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Muscle activation during the chin-up exercise versus the lat-pulldown exercise using different workloads

An Electromyography study

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Abstract

Background

Two commonly used strength training exercises are the chin-up- and the lat-pulldown exercise. Both exercises are performed by using similar movement patterns and by using the same primary muscles. Previous research has shown that each exercise can exhibit unique training stimulus and should not be considered interchangeably. However, there is limited research regarding comparison of muscle activation between the exercises. Knowing the amount of muscle activation when performing the exercises, can help strength training participants to choose exercise and relative workload according to the specific muscles they want to target.

Purpose

This study sought to compare muscle activation (measured as average) in m. latissimus dorsi (LD), m. biceps brachii (BB), middle m. trapezius (TR) and m. rectus abdominis (RA) between performing the chin-up at 100% of participants' individual bodyweight (BW) with lat-pulldown at 50%-, 65%- and 75% BW.

Methods

Twenty strength trained male participants (25.0 ± 3.3 yr; 181.0 ± 5.8 cm; 82.0 ± 7.8 kg) were examined during the study. Surface electromyography (SEMG) was collected from LD, BB, TR & RA during the exercises. Average muscle activation was expressed as percentage of maximum voluntary isometric contraction (%MVIC). Exercise execution was as identical as possible for both exercises and was performed using pronated handgrip and a grip width equal to 1.5 times the participants individual biacromial distance.

Results

Statistically significant ($p<0.05$) increases in average muscle activation were found in LD, BB and RA during chin-up 100% BW compared to lat-pulldown at 50%-, 65% and 75% BW. However, for TR no significant difference ($p=0.145$) was found between chin-up 100% BW and lat-pulldown when performed at 75% BW.

Conclusion

These results indicate that performing the lat-pulldown using workload somewhere between 75-100% BW can exhibit the same muscle activation as performing the chin-up at 100% BW.

Keywords: Strength training, Surface electromyography, Muscle activation, Chin-up exercise, Lat-pulldown exercise, Different workloads, Randomisation, Cross-over, Observational

Abstrakt

Bakgrund

Två vanligt förekommande styrketräningsövningar är chin-up och lat-pulldown. Övningarna utförs genom att använda liknande rörelsemönster och primära muskler, dock har tidigare forskning visat att varje övning kan ge unik träningsstimulans och därmed inte borde ses som direkt utbytbara. Det finns begränsad forskning som jämfört muskelaktivering emellan övningarna. Ökad kunskap angående muskelaktivering i övningarna kan hjälpa styrketränings utövare att välja övning och motstånd enligt de specifika muskler de vill träna.

Syfte

Denna studie syftade till att jämföra muskelaktivering i m. latissimus dorsi (LD), m. biceps brachii (BB), mellersta m. trapezius (TR) och m. rectus abdominis (RA) mellan att utföra chin-up med 100% av deltagarnas individuella kroppsvikt (BW) i motstånd och lat-pulldown utfört med 50%-, 65%- och 75% BW i motstånd.

Metod

Tjugo styrketränande manliga deltagare (25,0 ± 3,3 år; 181,0 ± 5,8 cm; 82,0 ± 7,8 kg) undersöktes under studien. Surface elektromyografi (SEMG) användes för att mäta muskelaktivering i LD, BB, TR och RA. Genomsnittlig muskelaktivering uttrycktes som procent av maximal frivillig isometrisk kontraktion (%MVIC). Utförandet var samma för båda övningar och utfördes genom att använda pronerat handgrepp och 1.5 gånger av deltagarnas individuella biacromial distans i greppbredd.

Resultat

I tre av fyra muskler som undersöktes hittades statistiskt signifikant ($p < 0.05$) ökning i genomsnittlig muskelaktivering i BB, LD och RA vid utförande av chin-up 100% BW jämfört med lat-pulldown 50%-, 65%- och 75% BW. Ingen signifikant skillnad hittades i TR ($p = 0.15$) mellan utförandet av chin-up 100% BW och lat-pulldown 75% BW.

Konklusion

Resultaten från studien indikerar att genomförande av lat-pulldown med ett motstånd någonstans emellan 75–100% BW kan uppvisa samma muskelaktivering som vid genomförande av chin-up 100% BW.

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Background

1.1 Strength training

Strength training has multiple positive health effects on all kinds of populations, regardless of training level, age or sex (Cardinale, Newton & Nosaka, 2011; Hegedus, Hardesty, Sunderland, Hegedus & Smoliga, 2016; Garber et al, 2011). Strength training has been shown to have positive effects on sport performance, for aesthetic purposes and in injury rehabilitation (Mcardle, Katch & Katch, 2014). Even for patients with lifestyle related diseases strength training can be used as a tool to improve overall quality of life (Artero, Lee, Lavie, Romero, Sui, Church & Blair, 2012; Giuliano, Karahalios, Neil, Allen & Levinger, 2017; Jewiss, Ostman & Smart, 2016). Strength training induces positive physiological health effects by increased skeletal muscle hypertrophy, increased tendon stiffness, increased net collagen syntheses, increased bone density and neural adaptions by increment in motor neuron recruitment and firing frequency (Cardinale et al, 2011).

Strength gains obtained from strength training are specific to the muscles activated during the exercise, a relationship known as the specific adaptations to imposed demands (SAID) principle (Koyama, Kobayashi, Suzuki & Enoka, 2010; Ratamess et al, 2009). Based on the SAID principle, strength training participants choose their training exercise in relation to the specific muscle they want to train. In order to achieve strength gains in the targeted muscle the participant has to overload the muscle, which is achieved by choosing a training load which is above the participant current neutral training level (Zatsiorsky & Kraemer, 2006). This relationship is known as the overload principle and can be achieved by participants choosing a combination of frequency-, intensity- and duration in their training which is above their current training level (Mcardle et al, 2014). Different types of training methods can be used to achieve a strength gain, including barbells, machines or using own bodyweight as workload (Sands, Wurth & Hewit, 2012).

1.2 Muscle contraction

During strength training, a repeated execution of muscle contractions is performed. A muscle contraction is initiated with an action potential propagating along a motor neuron which intervenes with multiple muscle fibres which together is called a motor unit (Cardinale et al, 2011). The motor neurons endplates release the neurotransmitter acetylcholine into the neuromuscular junction where it attaches to receptors at the sarcolemma of the muscle fibres. This leads to the forming of a new action potential along the sarcolemma and stimulation of the sarcoplasmic reticulum to release calcium into the sarcoplasm. When the calcium reaches the contractile proteins and attaches to tropomyosin on actin, myosin and actin form a crossbridge and crossbridge cycling begin, forming a muscle contraction. For each motor neuron action potential stimulation, all muscle fibres in the motor unit contract simultaneously (Haff & Triplett, 2016).

One way to detect the muscle activation that results from the muscle cells´ depolarization- and repolarization is by using surface electromyography (SEMG). The SEMG measure muscle activation through electrodes superficially placed on the targeted muscles, the electrodes record changes in the electric activity (voltage) that results from the muscles cells de- and repolarization (Mcardle et al, 2014). The muscle contraction generates increased muscle activation if more motor units are recruited and/or the motor neuron stimulation increases, which increases the amount of recorded electric activity (voltage) from SEMG measurements (Cardinale et al, 2011).

Usually the recorded SEMG muscle activation is presented in relation to the maximum voluntary isometric contraction (MVIC) to enable easier comparability of collected data (Youdas, Amundson, Cicero, Hahn, Harezlak & Hollma, 2010). Studies investigating muscle activation in strength training often use SEMG as a technique for comparing the muscle activation in different muscles and/or different exercises. Examples of previous research's applications are studies examining coordination of shoulder muscles (Brown, Wickham, McAndrew & Huang, 2007), effects of the squat exercise (Caterisano, Moss, Pellinger, Woodruff, Lewis, Booth & Khadra, 2002) and muscle activation during forced expiratory resistance (Ito, Ogava, Ogi, Matsunaka & Horie, 2016).

1.3 Upper body strength exercises

Upper body strength training can be performed using a broad variation of different exercises, including machines with self-selected workload or using participant own individually bodyweight as workload (Cardinale et al, 2011). Chin-up is an exercise were participant use their own bodyweight as workload, the exercise is considered to be a strength training exercise usually used as a tool for determining upper body strength (Youdas et al, 2010; Antinori, Felici, Figura & Marchetti, 1998). The chin-up exercise consists of vertically pulling the body up towards a fixed horizontal bar until the chin is over the bar. During the concentric phase of the exercise the participant flexes the elbow while simultaneously adducting the shoulder until the chin is over the bar, which is followed by the eccentric phase where the participant fully extends the elbows while simultaneously abducting the shoulders until reaching start position (Youdas et al., 2010). Primary muscles activated during the chin-up exercise are m. latissimus dorsi, m. trapezius and m. biceps brachii (Leslie & Comfort, 2013; Dickie, Faulkner, Barnes, & Lark, 2017).

Lat-pulldown exercise is conducted using a resistance machine and considered to be a similar exercise to the chin-up exercise and usually used as substitute because of the involvement of the same primary muscles during the both exercises (Johnson, Lynch, Nash, Cygan & Mayhew, 2009). Lat-pulldown exercise consists of pulling a bar fixed to an external load down towards the upper chest in a sitting position (Sperandei, Barros, Silveria-Junior & Oliverias, 2009). In the concentric phase the participant flexes the elbows while simultaneously adducting the shoulders until the bar is below the chin, which is followed by the eccentric phase where the participant fully extends the elbows while simultaneously abducting the shoulders until the bar reaches start position (Snarr, 2015). The lat-pulldown exercise enables the participant to self-select workload from light to heavy using external load, which contrasts with the chin-up exercise where the participant´s individual bodyweight serves as workload.

Both the chin-up and the lat-pulldown are exercises used by a diverse population practicing strength training, both in professional- and recreational training, as well for rehabilitation purposes. The lat-pulldown exercise can be used as a substitute for the chin-up exercise in participants who cannot perform the chin-up exercise, due to the high upper body strength that is required to perform the exercise (Doma, Deakin, & Ness, 2013). However, the exercises are not completely interchangeable since each exercise can exhibit unique training stimulus in specific muscles. A previous study compared the one repetition maximum (1RM) expressed in relation to the bodyweight (BW) in men- and women executing the lat-pulldown exercise with the chin-up exercise and found greater correlation in men ($r=0.78$) compared to women ($r=0.44$). Men exhibited chin-up 1RM equal to 1.16 ± 0.15 BW versus lat-pulldown 1RM equal to 0.93 ± 0.17 BW while women exhibited chin-up 1RM equal to 0.73 ± 0.09 BW versus lat-pulldown 1RM equal to 0.55 ± 0.11 BW. The conclusion drawn for the study is that although the exercises have similarities considering motion and primary muscle activation, they should not be used interchangeably (Johnson et al, 2009).

1.4 Comparison of chin-up- and lat-pulldown exercise

Previous studies which compare muscle activation between the chin-up- and lat-pulldown directly are limited. Most research has focused on the two exercises isolated, or compared how differences in grip technique and grip width impact muscle activation in the two exercises. Where the lat-pulldown exercise has been shown to have increased muscle activation in m. latissimus dorsi using the pronated grip (the palm of the hand directed away from the face) compared to the supinated grip (the palm directed towards the face) (Lusk, Hale & Russel, 2010; Signorile, Zink & Szwed, 2002; Lehman, Buchan, Lundy, Myers & Nalborczyk, 2004). In addition, no difference was found in m. trapezius and m. biceps brachii between using the supinated grip compared to using the pronated grip (Lusk et al, 2010; Lehman et al, 2004). In the present study, the pronated grip was chosen. Furthermore, the effects of using different grip widths during lat-pulldown exercise were investigated and showed increased muscle activation in m. biceps brachii during medium grip width (1.5 times biacromial distance) compared to narrow grip width (1.0 times biacromial distance) (Andersen, Fimland, Wiik, Skoglund & Saeterbakken, 2014). Thus, 1.5 times biacromial distance was chosen in this study. Another study has shown that training experience can affect muscle activation during execution of the lat-pulldown exercise. Increased muscle activation was recorded when participants were given verbal instructions how to properly execute the exercise compared to when no instructions were given (Snyder & Leech, 2009).

Increased muscle activation was found in m. biceps brachii during the chin-up exercise using the supinated grip compared to using the pronated grip, whereas increased muscle activation in the m. trapezius was found using the pronated grip (Youdas et al., 2010). Other studies have shown results indicating that grip alternations don´t alter muscle activation during the chin-up exercise (Dickie et al, 2017).

Previous research that compared the chin-up and lat-pulldown exercises directly by using the same execution and standardized workload between the exercises (100% of bodyweight during chin-up, and 79 ± 11.6 kg during lat-pulldown) have found increased muscle activation in m. biceps brachii during the chin-up exercise and increased muscle activation in m. rectus abdominis during the lat-pulldown exercise (Doma et al, 2013). In addition, a parallel study to the present one, investigated muscle activation in the chin-up and lat-pulldown exercises at 100% bodyweight and found increased muscle activation in m. rectus abdominis during the chin-up exercise when compared to the lat-pulldown. In addition, increased muscle activation in m. biceps brachii was found during lat-pulldown compared to chin-up, while no difference was found in m. latissimus dorsi and middle m. trapezius between exercises (Lofquist, personal communication, 2017).

Since the previous research comparing the chin-up- and the lat-pulldown exercises is limited and mostly have studied the two exercises isolated, a study comparing muscle activation between the chin-up- and lat-pulldown exercise have been endorsed (Johnson et al, 2009).

This study sought to identify differences and similarities in primary muscle activation by comparing the chin-up exercise and the lat-pulldown exercise using the same execution during both exercises. Also, to identify how using different workloads during the lat-pulldown exercise affect primary muscle activation compared to the chin-up exercise. If participants know the amount of muscle activation in specific muscles when performing the chin-up exercise compared to performing the lat-pulldown exercise at different workloads. Participants can choose exercise and relative workload during the lat-pulldown exercise according to the specific muscle they want to target. Earlier studies have shown that 1RM relative to bodyweight in the chin-up exercise does not equal the 1RM in lat-pulldown exercise and the muscle activation between chin-up and lat-pulldown at 100% bodyweight does to give similar muscle activation patterns (Johnson et al, 2009; Lofquist, personal communication, 2017). However, no previous study has tried to estimate at what workload relative to bodyweight is lat-pulldown equal to the chin-up at 100% bodyweight regarding muscle activation in specific muscles.

1.5 Aim

The purpose of this study was to compare muscle activation (measured as average muscle activation) in m. latissimus dorsi, m. biceps brachii, middle m. trapezius & m. rectus abdominis between performing the chin-up exercise at 100% bodyweight workload- and lat-pulldown exercise at 50%-, 65%- & 75% bodyweight workload.

1.5.1 Research questions

Research question 1. Are there differences in m. latissimus dorsi average muscle activation between performing chin-up at 100% bodyweight compared to performing lat-pulldown exercise using 50%-, 65% or 75% bodyweight as workload?

Research question 2. Are there differences in m. biceps brachii average muscle activation between performing chin-up at 100% bodyweight compared to performing lat-pulldown exercise using 50%-, 65% or 75% bodyweight as workload?

Research question 3. Are there differences in middle m. trapezius average muscle activation between performing chin-up at 100% bodyweight compared to performing lat-pulldown exercise using 50%-, 65% or 75% bodyweight as workload?

Research question 4. Are there differences in m. rectus abdominis average muscle activation between performing chin-up at 100% bodyweight compared to performing lat-pulldown exercise using 50%-, 65% or 75% bodyweight as workload?

Methods

2.1 Participants

Twenty well trained men (table 1) were recruited to partake in the study. All participants fulfilled the following inclusion criteria: The participants should A) have no previous or current health issues that would affect performance or health during the test session, B) have gym training experience including been training for at least three times a week the last three years but no longer than five years, C) have refrained from any form of training activity one day before the test was performed, D) be able to perform a minimum of five consistent strict repetitions of chin-ups without any rest, E) be accustomed performing the chin-up exercise and lat-pulldown exercise and lastly signed an letter of consent.

Table 1. Description of participants´ age, length, weight and biacromial width.

Variable	**Mean ± SD**	**Range**
Age (years)	25.3 ± 3.5	19-35
Length (cm)	180.9 ± 5.8	172-194
Weight (kg)	82.4 ± 7.8	67-95
Biacromial width (cm)	44.0 ± 2.0	40-47

2.2 Electromyography

Surface electromyography was used in this the study, which has been validated as method to measure skeletal muscle activation (Huebnera, Bernd, Schenka, Schollea & Ander, 2014; Arabadzhiev, Dimitrov, Dimitrova & Dimitrov, 2010). Placement of electrodes (Ag/AgCl Blue M-00-S, Ambu A/S, Ballerup, Denmark) was done according to recommendations by Konrad (2006). An inter-electrode distance of 2 cm was used. Electrodes and the reference electrode were placed superficially on the muscle bellies on m. latissimus dorsi, m. biceps brachii, middle m. trapezius & m. rectus abdominis along the muscle fibre direction (figure 1). A unilateral, right side EMG electrode placement was used on all participants. Problems considering validity from SEMG measurements can emerge if participants have high subcutaneous fat mass, wet skin or if deviation from recommended electrode placement occur (Huebnera et al., 2014; Cardinale et al, 2011). To ensure a good measurement signal all participants´ skin was wiped with alcohol and if needed shaved before placing the electrodes. Also, the placement of electrodes was carried out by the same examiner on all participants to ensure reliability. MegaWin wireless BioAmplifier system (ME6000, Mega Electronics Ltd, Kuopio, Finland) was used to record and collect raw muscle activation data. Root mean square was used to smooth raw muscle activation data, which is the recommended method and was performed by using MegaWin PC-software (3.1) (Konrad, 2006).

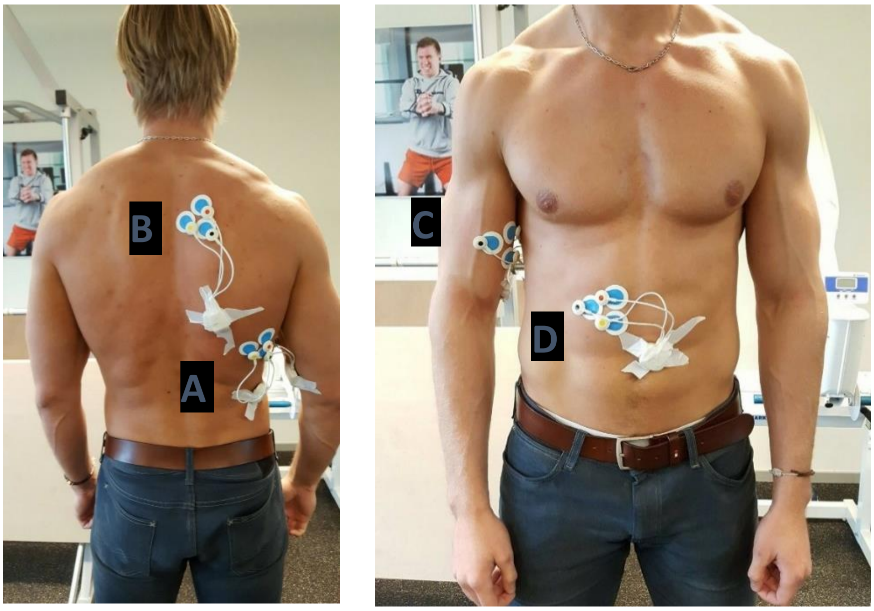

Figure 1. Illustration of electrode placement, A= m. latissimus dorsi; B= middle m. trapezius; C= m. biceps brachii; D= m. rectus abdominis.

Maximum voluntary isometric contraction (MVIC) was performed on the targeted muscles using maximum isometric lat-pulldown-, biceps curl-, shoulder extension- and sit-up exercise (For m. latissimus dorsi, m. biceps brachii, middle m. trapezius & m. rectus abdominis respectively) (Konrad, 2006). All MVIC tests were performed according to Konrad (2006) recommendations by three sets of six seconds long isometrics maximum contraction on external load, followed by one minute rest between sets. The average of the peak values from each set was used and set as a reference as the 100% of muscle activation in the specific muscle. Using the MVIC as reference value to recorded muscle activation has been endorsed in contrast to using other reference values (Burden, 2010).

2.3 Study protocol

The research was performed as a randomised cross-over observation study and figure 2 describes the test procedure and order of events that were used in the study.

Participants (n=20) were randomised in two groups to determine which exercise (lat-pulldown or, -chin-up) the participants would execute first. All participants had their length, weight (MPB 300K100P, Kern, Balingen, Germany) and biacromial width measured (table 1). The biacromial width of each participant was multiplied by 1.5 which gave the individual grip width that was used during both the lat-pulldown- and the chin-up exercise. The participants´ individual grip width was indicated by using tape markers. The individual grip width was used to standardise the participants´ execution during both exercises and has been used in previous studies (Andersen et al, 2014). The participants´ were given 10 minutes of general warm-up, performed on a bike (Monark 828E, Monark Exercise, Varberg, Sweden) with self-selected resistance. After warmup, the electrodes was attached and the MVIC test conducted (see above).

1 **Measurement:** Length-, weight-, and biacromial width measured

2 **Warmup:** 10 minutes general warm-up, performed on a bike, with self-selected resistance

3 **MVIC test:** Maximum voluntary isometric contraction measurement. 3 sets x 6 seconds for each muscle. One minute rest between each set.

4 **Rest**: 3 minutes

5 **Lat-pulldown exercise*:** Performed in order and by using workload equal to 50%-, 65%- and 75% of participants' bodyweight (BW). 5 reps x 3 sets, 3 minutes rest between each set. Grip width: 1.5* participant individual biacromial width. Rate of performance: 4 seconds for each rep.

6 **Rest:** 3 minutes

7 **Chin-up exercise*:** 5 reps x 1 set. Performed with same grip width and rate of performance as lat-pulldown exercise.

** Note: order of execution of the lat-pulldown exercise (step 5) before or after execution of the Chin-up exercise (step 7) depended on randomisation.*

Figure 2. Illustration of the test procedure and order of events that were used in the study

Before starting the actual testing with execution of the pre-determined initial exercise, participants were given three-minute rest. The chin-up exercise (figure 3) was performed by five repetitions with pronated hand grip, all repetitions was performed by full arm extension in the eccentric phase and chin over the bar in the concentric phase. Rate of performance were set at four seconds for each repetition (two seconds concentric phase, two seconds eccentric phase) indicated by a metronome. This rate of performance has been used in previous study (Lusk et al, 2010).

Figure 3. Illustration of the Chin-up exercise execution, performed with pronated grip.

Lat-pulldown exercise (figure 4) was performed seated with the same testing procedure as the chin-up exercise, in regard to rest between sets, rate of performance, grip width and pronated handgrip. In addition, lat-pulldown was performed in three sets at different external loads starting with 50%-, followed by 65%- and then 75% of participants' bodyweight (BW). Lat-pulldown at 100% bodyweight was conducted as well but in a different study, so the results will not be reported here, but are referred to in background and discussion. All tests were carried out by the same two test leaders to ensure reliability considering exercise performance. The same grip width, rate of performance, rest between sets and overall exercise execution was used to ensure standardisation.

Average muscle activation in each muscle was calculated from each participant recordings using the mean muscle data from the middle three repetitions during both exercises, this have been used in previous study (Doma et al, 2013). Average muscle activation was then divided with corresponding MVIC values, to get the average values in relations to MVIC (%MVIC). Furthermore, the group mean and standard deviation (SD) of the participants’ average muscle activation was calculated for each muscle, and in each exercise (chin-up and lat-pulldown).

Figure 4. Illustration of the lat-pulldown exercise execution, performed with pronated grip

2.4 Social and ethical considerations

The study test procedure was approved by a local ethics group at Halmstad university. Before enrolment in the study all participants were given both verbal and written information about the study. All participants signed a letter of consent (appendix 1) which informed participants they would be treated anonymously during the whole study procedure and that all participants could unconditionally drop out of the study at any given point. Each participant was given an identification number that was used to ensure that collected participant data would remain anonymously.

Furthermore, all collected data was stored on a USB-stick which only test leaders could access, and the identification key was stored apart from all collected data. The study included performing training exercises which always is correlated with minor risks, this risk was further minimized since exercisers were performed under supervision of experienced supervisors, and participants had a high level of experience with the selected exercises.

Chin-up exercise and lat-pulldown exercise are both historically and presently well used exercises in diverse populations practicing strength training. Strength training induces positive health effects on all kind of diverse populations, regardless of the participant goal is to improve health or to maximize sport performance (Garber et al, 2011). The present study hopes to give more insight considering primary muscle activation while performing the chin-up- and the lat-pulldown exercise and that this knowledge can be used while deciding exercise choice and relative workload while performing the lat-pulldown exercise.

2.5 Statistical analyses

All recruited participants (N=20) fulfilled the study and all collected data were included in the analysis. Data were analysed by using the SPSS statistics 20.0 (IBM Inc., Chicago, USA). The Shapiro-Wilks test was used to determine if collected data was normal distributed, and since results showed that not all data was normally distributed, non-parametric statistical analyses were performed. However, since most previous research using EMG in resistance exercises have reported their results parametrically, in this study average and standard deviation (SD) will be reported so that relevant comparisons can be made. Wilcoxon signed-rank test was used to determine the statistical differences between the chin-up exercise and lat-pulldown exercise using 50-, 65- and 75% BW workload in m. biceps brachii, m. latissimus dorsi, middle m. trapezius and m. rectus abdominis muscle activation. Statistical significance was set at $p \leq 0.05$.

Results

3.1 M. latissimus dorsi activation during chin-up vs lat-pulldown

Statistically significant greater average muscle activation was found in m. latissimus dorsi when comparing chin-up 100% BW with lat-pulldown performed at 50% BW ($p<0.00$), 65% BW ($p<0.00$) and 75% BW ($p<0.00$), as shown in table 2 and figure 5. A successive increase in average muscle activation was found in m. latissimus dorsi during lat-pulldown when increased workload was used, -from 32.88 ± 12.84 to 39.14 ± 15.00 to 43.58 ± 16.23 %MVIC from 50-65-75% BW respectively. Which was significantly lower when compared to 52.79 ± 18.69 %MVIC during chin-up 100% BW.

Table 2. Illustrates average EMG %MVIC value in m. biceps brachii, m. latissimus dorsi, middle m. trapezius and m. rectus abdominis during Chin-up- and Lat-pulldown (50-, 65-, 75% BW) exercises. Expressed as %MVIC, ± standard deviation (SD)

Average	**Chin-up 100% (C-U)**	**L-pulldown 75% (LP75%)**	*C-U 100% vs LP75% p-value*	**L-pulldown 65% (LP65%)**	*C-U 100% vs LP65% p-value*	**L-pulldown 50% (LP50%)**	*C-U 100% vs LP50% p-value*
BB %MVIC	25.99 ± 12.17	12.62 ± 6.08	p < 0.000	9.03 ± 5.22	p < 0.000	5.09 ± 4.54	p < 0.000
LD %MVIC	52.79 ± 18.69	43.58 ± 16.23	p < 0.000	39.14 ± 15.00	p < 0.000	32.88 ± 12.84	p < 0.000
TR %MVIC	37.10 ± 17.05	33.61 ± 19.44	p < 0.145	31.25 ± 17.90	p < 0.000	28.61 ± 18.99	p < 0.014
RA %MVIC	16.37 ± 12.47	6.57 ± 4.87	p < 0.002	5.00 ± 3.66	p < 0.000	6.09 ± 7.65	p < 0.000

BB = m. biceps brachii; LD= m. latissimus dorsi; TR= middle m. trapezius; RA= m. rectus abdominis; Chin-up 100%= Chin-up exercise 100% of bodyweight; L-pulldown 75%= Lat-pulldown exercise 75% of bodyweight; L-pulldown 65%= Lat-pulldown exercise 65% of bodyweight; L-pulldown 50%= Lat-pulldown exercise 50% of bodyweight

3.2 M. biceps brachii activation during chin-up vs lat-pulldown

Statistically significant increase in average muscle activation was found in m. biceps brachii when comparing chin-up 100% BW with lat-pulldown performed at 50% BW ($p<0.00$), 65% BW ($p<0.00$) and 75% BW ($p<0.00$). A successive increase in average muscle activation was found in m. biceps brachii when increased workload was used, -from 5.09 ± 4.54 to 9.03 ± 5.22 to 12.62 ± 6.08 %MVIC from 50-65-75% BW respectively. But still significantly lower when compared to 25.99 ± 12.17 %MVIC during chin-up 100% BW.

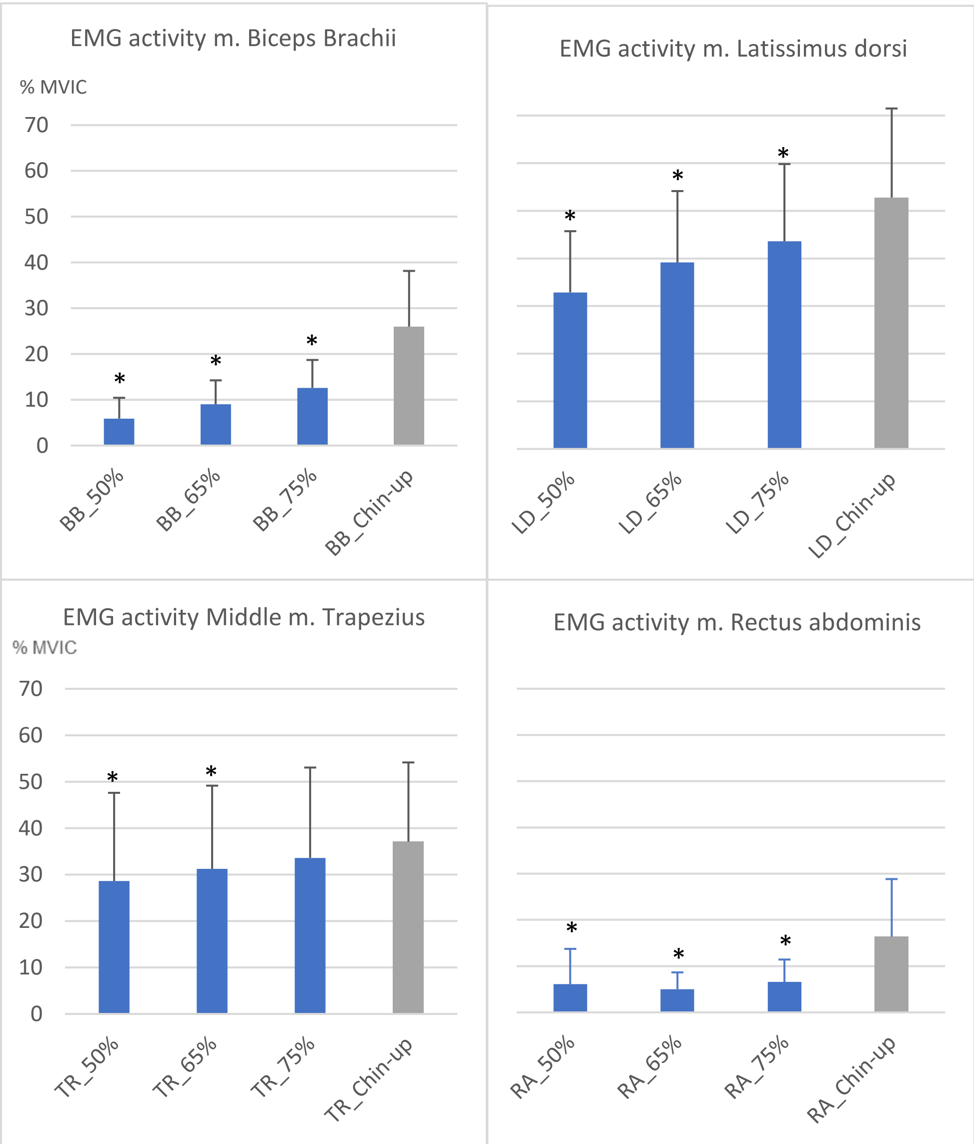

Figure 5. Average EMG %MVIC (±SD) during Chin-up 100% bodyweight and Lat-pulldown exercise, performed using workload of 50-, 65-, 75% bodyweight. BB = m. biceps brachii; LD= m. latissimus dorsi; TR= Middle m. trapezius; RA= m. rectus abdominis; *= Statistically significant difference from chin-up 100% BW ($p < 0.05$).

3.3 Middle m. trapezius activation during chin-up vs lat-pulldown

Statistically significant increase in average muscle activation was found in middle m. trapezius when comparing chin-up 100% BW with lat-pulldown performed at 50% BW ($p<0.01$) and 65% BW ($p<0.00$). No difference was found in middle m. trapezius when comparing chin-up 100% BW with lat-pulldown performed at 75% BW ($p=0.15$). A successive increase in average muscle activation was found in middle m. trapezius during lat-pulldown when increased workload was used, -from 28.61 ± 18.99 to 31.25 ± 17.90 to 33.61 ± 19.44 %MVIC from 50-65-75% BW respectively. But lat-pulldown performed at 50% and 65% BW was still significant lower when compared to 37.10 ± 17.05 %MVIC during chin-up 100% BW. Lat-pulldown performed at 75% BW showed no statistically difference in middle m. trapezius muscle activation when compared to chin-up 100% BW.

3.4 M. rectus abdominis activation during chin-up vs lat-pulldown

Statistically significant increase in average muscle activation was found in m. rectus abdominis when comparing chin-up 100% BW with lat-pulldown performed at 50% BW ($p<0.00$), 65% BW ($p<0.00$) and 75% BW ($p<0.00$). No increase in average muscle activation was found in m. rectus abdominis when workload increased during lat-pulldown.

Discussion

This study showed overall statistically significant ($p<0.05$) increases in average muscle activation in m. latissimus dorsi, m. biceps brachii, middle m. trapezius and m. rectus abdominis between performing the chin-up 100% BW exercise compared to perform the lat-pulldown exercise at 50%- and 65% BW. In lat-pulldown 75% BW, no difference in middle m. trapezius muscle activation was evident compared to the chin-up 100% BW ($p=0.15$).

4.1 Results discussion

4.1.1 M. latissimus dorsi activation during chin-up vs lat-pulldown

In the present study, average muscle activation in the m. latissimus dorsi during chin-up 100% BW was statistically significantly greater when compared to lat-pulldown performed at 50%, 65% and 75% BW. This in in contrast with Doma et al (2013) who found no difference in m. latissimus dorsi muscle activation between the exercises. However, a direct comparison to this study is hard to make considering Doma et al (2013) used workloads equal to 79.5 ± 11.6 kg (approximately 96% BW) while performing the lat-pulldown and this study used workloads equal to 61.2 ± 5.7 kg (75% BW). Also, Lofquist (personal communication, 2017) found no difference in m. latissimus dorsi muscle activation between the exercises when comparing chin-up 100% BW with lat-pulldown 82.4 ± 7.8 kg (100% BW). Doma et al (2013) and Lofquist (personal communication, 2017) related results can be explained by using higher workloads during lat-pulldown compared to the present study. These combined results indicate that performing the lat-pulldown using a workload somewhere between 75-100% BW can exhibit the same muscle activation in m. latissimus dorsi compared to perform the chin-up at 100% BW.

4.1.2 M. biceps brachii activation during chin-up vs lat-pulldown

In the present study, average muscle activation in m. biceps brachii during chin-up 100% BW was statistically significantly greater compared to lat-pulldown performed at 50%-, 65%- and 75% BW. This is similar with Doma et al (2013) who also found statistically significant greater muscle activation in m. biceps brachii during chin-up 100% BW when comparing with lat-pulldown performed at 79.5 ± 11.6 kg (approximately 96% BW). The present study higher muscle activation during chin-up can be explained by using higher workload compared to lat-pulldown. Doma et al (2013) higher muscle activation during chin-up can also be explained by using higher workload when compared to the lat-pulldown. Doma et al (2013) found smaller difference in m. biceps brachii muscle activation between exercises when compared to the present study, which can be explained by that Doma et al (2013) used smaller difference in workload between exercises compared to the present study. However, the present study and Doma et al (2013) results is in contrast with Lofquist (personal communication, 2017) results who found statistically significant lower muscle activation in m. biceps brahii during chin-up 100% BW when comparing with lat-pulldown 100% BW. An explanation for this might be that Lofquist used 100 % BW workload during lat-pulldown compared to the present study 75% BW and Doma et al (2013) who used approximately 96% BW as workload. Johnson et al (2009) has shown that 1RM in lat-pulldown is significantly lower when comparing with the 1RM in chin-up, this might suggest that preforming the lat-pulldown and chin-up using the same workload will require higher muscle activation during lat-pulldown due to that lat-pulldown is harder to perform. Which can explain Lofquist (personal communication, 2017) to find greater m. biceps brachii muscle activation during lat-pulldown 100% BW when comparing with chin-up 100% BW.

4.1.3 Middle m. trapezius activation during Chin-up vs lat-pulldown

In the present study, average muscle activation in chin-up 100% BW was statistically significantly greater compared to lat-pulldown performed at 50%- and 65% BW in the middle m. trapezius, but not greater when the lat-pulldown was performed at 75% BW. This is similar with Lofquist (personal communication, 2017) who also found no difference in average muscle activation in middle m. trapezius during chin-up 100% BW compared to lat-pulldown 100% BW. These results indicate that performing the lat-pulldown using a workload somewhere between 75-100% BW can exhibit the same muscle activation in middle m. trapezius compared to perform the chin-up at 100% BW. However, more studies are needed in order to determine if these findings can be seen valid.

4.1.4 M. rectus abdominis activation during Chin-up vs lat-pulldown

In the present study, muscle activation in chin-up 100% BW was statistically significantly greater compared to lat-pulldown performed at 50%-, 65%- and 75% BW in the m. rectus abdominis. This is similar with Lofquist (personal communication, 2017) who also found statistically significant greater muscle activation in m. rectus abdominis while performing the chin-up at 100% BW compared to performing the lat-pulldown at 100% BW. However, it is in contrast with Doma et al (2013) who found lower muscle activation in m. rectus abdominis during the chin-up 100% BW when compared with lat-pulldown performed at 79.5 ± 11.6kg (approximately 96% BW). An explanation for Doma et al (2013) finding lower muscle activation in m. rectus abdominis during chin-up compared to lat-pulldown might be that participants in Doma et al (2013) study used greater horizontal back displacement during chin-up 13.0 ± 5.2 degrees compared to 11.4 ± 5.5 degrees during lat-pulldown. Participant back displacement was not measured during the present study or Lofquist (personal communication, 2017) study and therefor it is hard to determine if Doma et al (2013) using greater back displacement during chin-up can explain lower m. rectus abdominis muscle activation during chin-up when compared to lat-pulldown.

4.1.5 Chin-up 100% BW vs lat-pulldown (50%-, 65% & 75% BW)

The present study showed overall statistically significantly greater average muscle activation in m. latissimus dorsi, m. biceps brahii, m. rectus abdominis between performing the chin-up 100% BW with the lat-pulldown at 50%-, 65% and 75% BW. Middle m. trapezius showed no difference in average muscle activation between performing the chin-up 100% BW with the lat-pulldown at 75% BW. Also, all muscles (m. latissimus dorsi, m. biceps brahii, middle m. trapezius) except m. rectus abdominis showed successive increase in average muscle activation when lat-pulldown 50%-, 65%- and 75% BW was performed, respectively. This together with the findings from Doma et al (2013) and Lofquist (personal communication, 2017) indicate that performing the lat-pulldown using workload somewhere between 75-100% BW can exhibit the same muscle activation as performing the chin-up at 100% BW.

4.2 Methods discussion

The present study research questions are descriptive and therefore does not explain why the muscles was more or less activated during the exercises. Johnson et al (2009) has shown that the chin-up and lat-pulldown can exhibited unique trainings stimulus and should not be considered interchangeably, even if the exercises are similar regarding muscles activated and motion. So even if the exercises seem the same, they are not and therefor being difficult to compare. Further, the present study only used workloads equal to 50%, 65% and 75% BW during lat-pulldown when comparing muscle activation with chin-up performed at 100% BW. To include higher workloads during lat-pulldown >75% BW would have been useful to determine which relative workload during lat-pulldown each muscle can exhibit the same muscle activation as chin-up. The present study showed that similar muscle activation in middle m. trapezius can be achieved when preforming the lat-pulldown at 75% BW compared to the chin-up 100% BW. Including higher workloads during lat-pulldown would have been helpful to find which workload the other examined muscles would exhibited related results.

Although, the participants in the present study were overall homogeneous regarding gender, age and training experience some differences in participants' individual ability to control muscle activation and differences in individual subcutaneous fat mass may have affected measurements during the study, which have been shown in previous research (Snyder & Leech, 2009; Huebnera et al., 2014; Cardinale et al, 2011). Higher recorded muscle activation in specific muscles might have been a result of participant high training experience and ability to target specific muscles. Further, the participants were given 10 minutes' general warmup preformed on a bike with self-selected resistance which also may have affected measurements during the study, to perform the warmup with a more standardized method instead may have been favourable. Also, this study chose to use MVIC as reference value to collected muscle activation data. Although, using the MVIC as reference value to recorded muscle activation have been endorsed in contrast to using other reference values, neither method is considered valid to determine how active a muscle is to its actual maximum activation capacity (Burden, 2010).

Finally, both the chin-up- and lat-pulldown exercises is well used and often considered substitute to each other because both exercises have similarities in motion and primary muscle activation during execution (Doma et al, 2013). Johnson et al (2009) has shown that each exercise can exhibit unique training stimulus and should not be considered interchangeable. Previous research has investigated muscle activation in each exercise isolated. However, limited research exits regarding comparison of muscle activation between the exercises. More future studies investigating muscle activation in the chin-up exercise compared with the lat-pulldown exercise will give greater knowledge that will benefit strength training participants and help them choose exercise and relative workload while performing the exercises. The presented study only included workloads equal to 50%-, 65%-, and 75% BW during lat-pulldown, future studies might benefit from including increased workloads (>75 % BW) when comparing the lat-pulldown exercise and the chin-up exercise.

Conclusion

This study showed statistically significant ($p<0.05$) greater average muscle activation in m. latissimus dorsi, m. biceps brahii, m. rectus abdominis between performing the chin-up 100% BW exercise with the lat-pulldown exercise at 50%-, 65%-, 75% BW. In lat-pulldown 75% BW, no difference in middle m. trapezius average muscle activation was evident compared to the chin-up 100% BW ($P=0.15$). These results indicate that performing the lat-pulldown using workload somewhere between 75-100% BW can exhibit the same muscle activation as performing the chin-up at 100% BW.

Finally, this study hopes to give more insight considering primary muscle activation while performing the chin-up- and the lat-pulldown exercise and that this knowledge can be used while deciding exercise choice and relative workload while performing the lat-pulldown exercise.

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Appendices

Informationsblad och informerat samtycke

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 Halmstad Högskola 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.

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 instrument 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 decinficeras i syfte att elektroderna ska fästas bättre. När elektroderna är på plats kommer du få utföra fem stycken chinups 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 nedanstånde krav:

- Kunna utföra fem strikta chinups. *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 chinups 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 konfidiellt. Viss data kan komma att publiceras men inget som kan göra att du kan bli identifierad. Förvaring av data sker på ett USB som finns inlåst i Halmstad Högskola dit labbpersonalen är de enda som har tillgång. Du som försöksdeltagare har rätt att vid förfrågan få ut insamlad data.

Urval

Du har blivit tillfrågad att medverka i studien för att du tillhör den forskningsgrupp 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

Forskningsansvariga, *Halmstad Högskola*

Isak Löfquist [redacted] [redacted]
Niklas Ekberg [redacted] [redacted]

Handledare, *Halmstad Högskola*

Charlotte Olsson [redacted]

Samtycke

Nedan ger du ditt samtycke att delta i den studie som undersöker muskelaktivering vid chinups 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 informerade samtycket och tagit del av informationen kring studien. Jag förstår vad deltagandet i studien innebär och ställer 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 (texta)

________________________　　　　________________________

Datum och plats

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