Comparison in muscle activity between bench press and push-up exercise

An electromyography study

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Bachelor’s Thesis in Exercise Biomedicine, 15 credits

Halmstad 2017-05-23
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2017–05-12
Bachelor Thesis 15 credits in Exercise Biomedicine
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Abstrakt

Bakgrund


Syfte

Syftet med studien var att jämföra muskelaktiviteten i pectoralis major och triceps brachii under armhävning och bänkpress med armhävningsliknande motstånd genom EMG-tester.

Metod

21 manliga testpersoner deltog i denna studie. EMG mätningar genomfördes på pectoralis major och triceps brachii för att mäta muskelaktiviteten. Efter en MVIC mätning för båda muskler, för att få ett referensvärde, genomfördes fem repetitioner bänkpress med 64% av kroppsvikten som motstånd i en takt av 40 taktslag per minut. Efter tre minuters vila, så fick testpersonerna genomföra fem repetitioner armhävningar i samma takt. Tre av de fem repetitionerna valdes ut för ytterligare analys. All data omvandlades till procent av MVIC (%MVIC) innan analys.

Resultat

Resultaten från denna studie visar på en signifikant högre aktivitet av pectoralis major under bänkpress övningen jämfört med armhävning (p=0.014). Resultaten visade ingen signifikant skillnad i aktiviteten av triceps brachii under övningarna.

Konklusion

Denna studie visar att för träning av pectoralis major, så är bänkpress övningen att föredra jämfört med armhävningar med samma motstånd. För träning av triceps brachii verkar övningarna vara utbytbara.
Abstract

Background
Physical activity has many benefits, including the prevention of multiple different diseases. One way to perform physical activity is through resistance training, where some sort of resistance is used to increase the load on the muscles during contraction. For training the upper-body, the bench press exercise is a good option. However, not everyone has the equipment to perform this exercise. The push-up exercise has a similar movement pattern and uses the same muscles as well as no requirement for equipment. Therefore, it would be interesting to see which exercise activates the pectoralis major and triceps brachii, respectively, more.

Aim
The aim of this study was to compare the muscle activation of the pectoralis major and triceps brachii during push-up and bench press with push-up replicated resistance through EMG-testing.

Method
21 male subjects participated in this study. EMG measurement was used on the pectoralis major and triceps brachii to record muscle activity. Following a MVIC test for both muscles, to get a reference value, five repetitions of the bench press exercise at 64% of the subject’s body weight, at rate of 40 beats per minute. Following a three-minute rest, the subjects performed five repetitions of the push-up exercise at the same rate. Three of the five repetitions were selected for further analysis. All data collected was converted to percent of MVIC (%MVIC) before any analysis.

Results
The results of this study showed a significantly higher activation of the pectoralis major during the bench press exercise compared to the push-up exercise (p=0.014). The results did not show a significant difference in the activation of the triceps brachii during the two exercises.

Conclusion
This study shows that for training the pectoralis major, the bench press exercise is preferable to the push-up exercise at the same load. For training the triceps brachii, the bench press and push-up exercises seem interchangeable at the same load.
# Table of Content

1. Introduction .......................................................................................................................... 5
2. Background ........................................................................................................................... 5
   2.1 Muscle Contraction ......................................................................................................... 5
   2.2 Electromyography .......................................................................................................... 6
   2.3 Resistance Training ......................................................................................................... 7
   2.4 Upper body Training ....................................................................................................... 8
      2.4.1 Bench press ............................................................................................................. 8
      2.4.2 Push-up .................................................................................................................. 8
   2.5 Comparable studies ........................................................................................................ 9
3. Aim ....................................................................................................................................... 10
4. Method .................................................................................................................................. 10
   4.1 Subjects .......................................................................................................................... 10
   4.2 Pretesting Procedure ...................................................................................................... 10
      4.2.1 Electromyography ................................................................................................. 11
      4.2.2 MVIC Registration ................................................................................................. 11
   4.3 Testing procedure .......................................................................................................... 12
   4.4 Ethical and social considerations .................................................................................... 13
   4.5 Statistics ....................................................................................................................... 13
5. Results ................................................................................................................................... 14
   5.1 Pectoralis major activation in bench press vs push-up .................................................... 14
   5.2 Triceps brachii activation in bench press vs push-up ...................................................... 15
6. Discussion ............................................................................................................................. 16
   6.1 Results ............................................................................................................................. 16
   6.2 Method ............................................................................................................................. 17
7. Conclusion ............................................................................................................................. 18
8. References ............................................................................................................................. 19
9. Appendix ................................................................................................................................ 22
1. Introduction

Physical activity has many health benefits, including preventing the following; premature death, cardiovascular diseases such as high blood pressure and stroke, metabolic diseases such as diabetes and obesity, cancer, fractures and psychological diseases such as dementia and depression (FYSS, 2011). The recommended dose for physical activity for all adults, 18 or older is at least 150 minutes a week at a moderate level. Each week a minimum of 75 minutes should be at a high intensity (FYSS, 2011). Besides targeting the cardiovascular system, it is also important to perform muscle-strengthening physical activity which should be performed at least twice a week, targeting the major muscle-groups (FYSS, 2011). One example of muscle-strengthening activity is resistance training. Resistance training is the type of training utilizing some type of resistance during muscle contractions, such as free weight, bodyweight or machine weight (Haff & Triplett, 2015). When performing muscle-strengthening activity, it is important to differ between upper-body and lower-body exercises for a more efficient training plan. For upper-body training, the bench press is one of the most fundamental free weight exercises utilizing resistance training. The bench press exercise does however require equipment which is not available to everyone. A similar exercise for training the upper-body is the push-up exercise (Topalidou et.al., 2012). Unlike the bench press, the push-up exercise does not require any equipment which makes it available for anyone at any time. Because of its similarity to the bench press exercise, a comparison of muscle activation in the prime movers, pectoralis major and triceps brachii, is necessary to investigate possible differences or similarities between the two exercises.

2. Background

2.1 Muscle Contraction

Physical activity can be defined as bodily movements that are the result of activation of skeletal muscles through energy usage (Caspersen, Powell & Christenson, 1985). Dynamic muscular contractions have two distinct phases, concentric and eccentric phases. During the concentric phase the muscle is shortened and the force produced during this contraction exceeds the resistance places on the muscle. The eccentric phase occurs when the force produced by the
muscle does not exceed the resistance placed and the muscle is lengthened (Haff & Triplett, 2015).

Adenosine triphosphate (ATP) is the main energy source for the human body and is required for muscle contraction. The skeletal muscles consist of two main protein filaments, actin and myosin. These filaments are positioned slightly overlapped in a relaxed muscle. The filaments lay in bundles called myofibrils and these bundles are surrounded by the sarcoplasmic reticulum containing large quantities of calcium ions. To contract a muscle an action potential is sent from the brain through nerve cells to the desired muscle. An action potential is an impulse caused by diffusion throughout the neuron. The diffusion moves potassium and sodium inside and outside of the membrane causing a difference in charge throughout the membrane. This charge is then transferred between nerve cells through the release of neurotransmitters from affected cell’s dendrite end on to the next cell. Once the action potential reaches the sarcolemma, the electrical charge spreads across the muscle cell. Once this electrical charge reaches the sarcoplasmic reticulum, calcium ions are released into the myofibrils. The calcium ions causes structural changes in the muscle protein and filaments, allowing so called myosin heads to bind to the actin filaments in the muscles (Alberts et.al., 2014).

For a contraction to happen ATP is needed to bind to the myosin head. ATP is then hydrolyzed into ADP, Pi and a release of energy. This energy causes a “power stroke” of the myosin head which moves up along the actin filament. The ADP molecule then releases from the myosin head allowing a new ATP to bind and begin the process again (Alberts et.al., 2014). When myosin heads throughout the muscle “climbs” along actin filaments a shortening of the muscle occurs and a muscle contraction occurs.

Since the contractions occur because of electrical impulses, it is possible to measure these impulses and thereby see how active a muscle is during a specific movement. One method to do just this is electromyography (Konrad, 2006).

### 2.2 Electromyography

Electromyography (EMG) is a useful method for recording muscle activity during specific movements. It can provide an insight into if the muscles are activated and, if a reference has been recorded, how much a specific muscle is activated compared to a maximum contraction. This is
made possible due to the measurement of the electrical impulses that cause muscle contractions. Two different kinds of EMG methods exist for measuring muscle activity. One method is the use of fine wire electrodes which involves hook wires inserted into the muscle fibers with the help of needles. This method is normally used to measure deeper located muscle tissue. The other method, which will be used in this study, is surface-EMG which instead of wire electrodes uses skin surface electrodes applied directly to the skin. This method is used when dealing with muscles located near the surface of the skin (Konrad, 2006).

Muscle contractions are the reason for every movement in the human body. During muscle strengthening training, the contractions can be used to move some sort of resistance such as bodyweight, free weight or machine weight. This is called resistance training (Haff & Triplett, 2015).

2.3 Resistance Training

Resistance training has many health benefits including increases in lean weight and metabolic rate, along with decreases in body fat weight (Westcott, 2012). It has been shown that adults that do not perform regular resistance training experience a loss of 1% to 3% of bone mineral density each year (Kemmler et. al., 2005). Resistance training has also shown benefits in adults in reducing fatigue, anxiety, depression, cognitive ability and improvements in self-esteem (O’Connor et.al., 2010).

A resistance training program can be designed in many ways, mainly depending on what the goal of the training is. Multiple set of an exercise has shown a higher increase of initial strength (48%) when compared to one set (25%) (Munn et.al., 2005). A higher training intensity seems to also give a higher strength adaptation when compared to a lower intensity. The same study indicated that separate high and low intensity training to failure can give an increase in muscle hypertrophy among trained young men (Schoenfeld et.al., 2015).

For resistance training, a split between upper and lower body can be made for a more efficient training program (Haff & Triplett, 2015). This study has chosen to focus on upper body training.
2.4 Upper body Training

2.4.1 Bench press
The bench press exercise is a fundamental upper-body resistance training exercise that activates a number of muscles including pectoralis major and triceps brachii (Calatayud et.al., 2014). The exercise is multi-jointed, meaning that during the exercise multiple joints have movement through them, allowing the different muscle groups to be strengthened simultaneously (Schick et.al., 2010), which can be time-effective. Being multi-jointed, the bench press exercise has an advantage over single-jointed upper-body exercises that can only target one muscle. The movement pattern for the bench press exercise is a flexion in the elbow joint during the eccentric phase. Once the barbell reaches the chest, or as far down as possible if restrictions are present, push the bar up by extending the elbows until the starting position is reached again (Haff & Triplett, 2015). During the exercise a stretch should be felt in the chest. A study has found that 200% of the performer’s biacromical breadth (BB) is optimal for power output (Wagner et.al., 1992). Using the bench press exercise as a core component of a workout program, strength increases in upper-body strength was found in junior athletes over a 6-week period (Drinkwater et.al., 2005).

The bench press exercise is not only a strength building exercise but also used for testing upper-body strength. Testing the one repetition maximum (1RM) in the bench press has been shown to be a reliable and simple method to test upper-body strength (Seo et.al., 2012). A previous study has also showed that bench press can be used to accurately predict load for assisting upper body exercises, such as dumbbell shoulder press and barbell biceps curls (Wong et.al., 2013). The exercise 6RM load showed a high correlation with the 4 assistance exercises used in the study (r= 0.8 to 0.93, p=0.01).

2.4.2 Push-up
A comparable functional exercise to the bench press is the push-up. The push-up exercise is a common and practical way to enhance upper-body fitness using the body-weight as resistance without the need of any gym equipment (Ebben et.al., 2011). The push-up mimics the bench press by being multi-jointed and following the same movement pattern. The push-up exercise also activates the pectoralis major, triceps brachii and anterior deltoid, similarly to the bench
press (Topalidou et al., 2012). The difference between the two exercises is that during the push-up the body will be at a slight angle which reduces the load to about 64% of the body weight of the performer (Ebben et al., 2011). While the two exercises are comparable, and have been used in previous studies, knowledge is still lacking about the particular muscle activation of the two exercises and if the exercises are interchangeable when looking at muscle activation. Higher percentage of muscle activation has been linked to higher muscle hypertrophy in the triceps brachii through a 12-week training intervention (Taku, Atsuki, Yasuo & Toshimasa, 2013). Thereby a higher activation would be preferable for exercise selection for optimal training effect.

2.5 Comparable studies

A few studies have looked at the bench press and push-up exercise to investigate the training effect of the different exercises as well as muscle activity through EMG measurement. Two studies have looked at the bench press exercise and elastic band resisted push-ups (Calatayud et al., 2015, Calatayud et al., 2014). Both studies found that the bench press and push-up exercise had no statistical difference in muscle activation for both the pectoralis major and triceps brachii through EMG-testing (p=0.927). These studies used high loads during testing procedure (6RM and 50%, 70%, 80% of 1RM). These results contradict the result of another study (Oliveira, Carvalho and de Brum, 2008). This study showed a higher activation in the pectoralis major during push-ups compared to the bench press. This study used axial body weight load and used only the dominant arm during testing procedure.

One thing that was made apparent with the previous studies were the lack of instructions for the push-up movement. This was taken in consideration for this study and was made a focus to provide standardized instructions for the push-up exercise. One study that provided a good blueprint for the standardization of the push-up exercise provided instructions for specific hand placement (Ebben et al., 2011). In the same study, it was found that a regular push-up equivalates to a resistance of 64% of the bodyweight. Therefore, this study will use 64% of the bodyweight as resistance for the bench press. Standardization of the push-up exercise is crucial for reproducing the results and thereby being able to use them.
3. Aim
The aim of this study was to compare the muscle activation of the pectoralis major and triceps brachii during the push-up and bench press with push-up replicated resistance exercises through EMG-testing.

The questions asked were:
- Does one of the exercises bench press and push-up activate the pectoralis major muscle more?
- Does one of the exercises bench press and push-up activate the triceps brachii muscle more?

4. Method
4.1 Subjects
21 male subjects aged 19-29 participated in this study. Subjects were recruited using social media and personal contacts. The including criteria for participation were the subjects needed a minimum of six months of weightlifting experience and needed to be able to perform a minimum of ten strict push-ups to ensure that they could perform the exercises correctly during the testing procedure. The excluding criteria were: if the subject had been sick within a week of the testing occasion and/or if they had any injuries that would have impaired their ability to perform the exercises.

4.2 Pretesting Procedure
The testing consisted of one test occasion that took about 30 minutes per test subject. The subjects were tested individually. At the test occasion the subject were weighed (KERN scale, Germany). The weight of the test subject was used to determine the resistance used for the bench press exercise. For the bench press and push up exercises to be assumed equally strenuous, 64% of the body weight was used as resistance for the bench press exercise according to results from previous research (Ebben et.al., 2011). The subject was then asked to remove their shirt so that an accurate palpation of the muscles, pectoralis major, triceps brachii and the biacromial breadth (BB). For the muscles, the muscle bellies were searched for and for the BB, both acromion heads were located and the distance between both heads were measured. The breadth was then used to
measure the grip for the bench press exercise and the width for the push up exercise. This study used 200% of BB due to this being the most optimal width for power output during bench press (Wagner et al., 1992). No study was found looking at hand width and push-up power output.

### 4.2.1 Electromyography

Following the BB measurement, once the relevant muscles were found, the muscle bellies were shaved and wiped off with alcohol to improve the connection between skin and electrode. Three electrodes (Ag/AgCl, Blue M-00-S, Ambu A/S, Ballerup, Denmark) were then placed on each muscle belly with two electrodes in the direction of the muscle fibers with one reference electrode placed square against the other two (Konrad, 2006). Receptors (Mega Electronics Ltd) were then applied to the electrodes so that the signal and muscle activity could be registered through the WBA Mega System (Mega Electronics Ltd). The signal was measured in the computer program MegaWin (3.1 Wireless), and the measurements were registered in microvolts (µV). Once a stable connection to the muscles had been established the test subject could put their shirt back on. Surface-EMG has shown to be valid through a cross correlation analyzes when looking at abdominal muscles during rapid limb movement (Marshall & Murphy, 2003). This study also showed that EMG proved to be reliable after a two-week period between tests. The subject was then allowed to warm up by performing light bench press repetitions with just the bar until the subjects felt warm and ready to begin testing.

### 4.2.2 MVIC Registration

Following the warm-up, a maximum voluntary isometric contraction (MVIC) test was performed for both muscles. MVIC is the maximum contraction value that the subject can perform with a specific muscle (Konrad, 2006). This value is then used in reference to the testing values to see the amount of activation during the exercises compared to the measured maximum possible value (Boren et al., 2011). To perform the MVIC for pectoralis major, a smith machine was used with a weight that the subject could not move. The subject laid down on a bench under the bar and gripped the bar with a 90-degree angle in the elbow joint (Konrad, 2006). Following a five second count down, the subject was instructed to press as hard as possible against the bar. After an additional five seconds the test leader instructed the subject to relax. This was repeated twice following the first attempt with a minute rest in-between. A second MVIC test for the triceps
brachii was then performed. This test was performed against a wall with the subject’s right fist against the wall and the elbow placed against a chair for a fixed area with the elbow angle at 90 degrees (Konrad, 2006). The same procedure as for pectoralis major was performed. Once a successful MVIC registration had been made for both muscles, the measurement were analyzed and the average peak value from the three tests for each muscle was registered and saved.

### 4.3 Testing procedure

For the actual testing session, following the MVIC tests, the test subject performed five repetitions of the bench press exercise with a resistance of 64% of their body weight. Their grip had been marked on the bar at 200% of BB where the index finger touched the mark. The subject had to have five contact points on the bench (head, upper back, glutes and both feet) during the repetitions where the bar was lowered to the chest and then pressed up while all contacts spots still touched the bench (Haff & Triplett, 2015). The repetitions were to be at a rate of 40 beats per minutes (Ellsworth et.al, 2006), to which a beeping metronome (Seiko DM70 Pocket Digital) was used to assist the subjects to keep this rate which equivalentates a three second eccentric phase and a three second concentric phase.

Following the bench press exercise the subject rested 3 minutes before performing five push-ups. This rest has shown to allow greater repetitions for multiple sets (de Salles, Simão, Miranda, Novaes, Lemos & Willardson, 2009). For this exercise two marks had been made to mark out 200% of the subject’s BB so that the bench press and push-ups were performed the same way. The subject assumed the starting position with both hands on the ground with each index finger on the marked spots and standing on the toes (Haff & Triplett, 2015. The top of the subject’s thumbs were to be linear with the subject’s nipples at the bottom position. Once the correct position had been found, the subject performed five repetitions at a rate of 40 BPM (Ellsworth et.al, 2006). Following the push-ups, the protocol in the MegaWin program was stopped. The data was analyzed and the middle three repetitions of the exercises were chosen for further analyzes. The average activation and peak value from these three repetitions was registered and saved.

Before any statistical tests, the results measured in µV were divided with the MVIC to percent of MVIC (%MVIC) for a more relevant result that could be compared between subjects.
4.4 Ethical and social considerations

This study followed the Declaration of Helsinki and its ethical principles for medical research involving human subjects. During the first meeting with the potential test subjects, oral information was given as well as an information form. The subjects were encouraged to ask questions and informed that participation is fully voluntary and that the subjects were free to leave the study at any time and any information or result connected to that subject would be terminated. All data and information from test subjects were handled with discretion and in consent with personuppgiftslagen (PUL). Surface-EMG is not perfectly comfortable with shaving and alcohol application necessary for the best possible connection between skin and electrode. The test subjects were made aware of this before any testing had begun so that time for reconsideration was possible.

The general population could use the result of this study to help their individual physical health and strengthen their upper extremities in a more efficient way using one of the exercises studied in this paper. Physical activity has proven to show many health benefits, including preventing premature death, cardiovascular diseases such as high blood pressure and stroke, metabolic diseases such as diabetes and obesity, cancer, fractures and psychological diseases such as dementia and depression (FYSS, 2011). Therefore, making physical activity more efficient and accessible to more people is positive and desirable.

All results found during testing and analyzing of the data can be found in this study. The author has not excluded any results for the benefit of a more valid result. This study had the goal to present a better understanding of muscle activity during different exercises to allow for a more efficient exercise selection and also to present different exercises for the same goal.

4.5 Statistics

The statistical program IBM Statistical Package for the Social Sciences (SPSS) version 24 was used for analyses of the registered data. The %MVIC for the pectoralis major and triceps brachii and exercises (bench press and push-up) were tested for normality through a Schapiro-Wilks test. The data was not normally distributed and thus non-parametric tests were chosen for statistical analyses. Wilcoxon signed-rank test was used to test for any statistical differences
between muscle activation in the pectoralis major and triceps brachii respectively during the different exercises. Statistical significance was set at a p-value of (≤ 0,05). Even though the EMG data was not normally distributed, I chose to present all data as mean ± standard deviation (SD) for comparison purposes.

5. Results

All subjects completed the testing without any complications. Anthropometric data of all subjects is shown in table 1.

Table 1. Anthropometric data of subjects (n=21)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean (SD)</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y)</td>
<td>23.19 (±2.56)</td>
<td>20 – 29</td>
</tr>
<tr>
<td>BB Breadth (cm)</td>
<td>41.02 (±2.80)</td>
<td>37 – 49</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>84.38 (±10.92)</td>
<td>65 - 104</td>
</tr>
<tr>
<td>Width Used (cm)</td>
<td>82.05 (±5.61)</td>
<td>74 - 98</td>
</tr>
<tr>
<td>Bench Press Resistance (Kg)</td>
<td>54.00 (±6.99)</td>
<td>41.5 – 66.5</td>
</tr>
</tbody>
</table>

SD = Standard deviation, BB = Biacromial breadth, Width Used = Grip width for bench press and width for hand placement for push-up

5.1 Pectoralis major activation in bench press vs push-up

The average %MVIC muscle activity from the bench press and push-up exercises show a higher activation in the pectoralis major in the bench press exercise with a statistical significance of p = 0,014 (Figure 1, Table 2).
5.2 Triceps brachii activation in bench press vs push-up

The average %MVIC muscle activity from the bench press and push-up exercises does not show a higher activation in the triceps brachii during the bench press exercise compared to the push-up with a statistical significance of $p = 0.332$ (Figure 1, Table 2).

Table 2. Muscle activity in pectoralis major vs triceps brachii (n=21)

<table>
<thead>
<tr>
<th>Muscle</th>
<th>MVIC (µV)</th>
<th>BP (µV)</th>
<th>BP (%MVIC)</th>
<th>PU (µV)</th>
<th>PU (%MVIC)</th>
<th>p-value of %MVIC in BP vs PU</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pectoralis Major</td>
<td>628.3 (±316)</td>
<td>249.2 (±108.6)</td>
<td>43.1* (±15.7)</td>
<td>215.5 (±165.8)</td>
<td>33.2 (±14.2)</td>
<td>0.014</td>
</tr>
<tr>
<td>Triceps Brachii</td>
<td>1297.1 (±289.9)</td>
<td>415.9 (±178.9)</td>
<td>36.6 (±24.9)</td>
<td>403.3 (±124.6)</td>
<td>32.3 (±11.3)</td>
<td>0.332</td>
</tr>
</tbody>
</table>

MVIC = Maximum voluntary isometric contraction, BP = Bench press, µV = Micro volt, PU = Push-up * = Statistical significance at $p<0.05$
6. Discussion

6.1 Results

The result of this study shows a statistically significant increase in average activation in the pectoralis major during the bench press compared to the push-up, whereas there was no difference between the two exercises in triceps brachii activation. In the present study, the bench press exercise gave a significantly higher activation of the pectoralis major than the push-up exercise at a similar load. These results are in disagreement with previous results, showing that the bench press and elastic band resisted push-ups elicited similar activation in the pectoralis major muscle (p = 0.96) (Calatayud et.al., 2015, Calatayud et.al., 2014). This discrepancy could be because of the difference in resistance in both the bench press and push-up exercises. Calatayud et.al. (2015) measured EMG-activity during a 6RM bench press and similarly resisted push-ups. The results of the present study are also in disagreement with another previous study, which showed a higher pectoral activation during the push-up exercise compared to the bench press (Oliveira, Carvalho and de Brum, 2008). This difference in results could be due to the previous study using only one arm for each exercise whereas the present study performed both exercises with both arms active.

This present study’s results also seem to indicate a non-statistically significant relation between the bench press and push-up exercises when looking at the triceps brachii muscle. This could mean that when comparing a push-up and a push-up resistance replicated bench press, the exercises could the interchangeable for training the triceps brachii. This result seems to be in agreement with previous studies showing a non-significant difference in activation for the triceps brachii during the bench press and push-up exercise (p = 0.96) (Calatayud et.al., 2015, Calatayud et.al., 2014).

The results in the present study indicate that for training the triceps brachii, the bench press and push-up exercises are equally useful at the same load. For training the pectoralis major, this study’s results indicate that the bench press is preferable due to a higher muscle activation of the pectoralis major at the same load.
6.2 Method

This study does have a few flaws. As shown by a previous study EMG testing has shown results leading to doubt about how relevant the recorded data is when looking at how much a muscle is activated (Hamill & Knutzen, 2010). This study also showed in contrast that EMG can be used to simply register if a muscle is active or not. However, surface EMG measurement have also shown to be valid through a cross correlation analyzes of abdominal muscles (Marshall & Murphy, 2003). Factors that could have affected the results of this study looking at the method used, is the importance of a clean area of skin that the electrodes are placed on (Konrad, 2006). If during the pretesting procedure, the skin was not perfectly prepared, results could have been skewed. The same is applied to the position of the electrodes on the pectoralis major and triceps brachii, respectively, where small differences between position of the electrodes between test subjects, results could be skewed (Konrad, 2006). During the testing, problems occurred with the connection between the electrodes and the WBA mega system which may have impacted results. This study also chose to only focus on male test subjects due to the ethical complications of EMG testing the pectoralis major on female test subject without the availability of a female test leader.

This study chose to only focus on the right side of the test subjects since this is a common way to do EMG measurements in previous research. This could have affected the results as a previous study has shown that a subject’s dominant hand is both stronger and better at controlling force than the non-dominant hand (p<0.05) (Noguchi, Demura & Aoki, 2009).

Two additional flaws of this study are the lack of a randomized order for the exercises and the lack of a standardized warm-up. These two points were planned to be included during the early phases, but were forgotten and lost during the test occasions. This does affect the validity of the results that have been found, specifically the statistically significant finding of the pectoralis majors higher activation in the bench press exercise. The bench press exercise was the first of the two exercises performed and could thereby give it bias. However, the experience of the test subjects and the relatively low resistance used during the bench press as well as a good rest time (de Salles, Simão, Miranda, Novaes, Lemos & Willardson, 2009) means that this bias may have been less prevalent than under other conditions. A study looking at muscle fatigue also found
that submaximal contractions were able to be sustained after an onset of muscle fatigue (Enoka & Duchateau, 2008). The lack of a standardized warm-up also lowers validity and reproducibility.

From a practical resistance training standpoint, a different load could have been used for both exercises, the bench press specifically. This is due to higher loads than 64% of a subject’s body weight being common for training. An increase in load is important for adaptation and increase muscle hypertrophy and muscle strength (Haff & Triplett, 2015). Using higher loads for the bench press, an increase in push-up load would also have been necessary in order to compare the exercises, similarly to previous studies (Calatayud et.al., 2015, Calatayud et.al., 2014). In the present study, we opted to use only the bodyweight as resistance since it was of interest to investigate possible differences in muscle activation in a push up and bench press under as standardized conditions as possible. With the use of a lower load, results of this study are more easily applied to the general public and team sport training.

An interesting follow-up to this study would be to see if the weight of the test subjects impact the activation, if the load is in relation to the body weight. With a higher number of the Swedish population being overweight (Juul & Henningson, 2014), seeing how that affects activation could be interesting to see if the push-up exercise is similarly affective to the bench press.

7. Conclusion

The results of this study showed that pectoralis major had a significantly higher activation during the bench press exercise compared to the push-up exercise. The triceps brachii muscle did not show a significant difference in activation during the two exercises when in reference to the MVIC value. These results mean that for training the pectoralis major muscle, the bench press exercise is preferable compared to the push-up exercise. For training the triceps brachii, the two exercises could be deemed interchangeable at the same load. The results of this study could be of use for coaches and athletes wanting to optimize training results through an efficient exercise selection. Many non-athletes could also use the information as a guideline in their training, no matter if it is in a gym or at home.
8. References


9. Appendix

Informationsblad för:
Jämförelse av bänkpress och armhävning med EMG samt jämförelse av olika grepp vid bänkpress med EMG

Hej!
Vi är två studenter från Halmstad Högskola och går på utbildningen Biomedicin med inriktning fysisk träning. Vi ska påbörja vårt examensarbete och som del i detta har vi valt att genomföra tester där vi ska titta på muskelaktivering vid olika variationer av vanliga styrketräningsövningar och vi undrar om du är intresserad att vara del av vår undersökning.

Syfte: Syftet med denna studie är att jämföra muskelaktivering av bröstmuskeln och triceps i övningarna bänkpress och armhävning och dels att jämföra muskelaktivering i samma muskler vid olika grepp bredder i övningen bänkpress


Nytta: Studien siktar på att kunna assistera till ett mer effektivt träningsupplägg för såväl erfarna lyftare som för amatör motionärer. För dig som deltagare i studien kommer du att få delta i en vetenskaplig studie och vara närvarande vid kritiska punkter för studierna. Denna information kan vara nyttig att veta om du skulle vilja delta i andra framtida studier eller siktar på att genomföra liknande studie själv. Du kommer även få inblick i hur din egen kropp arbetar vid bänkpress och även armhävning, hur just dina musklar arbetar under övningarna.

Risker: För dig som deltagare kommer små risker att medfölja. Dessa är träningssvårer som kan uppstå dagarna efter testtillfället men som bör försvinna efter några dagar. Om värken skulle vara kvar uppmontras du att kontakta kontaktpersonerna vars uppgifter finns nedan. Viktorna som används till bänkpressen kommer vara 64% av kroppsvikten vid testtillfället och kan medföra risker om du inte orkar lyfta vikten allt efter som testen pågår. Dock kommer en testledare vara beredd att hjälpa till om detta skulle vara fallet. Ett obehag kan även komma att uppstå vid testtillfället då testledare behöver palpera (känna efter var muskeln är) på dig samt
att delar av musklerna kommer även behöva rakas och torkas av vilket kan medföra ett visst obehag.


Deltagande: Deltagande i denna studie är fullständigt frivillig och man har rätt att när som helst, utan förklaring, avbryta sin medverkan i studien. Vid eventuell avbrytning av medverkan i denna studie kommer inte bemötandet och omhändertagandet av dig att påverkas. Vid avbruten medverkan kommer eventuella resultat och uppgifter som dokumenterats om dig att förstöras.

Testledare och ansvariga för denna studie:

Namn
Max Turnstedt
Christopher Danielsson

Handledare på Högskolan i Halmstad:

Charlotte Olsson
Samtycke

Nedan ger du ditt samtycke till att delta i den studie som undersöker muskelaktivering vid övningarna bänkpress och armhävning. Läs gärna igenom informationen för studien noggrant och gärna flera gånger. Om du vill delta ger du ditt medgivande till deltagande genom att signera med namnteckning nederst på denna sida.

- Jag bekräftar att jag har tagit del av denna skriftliga information om forskningsstudien och förstår vad den innebär.
- Jag har fått ställa frågor, och jag vet vem som är ansvarig för studien om jag skulle vilja ställa fler frågor.
- Jag accepterar att mina personuppgifter hanteras på det sätt som beskrivits.
- Jag förstår att jag kan avbryta min medverkan i studien när som helst utan anledning och efterföljande konsekvenser.
- Jag intygar härmed att jag har läst det informerade samtycket samt tagit del av informationen kring studien. Jag förstår vad deltagande i denna studie innebär och ställer upp frivilligt.

……………………  …………………..  …………………..
Datum              Deltagarens namnteckning  Namnförtydligande

…………………………………………
Deltagarens födelsedatum (år (fyra siffror), månad och dag)

Undertecknad har gått igenom och förklarat studiens syfte för ovanstående deltagare samt erhållit deltagarens samtycke. Deltagaren har även fått en kopia av av det informerade samtycket.

……………………  ………………………  ………………………
Datum              Namnteckning              Namnförtydligande
My name is Christopher Danielsson and I’m 21 years old. I grew up in Kristianstad, Sweden and I now study exercise biomedicine at Halmstad University. I love exercise and training and have as a goal in life to help people towards a more active and healthy lifestyle.