



Differences in muscle activity during the chin-up versus lat pulldown exercise. An electromyographic study.

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Foreword

I would like to thank all the subjects who participated in this study. Without you, this study would not been able to be implemented. I would also like to thank my supervisor Charlotte Olsson who has given me guidance and helped me during my work.

Another thanks to Idrottscentrum gym for letting me carry out the tests in their facilities and for borrowing their gym equipment.

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Abstrakt

Syftet med denna studie var att undersöka om muskelaktiviteten hos latissimus dorsi, biceps brachii, trapezius pars transversa och rectus abdominis skiljde sig mellan en chin-up och en latsdrag, båda med 100 % kroppsvikt som motstånd. I denna studie deltog 20 män (ålder, $25,3 \pm 3,5$ år; längd, $180,9 \pm 5,8$ cm; vikt, $82,4 \pm 7,8$ kg; biakromialt avstånd, $44,0 \pm 2,0$ cm) och utförde fem stycken chin-ups och latsdrag på 100 % av deras kroppsvikt. Försökspersonerna hade minst ett års erfarenhet av regelbunden gymträning minst två gånger i veckan. Hälften av försökspersonerna startade med chin-ups och de andra med latsdrag. Muskelaktiviteten jämfördes mellan chin-ups och latsdrag med 100 % kroppsvikt för latissimus dorsi (LD), biceps brachii (BB), trapezius pars transversa (Tr) och rectus abdominis (RA). För övningen chin-up hade BB en signifikant lägre genomsnittlig muskelaktivitet ($p=0,048$) och RA en signifikant högre genomsnittlig muskelaktivitet ($p=0,021$) jämfört med övningen latsdrag. För de två ryggmusklerna; Tr och LD hittades inga signifikanta skillnader för den genomsnittliga muskelaktiviteten mellan de två övningarna (Tr $p=0.135$, LD $p=0.627$). LD hade en signifikant högre muskelaktivering i både chin-up och latsdrag jämfört med både BB ($p<0,01$) och RA ($p<0,05$) men inte jämfört med Tr ($p>0,8$). Slutsatsen är att latsdrag med fördel kan användas om målet är att stärka biceps brachii, och chin-up kan väljas om målet är att utföra en övning som aktiverar mer rectus abdominis. Är målet istället att aktivera latissimus dorsi eller/och trapezius pars transversa visade den här studien på att valet av övning inte spelar någon signifikant roll om den görs på 100 % kroppsvikt.

Abstract

The purpose of this study was to investigate if the muscle activity in latissimus dorsi, biceps brachii, trapezius pars transversa and rectus abdominis differed between a chin-up and a lat pulldown exercise, both at 100 % bodyweight load. In this study 20 men (age, 25.3 ± 3.5 years; height, 180.9 ± 5.8 cm; weight, 82.4 ± 7.8 kg; biacromial distance, 44.0 ± 2.0 cm) participated and performed five chin-ups and lat pulldowns at 100 % of their bodyweight. The subjects had at least one year of experience with regularly gym training for a minimum of two times a week. Half of the subjects started with chin-ups and the other half with lat pulldowns. Muscle activity was compared between the chin-up and lat pulldown exercises at 100 % bodyweight for the latissimus dorsi (LD), biceps brachii (BB), trapezius pars transversa (Tr) and rectus abdominis (RA). For the chin-up exercise, the BB had a significantly lower average muscle activity ($p=0.048$) and the RA a significantly higher average muscle activity ($p=0.021$) compared to the lat pulldown exercise. For the two back muscles; Tr and LD no differences for the average muscle activity between two exercises were found (Tr $p=0.135$, LD $p=0.627$). The LD had a significantly higher muscle activity in both the chin-up and the lat pulldown compared both to BB ($p<0.01$) and RA ($p<0.05$) but not to Tr ($p>0.8$). The conclusion is that the lat pulldown exercise can preferably be used if the goal is to strengthen biceps brachii, and the chin-up can be the choice if the goal is to perform an exercise which activates more rectus abdominis. However if the goal is to activate latissimus dorsi or/and trapezius pars transversa the findings in this study showed that the choice of exercise does not significantly matter if performed at 100 % bodyweight.

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1. Background

1.1 Resistance training

Resistance training can develop strength, endurance and skeletal muscle mass. This form of training involves a muscle contraction against a resistance which can be free weights, machines, elastic bands and springs, or the bodyweight itself (Winett & Carpinelli, 2001). Resistance training does not only develop skeletal muscle mass but has a range of health benefits. It can help prevent osteoporosis, sarcopenia and cardiovascular diseases like diabetes, insulin-resistance, cancer, obesity and hypertension. Another benefit is a better body composition with more fat free mass and less fat mass (Winett et al, 2001). The American College of Sports Medicine (ACSM) minimum recommendations for adults to maintain a good health are 30 minutes of moderate-intensity aerobic physical activity five days a week, or 20 min of vigorous-intensity three days a week. The minimum recommendations for resistance training are 8-10 exercises per session at least two times a week to maintain or increase muscular strength and endurance. For additional health benefits the ACSM recommends to perform greater amounts of activity, both aerobic and weight bearing activities (Haskell, et al. 2007). Amateurs, elite athletes and bodybuilders all perform resistance training but with different goals. The amateurs might perform a general training with their well-being as a goal, while the elite athletes might train specific movements for explosiveness or maximum strength as their goal. Bodybuilders often train muscles specifically with the goal of maximum hypertrophy for each individual muscle (McArdle, Katch & Katch, 2015, p.528).

1.2 Muscle contraction and electromyography

Performing resistance training makes the muscle fibers contract. A muscle fiber is made up of myofibrils. Every myofibril consists of a large amount of sarcomeres which consists of the proteins actin and myosin in addition to a large amount of other structural and elastic proteins as well (McArdle et al, 2015, p.360). A muscle contraction occur when an action potential initiates a membrane depolarization which increased the intracellular calcium, which in turn binds to tropomyosin for a conformational change opening up the myosin-binding site of actin. When myosin attaches to the actin the pulling of the myosin heads shortens the sarcomere in the presence of adenosine triphosphate (McArdle et al, 2015, p.363). The muscle

contraction can differ in force depending on the strength of the action potential and the numbers of active motor units.

The action potential that initiates a muscle contraction is transmitted as electrical signals from the brain through motor neurons to the muscle fibers in question (McArdle et al, 2015, p.384). One motor neuron can alone innervate hundreds or even thousands of muscle fibers (together called a motor unit). If a motor neuron send a stimulus, all the muscle fibers will contract at the same time. This is known as the all-or-none principle (McArdle et al, 2015, p.399). Muscle contractions requiring low force only activates a few motor units but when a greater force is needed the numbers of active motor units are higher. Increased motor unit recruitment happens when the strength demands on the muscle increases, the axon networks progressively expand and the number of motor neuron becomes more. This happens at progressive overload resistance training and is known as the size principle (McArdle et al, 2015, p.399). In order to gain muscle hypertrophy progressive overload is required. When lifting weights the size principle means that no matter workout intensity the slow-twitch fibers type 1 will be recruited first and if necessary to lift heavier weights or perform fast moving motions the type 2a or 2b will be recruited thereafter (McArdle et al, 2015, p.374).

Surface electromyography (EMG) is a method which measures electrical signals from the muscles. When the action potential propagates along the cell membranes the changes in ionic concentrations in- and outside of the cell can be measured as an electrical signal (McArdle et al, 2015, p.359). Normally three electrodes attaches to the skin at the area of interest. The two measurement EMG electrodes record muscle action potentials, and the third electrode acts as a reference electrode which aids in removing background noise and nonrelated frequencies. Sensors amplify and filter the signals and an encoder converts the signals to a computer (Konrad, 2006, p13). The surface EMG is an important, non-invasive tool for both rehabilitation purposes in clinical populations and for performance assessments in athletes. The EMG can help in the choice of rehabilitation programs and what muscles to prioritize in a training program (Halaki & Ginn, 2012; Criswell, 2010, p.239; Konrad, 2006, p.6). In the present study EMG is used to see differences in muscle activity among four different muscles in two different gym exercises.

1.3 Train with machines or with bodyweight as resistance

Resistance training can be performed in machines or with free weights. Free weights including bodyweight resistance, barbells, dumbbells, associated benches and medicine balls

etcetera (Haff, 2000). Both ways of exercising has advantages and disadvantages (Haff & Triplett, 2016, p.443). Machine training can increase the stability compared with free weights which makes it easier to perform the exercise. For machine training there are fewer skills required and there is no need for spotting at heavier loads. In contrast, training with free weights is better if the goal is to develop power and motor skills. Overall muscle mass and strength seems to be more stimulated by multi-joint free weight training compared to single-joint isolation weight training. In addition, free weight training also has the greatest transfer to explosiveness and athleticism (Brown & Hillbert, 1999; Haff, 2000).

1.4 The chin-up and the lat pulldown

A chin-up is a well-known free weight resistance training exercise and is sometimes referred as one of the basic exercises that can be implemented in most training programs. The exercise can be used by the recreational gym exerciser and by different athletes that need to improve shoulder girdle strength, stability and pulling force (Ronai, 2014). The exercise is performed by first hanging fully extended from a horizontal bar and then pulling all the way up until the chin is over the bar. The chin-up exercise can be made more difficult or easier to perform by either maintaining a straight position through the lift or use momentum to swing up. Using extra weight or an elastic band can also alternate the difficulty of the exercise (Ronai, 2014). When performing a chin-up, the latissimus dorsi and biceps brachii are the primary working agonist muscles. Other muscles that are activated in the chin-up are the antagonist's pectoralis major and triceps brachii, and to a smaller degree the synergist's infraspinatus, teres major and the trapezius pars transversa which all assist through the lift (Ricci, Figura, Felici & Marchetti, 1988; Youdas, Amundson, Cicero, Hahn, Harezlak & Hollman, 2010; Doma, Deakin & Ness, 2013).

A lat pulldown is a popular exercise for the back which is quite similar to the chin-up. This exercise can also be implemented in most training programs. The difference is instead of hanging in a barbell and pull the body up, the person executing the exercise is seated at a machine and pulling a barbell down to the chin (Snarr, Eckert & Abbott, 2015). The barbell is connected by a cord to a stack of weights which means that the resistance is adjustable. When performing the lat pulldown the same muscles that are working in a chin-up are going to be used (Doma et al, 2013; Snarr et al, 2015). However, it is not known if there are any differences in muscle activation when performing the chin-up and the lat pulldown exercises at the same load relative to bodyweight.

Most previous research comparing the chin-up and lat pulldown have looked at grip variations comparing pronated and supinated grip or differences in grip width (Youdas et al, 2010; Lusk, Hale & Russell, 2010; Andersen et al, 2014). Previous research found that a supinated grip activated more biceps brachii and a pronated grip more latissimus dorsi (Youdas et al, 2010). Another study found that latissimus dorsi had a greater muscle activity with a pronated grip compared to a supinated (Lusk et al, 2010). Grip widths at 1, 1.5 and 2 times the biacromial distance were compared and the biceps brachii showed a greater activation with the medium grip than with the narrow and wider grip. For latissimus dorsi there was a greater activation in the eccentric phase using the wide grip than the medium, and a greater activation for the medium grip than for the narrow one (Andersen et al, 2014). In this study a pronated grip was used and a width of 1.5 times biacromial distance.

A few previous studies have compared the chin-up and lat pulldown exercises for strength and muscle activation (Johnson, Lynch, Nash, Cygan & Mayhew, 2009; Halet, Mayhew, Murphy & Fanthorpe, 2009; Doma et al, 2013). The chin-up and lat pulldown have been found to have similar movement patterns in the upper extremity (Doma et al, 2013; Snarr et al, 2015). A study investigated the relationship between chin-up and lat pulldown for 1-repetition maximum (1RM) in both men and women. They found that both sexes could perform the 1RM chin-up with a higher weight compared to the 1RM lat pulldown, both relative to their body mass (Johnson et al, 2009). Another study related the number of chin-up repetitions with 100 % bodyweight, with lat pulldown repetitions at 80 % of 1RM and 1RM lat pulldowns in elite women swimmers (Halet et al, 2009). Results showed that the chin-up repetitions correlated strongly ($r=0.69$) with the 1RM lat pulldown per kg bodyweight, but not with the lat pulldown repetitions at 80 % of 1RM. This indicate that although the chin-up and lat pulldown exercises are similar and strongly correlated, they possibly cannot replace each other completely in a training program (Halet et al, 2009).

EMG comparisons have been made and one study investigated muscle activity in the concentric and eccentric phase between the chin-up and lat pulldown exercises (Doma et al, 2013). The subjects performed chin-up repetitions to failure and did lat pulldown at a load where the equivalent repetitions would lead to failure. Important findings in this study were that the biceps brachii had a higher muscle activity in the concentric phase for the chin-up compared to the lat pulldown. In the eccentric phase the rectus abdominis had a greater

muscle activity in the lat pulldown compared to the chin-up. The results also showed that in the concentric phase both exercises had greater muscle activity in the agonists' biceps brachii and latissimus dorsi compared to the antagonists' pectoralis major and triceps brachii. In the eccentric phase the chin-up had a greater muscle activity in the agonists compared to the antagonists, but in the lat pulldown only the latissimus dorsi had a greater muscle activity compared to the antagonists (Doma et al, 2013).

Although the execution of the chin-up and lat pulldown supposedly activate the same major muscle groups, previous research have demonstrated that there are differences between the exercises. The 1RM chin-ups could be performed with more weight than the 1RM lat pulldowns, relative to bodyweight (Johnson et al, 2009). In addition, chin-up repetitions correlated strongly with the 1RM lat pulldown per kg bodyweight (Halet et al, 2009), and there were differences in both muscle activity and kinematics (Doma et al, 2013). Whether differences exist due to variations in muscle activity between the two exercises is unclear, therefore this study will examine if there are any differences in muscle activity between the chin-up and the lat pulldown at 100 % bodyweight. No study has previously compared muscle activity where the load was 100 % bodyweight in both the chin-up and lat pulldown exercise, which would be a more direct comparison between the two exercises.

1.5 Aim

The purpose of this study was to investigate if the muscle activity in latissimus dorsi, biceps brachii, trapezius pars transversa and rectus abdominis differed between a chin-up and a lat pulldown exercise, both at 100 % bodyweight load.

1.5.1 Research question

- Is there a difference in muscle activity for latissimus dorsi, biceps brachii, trapezius pars transversa and rectus abdominis between a chin-up and a lat pulldown at 100 % bodyweight?
- Which muscle is activated the most in the exercises chin-up and lat pulldown at 100 % bodyweight?

2. Methods

2.1 Subjects

In this study 20 men participated with an average age of 25 ± 3 years. They had at least one year of experience with gym training for a minimum of two times a week. The subjects had control of the execution in the exercises chin-up and lat pulldown and were required to be able to perform five strict chin-ups and five strict lat pulldowns with their bodyweight as a resistance. The subjects were excluded from participation if they had any injuries or past problems which could prevent them from performing their best, nor could they have an illness which affected the body. The subjects were asked not to drink alcohol or take any other substances that could affect their performance, or perform any heavy resistance training for the upper body 24 hours before the test. The subjects were only men because it was difficult to recruit women who fit the inclusion criteria in the amount of time available for this project. The subjects were recruited on social media and on local gyms.

2.2 Study design

The study design was a randomized crossover where half of the subjects started with the chin-up followed by the lat pulldown exercise, and the other half started with the lat pulldown followed by the chin-up. The test protocol for both the chin-up and lat pulldown lasted for approximately 60 to 90 minutes and was completed during one test session performed in a strength and conditioning gym.

2.3 Testing procedures

2.3.1 Preparation

Data for the subjects' age, height, weight and the biacromial distance were collected and thereafter a general warm up on a bicycle for ten minutes followed. The bicycle was chosen because it is an easy warm up routine to perform. Afterwards the subjects got their skin prepared. The skin preparation was done after the warm up because sweat could make the adhesion of the electrodes to the skin inferior (Konrad, 2006, p.15).

2.3.2 Electromyography and maximum voluntary isometric contraction

For measuring the muscle activity a surface electromyography device (WBA Wireless Bioamplifier System, Mega Electronics Ltd., Kuopio, Finland) with associated wireless

electrodes was used. The WBA measured electrical signals from the muscles and it was recorded on an associated computer with the program Megawin Software, Version 3.1 (Mega Electronics Ltd., Kuopio, Finland). The electrodes were pre-gelled Ag/AgCl self-adhesive electrodes model Blue M-00-S (Ambu A/S, Ballerup, Denmark).

For a better connection the skin was shaved and disinfected where electrodes were going to attach. The electrodes were attached on the subjects' right sides to the following muscles, Latissimus Dorsi (LD), Biceps Brachii (BB), Trapezius pars transversa (Tr) and Rectus Abdominis (RA). At each muscle belly two measuring electrodes were attached in the direction of the muscle fibers with an inter-electrode distance of 2 cm with a reference electrode placed perpendicular to the measuring electrodes (figure 1). The electrodes remained on the muscles during the whole test session. Since the EMG is sensitive for electrical signals, no radio transmitting devices, medical devices like x-ray machines or different neon light were present during the time of the tests (Criswell, 2010, p.35). After data collection the root mean square (RMS) function was used to smooth the raw data to make it easily analyzable. The RMS is a standard process in kinesiological EMG (Konrad, 2006, p.29) and after RMS was applied the average EMG values could be collected.

To increase EMG validity it is recommended to use maximum voluntary isometric contraction (MVIC) as a normalization test. The MVIC test gives a maximum EMG value which can be used in relation to the measured EMG during the exercises to obtain the percentage activation a specific muscle produce during a specific exercise (Halaki et al, 2012; Criswell, 2010, p.50). The subjects performed a 6 s isometric contraction three times for each muscle investigated with a rest period of one min between sets. The three peaks from the MVIC tests were averaged and used as a maximal value in relation to the measured EMG values. This resulted in new variables which showed percentage of how much muscle activity a specific muscle produced in a specific exercise.

The isometric contractions were performed using MVIC standardization (Konrad, 2006, p32-33) and for static resistance the smith machine and lat pulldown machine were used. The MVIC for BB was performed like a bicep curl holding the barbell in the smith machine with the upper arm against a bench. The MVIC for Tr was also done in the smith machine, the subject stood up and performed a shoulder elevation while holding the barbell. For LD the subject was seated at a lat pulldown machine where an isometric pull was performed. The

subject performed the isometric contraction with fully extended arms in the start position of a lat pull. For the BB, Tr and LD the resistance was more than the subject could lift thus making the resistance isometric. For the RA the subject lay on the floor and performed a crunch with the spine at 30 degrees flexion. One test leader pressed the subject down the floor and by resisting the subject's RA got maximum activated (Konrad, 2006, p.33).



Figure 1. Placement of the two measuring electrodes and the reference electrode for latissimus dorsi, biceps brachii, trapezius pars transversa and rectus abdominis.

2.3.3 Protocol

The subjects had a pronated grip both in the chin-up and lat pulldown exercises and the distance between their hands were 1.5 times their biacromial distance (Andersen et al, 2014). Biacromial distance means the distance between the acromion part of each shoulder.

The chin-up started by hanging fully extended in a barbell with straight arms. Thereafter the subjects pulled themselves up until the chin was over the bar (Ronai, 2014). The chin-ups were made strict with a neutral straight position through the lifts, and kipping or swinging (i.e., using the momentum to get over the bar) were not allowed (figure 2). To standardize the execution of the exercises, each of the five repetitions was set to a 2 s concentric phase and a 2 s eccentric phase (total 4 s/repetition) where a metronome was used (Doma et al, 2013). At every metronome signal the subjects were either going to have the barbell at the chin, or fully extended with straight arms for the chin-up and seated upright with straight arms for the lat pulldown. The rest between the chin-ups and the lat pulldowns were three min. To get accustomed to the metronome the subjects were allowed to do two test sets before the measurement started. The subjects were told not to go to failure in these sets. The subjects thereafter completed five strict chin-ups with their bodyweight as a resistance. These repetitions were measured and the three middle repetitions were analyzed for the average muscle activity.

The lat pulldown started in a sitting position at a machine. The subjects held a barbell with straight arms which they pulled down to the chin (Snarr et al, 2015). The barbell was connected by a cord to a stack of weights. The lat pulldowns were made strict which mean that the subjects held the metronome tempo and remained seated upright but still had a neutral body position through the exercise (figure 3). To get accustomed to the metronome the subjects were allowed to do two test sets with a resistance at 65 respective 75 % of their bodyweight before the measurement started. The subjects thereafter completed five strict lat pulldowns with their bodyweight as a resistance. These repetitions were measured and the three middle repetitions were analyzed for the average muscle activity.

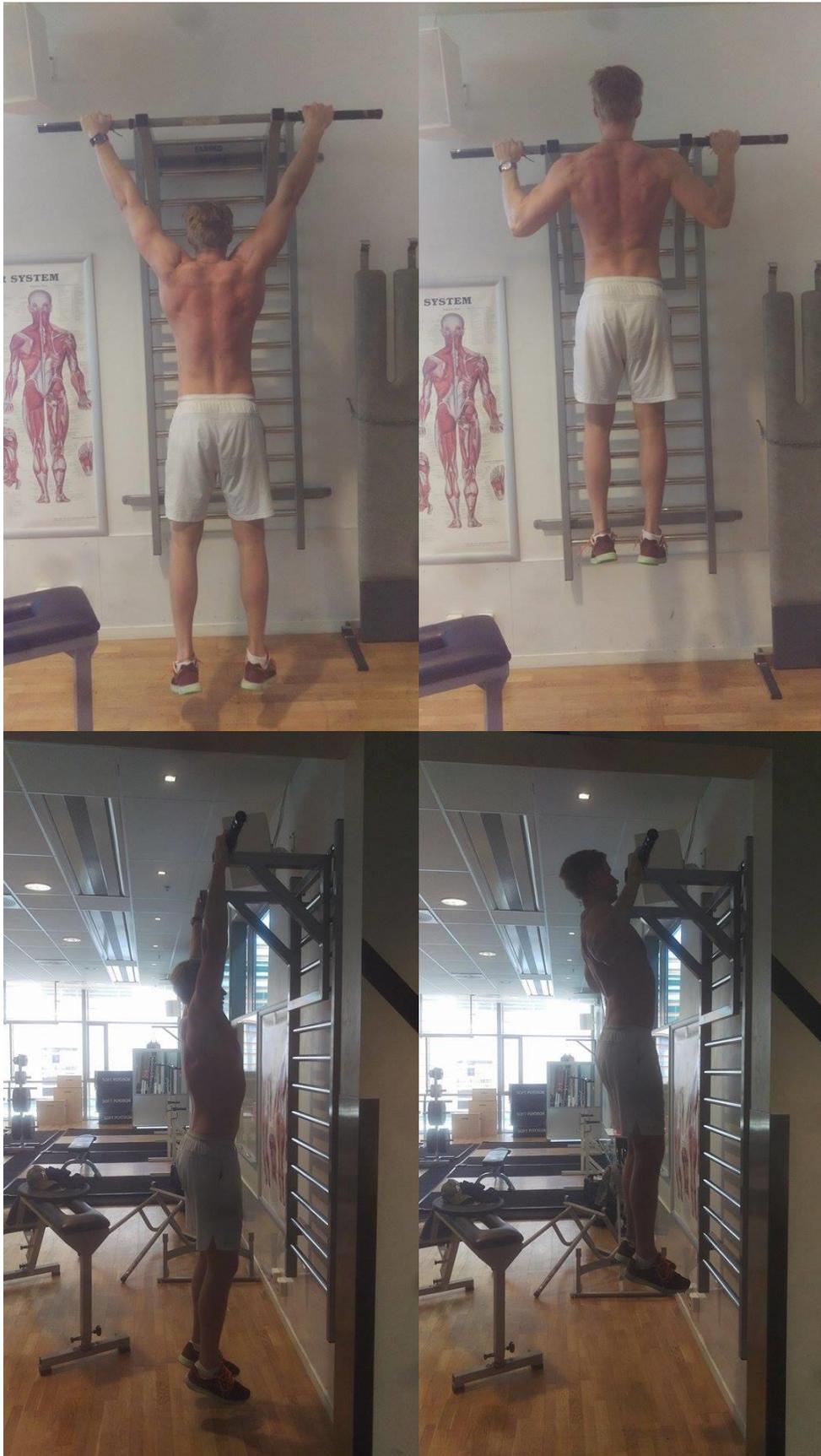


Figure 2. Start and top position of the chin-up exercise.

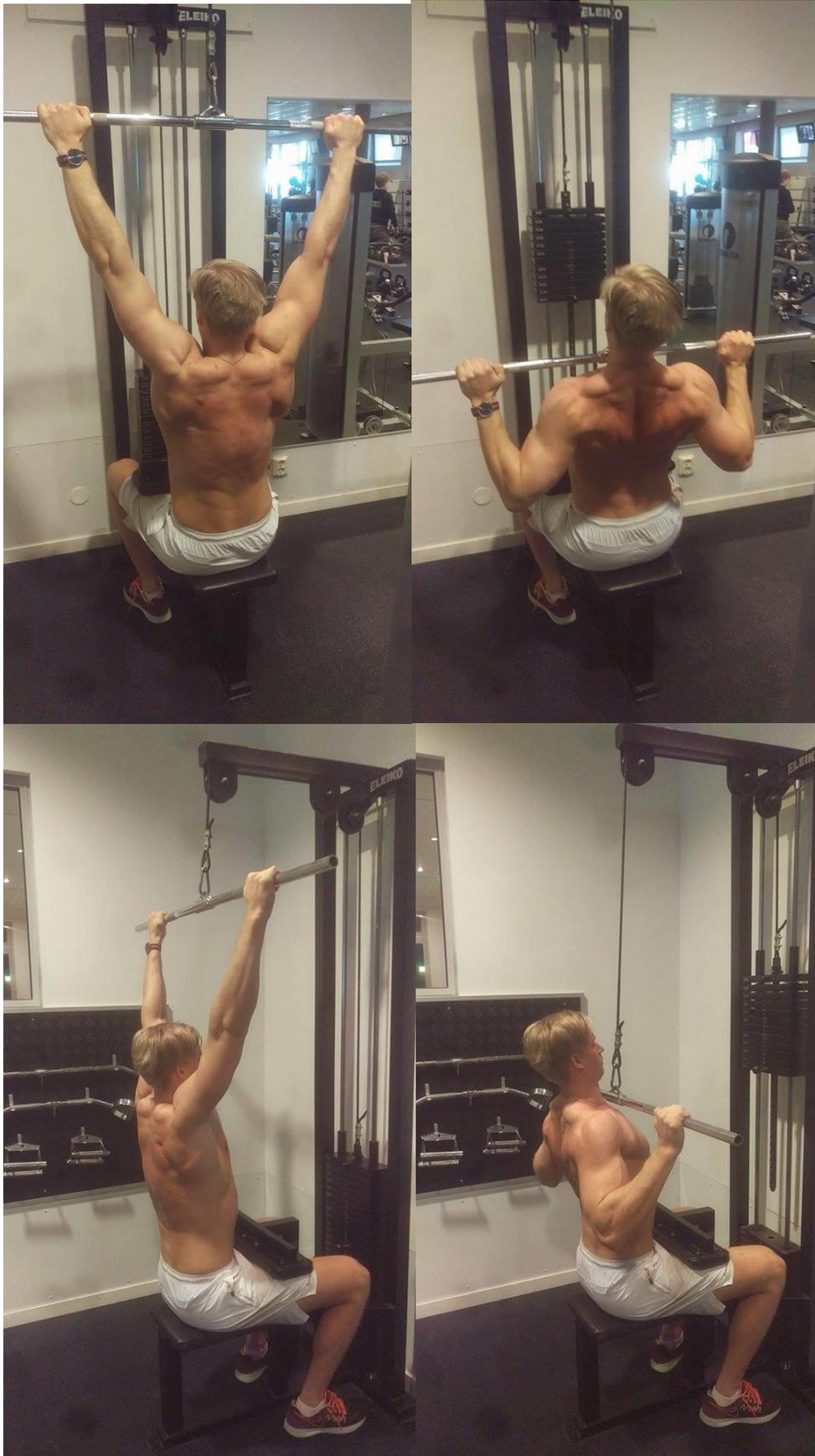


Figure 3. Start and bottom position of the lat pulldown exercise.

2.4 Ethical and social considerations

In this study the ethical considerations from Helsinki declaration were followed. All subjects got information both verbally and written before they signed the informed consent to approve their participation. The information contained the procedures of the study and possible risks. None of the subjects were exposed to danger and they were aware of the small risks and the discomfort that could occur. Their participation was voluntary and the subjects were made aware they could discontinue their participation at any time without any explanation. The data has only been handled by the test leaders and no names or collected data can identify the subjects.

Regardless the level of the practitioner, resistance training has a range of health benefits. It is recommended to perform at least two resistance training sessions per week (Haskell et al., 2007). Recreational, amateurs and professional athletes all have different goals with their resistance training. The amateur's goal might be to generally work out for the health benefits. Then it might be of less importance to use the most complex exercise, or to specifically target individual muscles. Athletes however, involved in sports made up by complex movements will want to have better control over their resistance training so they besides a general strengthening regime, also target specific muscles of particular interest for the sport-specific movements. For those it could be beneficial to perform an exercise which provides a high level of activity in the muscles of interest. Furthermore if an athlete is injured, s/he might need to prioritize a specific muscle or/and avoid to train another one. It could then be beneficial to know which exercise gives the highest amount of activity for a specific muscle. This might also be helpful for coaches when they are going to design a training or a periodization program (McArdle, Katch & Katch, 2015, p.499). The results from this study will contribute with knowledge about the differences in muscle activity for latissimus dorsi, biceps brachii, trapezius pars transversa and rectus abdominis between the exercises chin-up and lat pulldown.

2.5 Statistical analysis

In this study average EMG normalized to MVIC (% MVIC) was used to investigate the level of muscle activity in latissimus dorsi, biceps brachii, trapezius pars transversa and rectus abdominis. To find out if the data were normally distributed or not, the Shapiro Wilks test was used (SPSS version 20, IBM, Chicago, IL, USA). The data were not normally distributed and therefore the non-parametric Wilcoxon test was used to test for statistical significance for the

same muscles between the exercises (chin-up vs lat pulldown). The Friedman's test was used to test for differences in muscle activity between the different muscles in each exercise, and if a difference at the $p < 0.05$ -level was detected an asymptotic significance 2-sided post-hoc test was used for pairwise comparisons to investigate further where differences occurred. The statistical significance level was set to $p < 0.05$ (Jakobsen, Gluud, Winkel, Lange & Wetterslev, 2014). Previous research about muscle activity have reported their results as means and standard deviations (SD). To easier compare the results in this study with previous, data are expressed as group mean values \pm SD.

3. Results

In this study 20 men (mean \pm standard deviation, age, 25.3 ± 3.5 years; height, 180.9 ± 5.8 cm; weight, 82.4 ± 7.8 kg; biacromial distance, 44.0 ± 2.0 cm) participated (table 1).

Table 1. Subject characteristics (n=20) age, height, weight and biacromial distance.

Variable	Mean \pm SD
Age (years)	25.3 ± 3.5
Height (cm)	180.9 ± 5.8
Weight (kg)	82.4 ± 7.8
Biacromial distance (cm)	44.0 ± 2.0

Muscle activity was compared between the chin-up and lat pulldown exercises at 100 % bodyweight for the latissimus dorsi (LD), biceps brachii (BB), trapezius pars transversa (Tr) and rectus abdominis (RA). For the chin-up exercise, the BB had a significantly lower average muscle activity ($p=0.048$) and the RA a significantly higher average muscle activity ($p=0.021$) compared to the lat pulldown exercise. For the two back muscles; Tr and LD no differences for the average muscle activity between two exercises were found (table 2 and figure 4).

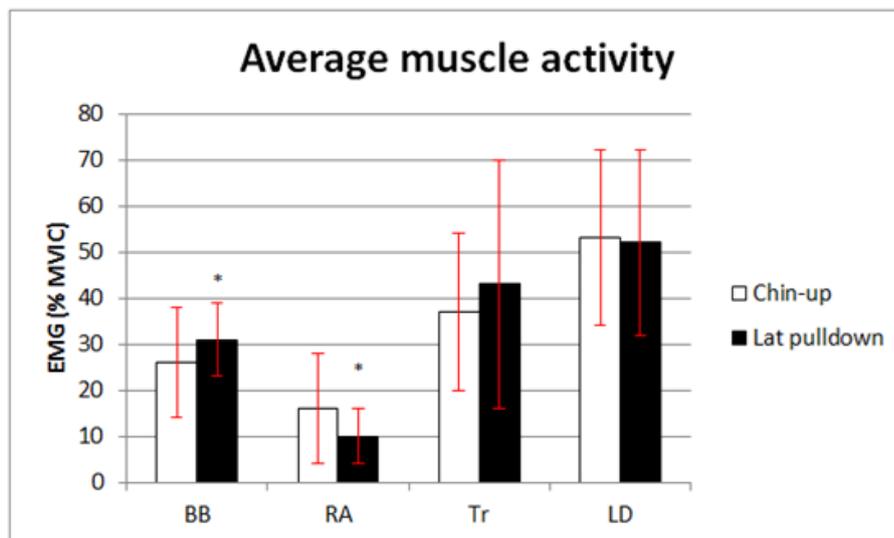


Figure 4. Group mean values (\pm standard deviation) for the average muscle activity in Biceps Brachii (BB), Rectus Abdominis (RA), Trapezius pars transversa (Tr) and Latissimus Dorsi (LD). The values are shown as percentage in relation to MVIC. * Statistically significant different muscle activity compared to chin-up ($p < 0.05$)

The muscles with the highest activation were LD and Tr. The LD had a significantly higher muscle activity in both the chin-up and the lat pulldown compared both to BB (chin-up $p = 0.002$, lat pulldown $p = 0.004$) and RA (chin-up $p = 0.013$, lat pulldown $p = 0.020$). There were no significant difference between the muscle activity for the LD and Tr in both of the exercises (chin-up $p = 1.000$, lat pulldown $p = 0.850$).

Table 2. Mean muscle activity in mV and percent of MVIC with standard deviation (SD) for the Latissimus Dorsi (LD), Biceps Brachii (BB), Trapezius pars transversa (Tr) and Rectus Abdominis (RA). Friedmans test with asymptotic significances (2-sided tests) post-hoc-differences in average muscle activity for the LD, BB, Tr and RA.

	Chin-up		Lat pulldown		Chin-up vs. lat pulldown p-value
	mV	% MVIC	mV	% MVIC	
LD	267(\pm 93)	53(\pm 19)	259(\pm 101)	52(\pm 20)	0.627
BB	650(\pm 228)	26(\pm 12)	620(\pm 239)	31(\pm 8)	0.048
Tr	390(\pm 207)	37(\pm 17)	465(\pm 342)	43(\pm 27)	0.135
RA	114(\pm 134)	16(\pm 12)	66(\pm 62)	10(\pm 6)	0.021
Friedman test, p-value		$p < 0.05$		$p < 0.05$	
Post-hoc-differences					
LD > RA		$p = 0.010$		$p = 0.020$	
Tr > RA		$p = 0.000$		$p = 0.000$	
BB > RA		$p = 0.000$		$p = 0.000$	
LD > BB		$p = 0.002$		$p = 0.004$	
LD > Tr		$p = 1.000$		$p = 0.850$	
Tr > BB		$p = 0.061$		$p = 0.300$	

4. Discussion

The main results from the present study showed that for the chin-up exercise there was a lower average muscle activity for the biceps brachii and a higher average muscle activity for rectus abdominis compared to the lat pulldown exercise. The muscles with the highest activation in the exercises chin-up and lat pulldown were the latissimus dorsi and trapezius pars transversa.

4.1 Discussion of results

The chin-up had a lower average muscle activity for the biceps brachii compared to the lat pulldown which shows the opposite of previous findings by Doma et al. (2013) who found that biceps brachii had the higher average muscle activity both in the concentric and eccentric phase in the chin-up compared to the lat pulldown. In addition the rectus abdominis had a higher average muscle activity in the chin-up compared to the lat pulldown which shows the opposite compared to previous research where rectus abdominis had the highest average muscle activity both in the concentric and eccentric phase in the lat pulldown compared to the chin-up (Doma et al, 2013). The reason for this discrepancy could be due to different standardizations and execution of the chin-ups and lat pulldowns. In the study from Doma et al. (2013) they did not compare 100 % bodyweight between the chin-up and lat pulldown exercises. Instead the subjects did chin-up repetitions to failure and then they performed the lat pulldown with a load where the equivalent repetitions also would lead to failure.

Other differences in set-up between the present study and Doma et al. (2013) was that the hand grip was different where the barbell they used in the chin-up and lat pulldown exercises was bent whereas subjects in our study used a straight barbell (figure 1). The grip width standardization also differed between the two studies where the subjects in Doma et al. (2013) used a grip width which was calculated by measuring the distance between their hands and the seventh cervical vertebrae while holding the arms laterally extended pointed away from the body, whilst in this study a grip width at 1.5 times the biacromial distance were used, however both studies used a pronated grip. It is possible this difference in hand grip could affect the muscle activity for biceps brachii (Youdas et al, 2010; Lusk et al, 2010; Andersen et al, 2014). Another difference between Doma et al (2013) and this study was the time for the repetitions done. In their study there was a 1 s concentric respectively eccentric phase and in this study the time instead was 2 s.

The subjects in Doma et al. (2013) performed their chin-ups with their legs bent instead of hanging fully extended like they did in this study (figure 2). Perhaps this difference could affect the muscle activity for rectus abdominis as its function is flexion (Cael, 2011, p.280). When performing a chin-up the lower extremity hangs freely compared to the lat pulldown where the lower extremity is in a locked position (figure 2 and 3). In our study the rectus abdominis was activated more in the chin-up, possibly to stabilize the lower extremity and make the body maintain a neutral straight position through the lift, and this need for stabilization could be slightly alleviated if the legs are bent during the chin-up as done in Doma et al. (2013).

Previous research demonstrated that for the chin-up exercise the displacement of the shoulder was greater compared to the lat pulldown exercise (Doma et al, 2013). This means that in the end of concentric phase, the shoulder joint was in a higher position compared to the starting position with straight arms, for the chin-up compared to the lat pulldown. The different displacement might affect the muscle activation and perhaps it could explain the differences in muscle activity for the biceps brachii between the chin-up and the lat pulldown in this study, however it does not explain the different results from this study compared with Doma et al. (2013).

For both of the exercises chin-up and lat pulldown, the latissimus dorsi and trapezius pars transversa were found to be the muscles with the highest average muscle activity. The latissimus dorsi had a significantly higher activation compared to biceps brachii and rectus abdominis, but not to trapezius pars transversa. This partially confirms previous research where the latissimus dorsi had the highest average muscle activity in the chin-up (Youdas et al, 2010) and also in the lat pulldown (Lusk et al,2010).

4.2 Discussion of the methods

MVIC is an important normalization test to increase EMG validity. It is important for comparison purposes that all investigators use the same MVIC for the same muscles (Halaki et al, 2012; Criswell, 2010, p.50). The MVIC tests performed in this study (Konrad, 2006, p32-33) might not be the optimal normalization test, since subjects exceeded their peak MVIC in some of the muscle contractions during the testing. There are differences in both skeletal and muscle structures among the population which gives different biomechanical conditions (Marieb & Hoehn, 2007, p.328). This perhaps can affect the angle where the muscle can contract and produce the greatest amount of activity. If the subjects instead of these MVIC

tests would have done a set to failure with full range of motion (ROM), perhaps the muscle activity would have been higher and more close to 100 %? However, standardization is important for comparisons between different studies, therefore it is important to follow the normalization tests as it is today. Hopefully in the future there will be other normalization tests which provides values closer to 100 %.

A source of error could have been the subcutaneous fat tissue which can lower the recorded EMG activity. This subcutaneous tissue is between the electrodes on the skin and the contracting muscle, and the greater amount of this fat tissue the lower recorded EMG activity (Hemingway Biedermann, & Inglis, 1995), although performing MVIC and relating the EMG to this, can to a large degree take care of this concern. Another source of error could be crosstalk which is a phenomenon when the EMG measures not only from the specific muscle of interest but from the one or others next to it. It is almost impossible to isolate the EMG to one specific muscle (Criswell, 2010, p6). In this study we followed the standard recommendations concerning the application of the electrodes which hopefully minimized the crosstalk source of error.

Something else that could have affected the results in this study is the phenomenon “mind muscle connection” which means that when exercising and concentrating on a specific muscle working, the muscle will have a higher amount of muscle activity (Schoenfeld & Contreras, 2016). In this study that could be a source of error if some of the subjects applied this principle while performing the MVIC or/and the chin-up and lat pulldown exercises.

In this study comparisons between the chin-up and lat pulldown exercises was done at 100 % bodyweight. Previous research has demonstrated that the performance in 1RM lat pulldown is less than the 1RM chin-up relative to the bodyweight (Johnson et al, 2009). The 1RM chin-up was performed with more weight than the 1RM lat pulldown. Based on previous research, if comparing 100 % bodyweight this gives different percentages of 1RM. In this case the lat pulldown had a higher percentage of 1RM compared to the chin-up. Several of the subjects in this study announced that the lat pulldown repetitions were much harder to perform than the chin-up repetitions. Is it possible to draw conclusions about differences in muscle activity at 100 % bodyweight then? One way to investigate this further would have been to include a scale of perceived effort where subjects could have rated how hard the different exercises were to perform. However, in this study we did not realize this dilemma until after the data was already collected.

4.3 Conclusions

For the chin-up exercise, the biceps brachii had a significantly lower average muscle activity ($p=0.048$) and the rectus abdominis a significantly higher average muscle activity ($p=0.021$) compared to the lat pulldown exercise. For the two back muscles; trapezius pars transversa and latissimus dorsi no differences for the average muscle activity between two exercises were found. The LD had a significantly higher muscle activity in both the chin-up and the lat pulldown compared both to BB ($p<0.01$) and RA ($p<0.05$) but not to Tr ($p>0.8$).

These findings can be useful for all individuals who perform resistance training, all at different levels. The lat pulldown exercise can preferably be used if the goal is to strengthen biceps brachii, and the chin-up can be the choice if the goal is to perform an exercise which activates more rectus abdominis. However if the goal is to activate latissimus dorsi or/and trapezius pars transversa the findings in this study showed that the choice of exercise does not significantly matter if performed at 100 % bodyweight.

This study confirms that there are differences in muscle activity between the two exercises, both at 100 % bodyweight. The differences could be due to different biomechanical factors, but more research is needed to confirm this.

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Appendices

Informed consent



**HÖGSKOLAN
I HALMSTAD**

Skillnader i muskelaktivitet under övningarna chin-up kontra latsdrag.
En elektromyografisk studie.

Informationsblad

Hej, vi är två studenter från Biomedicinprogrammet med inriktning fysisk träning. Vi studerar sista året på Högskolan i Halmstad och ska nu påbörja vårt examensarbete. Som examensarbete har vi valt att fördjupa oss inom skillnader i muskelaktivitet vid utförande av två olika övningar inom styrketräning och vi undrar nu om du skulle vara intresserad av att ställa upp som deltagare i denna undersökning.

Syfte

Syftet med denna studien är att undersöka om det finns några skillnader i muskelaktivitet för chin-up respektive latsdrag. Frågeställningen som används är följande:

-Finns det några skillnader i muskelaktivitet för de breda ryggmusklerna, kappmuskeln, biceps och de ytliga magmusklerna mellan övningarna chin-up och latsdrag?

Bakgrund

Chin-up och latsdrag är två stycken populära övnignar på de flesta gym världen över. Chin-up genomförs genom att man hänger fritt med båda händerna i en stång och därefter häver sig upp tills hakan är över stången. Här används kroppsvikten som motstånd. Latsdrag är en motsvarande övning fast istället för att hänga fritt i en stång sitter man ned i en maskin och håller om en skivstång som man istället drar ned till hakan. Här används inte kroppsvikten utan ett externt viktmagasin. Vid mätning av muskelaktivitet används vanligtvis ett intrument som kallas "EMG" (elektromyografi). Testpersonerna får bära elektroder på kroppen som fästs mot de muskler som ska mätas, elektroderna mäter elektriskt aktivitet i musklerna. När personen sedan aktiverar musklerna under ett arbete skickar elektroderna vidare information till en dator som kan se hur pass mycket musklerna aktiveras.

Genomförande

Alla tester kommer genomföras vid ett tillfälle på Idrottscentrum vid Halmstad högskola. Den beräknade tiden för testet är ungefär en timme. Delar av testerna kommer ske utan något plagg på överkroppen för att elektroderna ska kunna fästas.

Vid testerna kommer din vikt, längd och ålder inhämtas. Du kommer få genomföra en tio minuter långt uppvärmning på en cykel. Därefter ska elektroder placeras på huden vid de musklerna som ska mätas. Det kommer sitta tre elektroder vid varje muskel och de fyra olika musklerna som ska mätas är den breda ryggmuskeln, kappmuskeln, biceps och den ytliga magmuskeln. Innan elektroderna placeras kommer området rakas och desinficeras i syfte att elektroderna ska fästas bättre. När elektroderna är på plats kommer du få utföra fem stycken chin-ups samt latsdrag på olika procent av kroppsvikt.

Risker

Riskerna med att medverka i denna studien anses minimala men det kan uppstå en viss känsla av obehag vid applicering och borttagning av elektroderna samt vid rakning av de delar där elektroderna ska fästas. De olika momenten övervakas av testledarna som har stor kunskap inom området.

Krav för deltagande

För att delta i studien ska du uppfylla nedanstående krav:

- Kunna utföra fem strikta chin-ups. *Strikt i det här fallet innebär att du som utför övningen häver dig upp till hakan utan vare sig sving eller med hjälp av underkroppen.*
- Ha tränat styrketräning regelbundet minst ett år. *Regelbundet i detta fall innebär att du ska ha tränat två till tre gånger i veckan.*
- Känna dig van att utföra de båda övningarna chin-ups och latsdrag. *Van innebär att du har utfört de båda övningarna flertalet gånger.*
- Vara frisk och får inte ha någon nuvarande eller tidigare skada alternativt sjukdom som hindrar dig från att prestera maximalt.
- Du får inte ha utfört någon tung fysisk aktivitet för övre extremitet 24 timmar innan testtillfället.

Hantering av data och sekretess

Informationen kommer endast behandlas av testpersonalen och datan kommer hanteras konfidentiellt. Viss data kan komma att publiceras men inget som kan göra att du kan bli identifierad. Förvaring av data sker på ett USB-minne som finns inlåst på Högskolan i Halmstad dit labbpersonalen är de enda som har tillgång. Du som försöksdeltagare har rätt att vid förfrågan få ut insamlad data om dig själv.

Urval

Du har blivit tillfrågad att medverka i studien för att du tillhör den grupp som efterfrågas till studieupplägget. Du är en man mellan 18-35 år som har styrketränat regelbundet minst ett år och kan utföra fem stycken strikta chin-ups.

Frivillighet

Medverkan i studien är helt frivillig och du kan när som helst välja att avbryta din medverkan utan att ange orsak och utan att det blir några påföljder.

Nyttan med projektet är att du bidrar till en ökad förståelse hur muskelaktiviteten ser ut för de båda övningarna. Detta kan i sin tur appliceras vid val av till exempel träningsprogram eller periodiseringsschema.

Kontaktuppgifter vid frågor och funderingar

Isak Löfquist

Niklas Ekberg

Handledare på Högskolan i Halmstad: Charlotte Olsson

Nedan ger du ditt samtycke att delta i den studie som undersöker msukelaktivering vid chin-ups och latsdrag. Läs igenom informationen noggrant och ge ditt medgivande genom att signera ditt namn nederst på sidan.

Jag medgiver att jag:

- Har tagit del av informationen kring studien och förstår vad den innebär.
- Har fått ställa de frågor jag önskar och vet vem som är ansvarig huvudman om jag har fler frågor.
- Deltar frivilligt i studien och förstår varför jag har blivit tillfrågad.
- Vet att jag när som helst kan avbryta mitt deltagande i studien utan att ange orsak.
- Jag intygar att jag har läst det informerande samtycket och tagit del av informationen kring studien. Jag förstår vad deltagandet i studien innebär och stället upp frivilligt.
- Jag tillåter att mina personuppgifter registreras enligt den informationen jag har fått och att insamlad data om mig förvaras av studieansvarig.

Deltagarens underskrift

Deltagarens namn (text)

Datum och plats



My name is Isak and I have studied Exercise Biomedicine for 3 years. It's been a great time with lot of fun stuff together with my classmates. Learned so much about nutrition and training in only 3 years. Thank you all!



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