weights, such as the barbell bench press and the dumbbell chest press. This may be because the muscles are working to stabilize the subject as well.

Overall, nine different chest exercises were compared using EMG and RPE analyses. The barbell bench press, the peck deck machine, and bent-forward cable crossovers were found to be equally effective at activating the pectoralis major muscle. When looking at the RPE analysis, this data agreed with the EMG analysis, with the exception of the inclined dumbbell flys. Thus, the barbell bench press could be used interchangeably with the peck deck machine or bent-forward cable crossovers.

Practical Application

The practical application for the results of this study is that athletes and personal trainers can use these three lifts (barbell bench press, peck deck machine, and bent-forward cable crossovers) to train the pectoralis major muscle effectively and in a time-saving manner. If individuals see greater gains in less time, they are more likely to adhere to a strength-training exercise regimen.

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APPENDIX A

INFORMED CONSENT

INFORMED CONSENT

ELECTROMYOGRAPHIC ANALYSIS THE PECTORALIS MAJOR MUSCLE DURING VARIOUS CHEST EXERCISES

I, ____________________________, agree to participate in a research study conducted at the University of Wisconsin, La Crosse.

Purpose and Procedures

- The purpose of this study is to use electromyography (EMG) to determine which chest exercise results in the greatest muscle activation; hence, determining which exercise is the most effective for strengthening the pectoralis major.
- My participation in this study will require me to complete 2 testing sessions, requiring a total time commitment of approximately 3 hours.
    - On the first day, my one repetition maximum will be determined for 10 different chest exercises.
    - On the second day, I will wear surface electrodes on my chest so that muscle activity can be recorded.
- The testing will take place on the University of Wisconsin-La Crosse campus in the Mitchell Hall weight room.
- This study will be conducted under the direction of Whitnee Schanke, a graduate student in the Department of Exercise and Sport Science. She is working under the supervision of Dr. John Porcari, who is a Professor in the same department.

Potential Risks

- Fatigue and muscle soreness are potential risks related to participating in this study.
- There is the possibility to have skin irritation from the EMG electrodes.
- Throughout all testing sessions there will be individuals present who are trained in CPR and Advanced Cardiac Life Support.
- For healthy individuals, like myself, the risk of serious or life-threating complications (e.g. heart attack, stroke, death) are minimal during this study.

Potential Benefits

- Athletes, coaches and trainers will potentially benefit from this study by gaining knowledge about which chest exercises are the most effective.

Risks and Confidentiality

- I agree to participate in this study voluntarily.
- I have the right to withdraw from this study at any time, for any reason, without being penalized.
- All personal information collected during this study will be kept confidential. However, the research findings of this study may be published or presented using group data.

I have read all of the information above and understand the purpose of the study, what the procedures will include, what is expected of me, what potential risks are involved, as well as the benefits that may be associated with volunteering for this study.

If I have any questions I will freely contact the principal investigator, Whitnee Schanke at 608-393-3208, or her study advisor, Dr. John Porcari, 141 Mitchell Hall, 608-785-8684. Any questions in regards to the protection of human subjects can be directed to the Chair of the University of Wisconsin-La Crosse Institutional Review Board for the Protection of Human Subjects at 608-785-8124.

Subject: ___________________________ Date: _______________

Investigator: ________________________ Date: _______________

APPENDXIX B

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Resistance training should be performed a minimum of 2-3 days per week, along with aerobic exercise 5-7 days per week for a minimum of 30 minutes per day (ACSM, 2009). Because of a lack of motivation, and time, only 10% of people are actually meeting these requirements (Leepson, 1992). Looking at the factor of time, this is one of the most commonly used excuses to not exercise (Cantwell, 2004). By determining which exercises are the most efficient, time spent doing resistance training could be reduced, while potentially getting the same benefits. By using electromyography, exercises can be tested to determine which ones are activating desired muscles or muscle groups the greatest. This review of literature will discuss how EMG can help to determine which chest exercises are the most effective.

Basics of EMG

Electromyography is used to study the function of muscle through the analysis of electrical signals derived by the muscle (Basmajian and De Luca, 1985). The interest in EMG has significantly increased over the past six decades. In the early 1950's, only a limited amount of research was done with the use of EMG, now there are over 2,500 publications yearly (Kamen and Gabriel, 2010).

In order to understand EMG, it is important to understand certain components of the anatomy and physiology of muscles. Within the neuromuscular system there are motor units. Motor units are the basic unit of control and each is made up of a single motor neuron along with several muscle fibers. For example, limb muscles, generally have a single motor neuron with somewhere around 300 muscle fibers. Because of this, it is not possible to stimulate just one fiber, but rather a group of muscle fibers are activated by the motor unit (Kamen and Gabriel, 2010).

In order to measure the muscle activity, an amplifier is used. The amplifier should be as close to the leads as possible. For action potentials, the amplitude depends on the following: the muscle fiber's diameter, how far apart the active muscle fiber is from the detection site, and the electrode's filtering properties (Basmajian and De Luca, 1985).

EMG Electrodes

To measure EMG, testing electrodes are used. Ionic potentials created by the muscle can be converted to electronic potentials via electrodes. An amplifier can then measure these potentials (Kamen and Gabriel, 2010). There are two main types of electrodes used for EMG: surface and indwelling. Surface electrodes are placed on the surface of the skin over the muscle. Indwelling electrodes are inserted directly into the belly of the muscle (Kamen and Gabriel, 2010). There are advantages and disadvantages to each type.

Although surface electrodes can only be used on larger superficial muscles and can often have interference (cross talk) from adjacent muscles, they are convenient, easy to apply, and involve minimal discomfort to the subjects (Basmajian and De Luca, 1985). There are two types of surface electrodes, passive and active. Passive electrodes are thought of as "floating electrodes" given that only the unit is used, without any other electrical devices (Kamen and Gabriel, 2010). Active surface electrodes have become more common (Basmajian and De Luca, 1985). These electrodes use a preamplifier and transmit a greater EMG signal (Kamen and Gabriel, 2010). Both the passive and active surface electrodes are composed of conductive materials. The electric potential is processed by signal transduction, meaning that when a muscle is stimulated the electrodes are able to convert the electric potential to an electrical signal. This signal is created through wires to the amplifier (Kamen and Gabriel, 2010). It is also important to note that when using surface electrodes, the amount of fatty and skin tissues should be considered (Kamen and Gabriel, 2010).

Indwelling electrodes consist of two different types as well: needle and wire. Needle electrodes have the capability of revealing individual motor unit action potentials (MUAPs). It is also easier to improve the quality of the electrical signal because needle electrodes are easy to relocate (Basmajian and De Luca, 1985). These are most commonly used in the clinical setting. There are single wire and double wire electrodes. This type of electrode is best for revealing action potentials with less accessible tissue (Kamen and Gabriel, 2010). The major disadvantages of needle electrodes are they are more invasive than surface electrodes and generally the needle has to be held in place, which makes it difficult to use this type during dynamic contractions. When using the other type of indwelling electrodes, relocation is not possible without total reinsertion. Yet, unlike needle electrodes, these are better with dynamic movements because they are actually hooked into the muscle (Kamen and Gabriel, 2010). Yet, as Basmajian and De Luca explain, the difficulty and invasiveness of inserting the wire electrodes makes them much less commonly used (1985).

Surface Electrode Placement

Electrode placement is a crucial component of a successful EMG measurement. If electrodes are placed in the wrong spots in respect to the targeted muscle, EMG variables can be skewed (Merletti, et al., 2005). The electrodes are placed on the skin over the target muscle. It is also crucial to make sure the skin is completely prepped before applying the electrodes. The skin should be abraded to remove the dead skin often found on the surface layer of the skin, as well as oils. This will help in decreasing the amount of electrical impedance. By applying saline gel or paste, the electrical contact will be greater (Basmajian and De Luca, 1985).

The pair of electrodes should be place 1 cm apart (Król, et al., 2007). Basmajian and De Luca (1985) explain, "the preferred location of an electrode is in the region halfway between the center of the innervation zone and the further tendon". Also, when placing the electrode, it is important to consider the following three things: signal-to-noise ratio, signal stability, and cross-talk from adjacent muscles (Basmajian and De Luca, 1985). When the muscle is activated, the electrical signal is revealed between the electrodes (Merletti, et al., 2005).

When placing surface electrodes there are usually two electrodes placed (M1 and M2) over the targeted muscle, as well as one ground electrode. The ground wire should be placed on a site that is neutral, but near the target muscle. A good example for this would be a bony landmark, such as the clavicle. The signal from M1 and M2 are sent to a differential amplifier where M2 input is reversed (Kamen and Gabriel, 2010). The differential amplifier improves the EMG signal and reduces the amount of noise during the transmission. The amplifier takes M1 and subtracts M2 to amplify the difference, as shown in Figure 1, respectively. This is known as the common mode rejection ratio (CMRR), measuring how accurate the subtraction of the amplifier is.

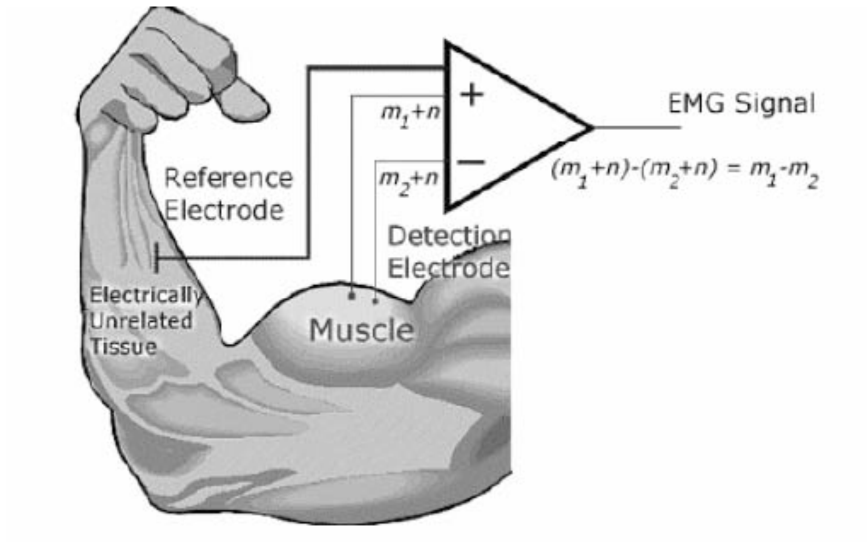

Figure 1. The common mode rejection ratio (CMRR)

Pectoralis Major And Other Chest Muscles

The chest muscles begin at the collarbone and sternum. They insert into the upper arm. Chest muscles are used in many different ranges of motion, including adduction, internal rotation, and forward flexion of the humerus (Manocchia, 2008).

When looking at the pectoral muscles, the larger of the two is the pectoralis major. This muscle is fan-shaped and covers the ribs. There are three portions to the pectoralis major: clavicular, sternal and abdominal. The clavicular portion attaches to one half of the medial and front edges of the clavicle. The sternal portion attaches to the outer length of the sternum and the anterior side of the costal cartilages of the first six to seven ribs. Lastly, the abdominal portion blends with the sternal portion. The pectoralis major is mainly used to move the arm, where it aids in climbing, throwing and pushing (Winslow, 2009).

The pectoralis minor muscle is a deeper and smaller muscle than the pectoralis major. It originates from the anterior surfaces of the sternal ends of the third to fifth ribs and inserts at the coracoid process of the scapula. The pectoralis minor's main responsibility is to draw the scapula forward and downward (getbodysmart.com)

Related Studies

There have been various studies conducted comparing muscle activation with the use of EMG during various chest exercises, but none have solely focused on the pectoralis major. For example, in 2005, Welsch and colleagues used EMG of the pectoralis major and anterior deltoid muscles to compare the barbell (BB) bench press, dumbbell (DB) bench press, and DB flys. They found no significant difference in muscle activation of the pectoralis major muscle between the three lifts. It was interesting to note that the pectoralis major did have a longer activation time during the BB bench press than during the other two exercises.

Cogley et al. (2005) conducted a study investigating EMG of the pectoralis major and triceps brachii muscle during a push-up. The study compared three base positions for the hands during the push-up: shoulder width, wide, and narrow. They found that the pectoralis major was activated the greatest with the use of the narrow base push-up.

There have also been studies conducted using EMG to compare stable surface to unstable surface during chest exercises. Andersen and Behm conducted a study in 2004 comparing the DB bench press on a stable surface and on an unstable surface (Swiss ball). They found that when looking at the movement as a whole, there were no major differences in muscle activation. Yet, if the contraction type was broken down into concentric and eccentric phases, there was more muscle activation during the concentric phase than the eccentric phase.

Saeterbakken et al. (2011) also conducted a study that looked at three different chest press exercises with different stability criteria. This study compared one-repetition maximums of three chest-press exercises: DB bench press, BB bench press, and Smith Machine chest press. The study found that when looking at the movement as a whole, the DB and BB bench presses activated the pectoralis major more than the Smith Machine chest press. When breaking the exercise down into concentric and eccentric phases, the DB bench press elicited greater muscle activation during the eccentric phase than the BB bench press.

Summary

There have been various studies conducted over the years that have investigated pectoralis major muscle activation during various chest exercises. However, those studies included only a selected few exercises, whereas this study will look at several different chest exercises and identify which exercise activates the pectoralis major to the greatest degree. With studies being conducted using EMG, time spent exercising can be more efficient, which may encourage people to dedicate more time to exercise.

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