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Variations in muscle activation levels during traditional latissimus dorsi weight training exercises: An experimental study.

Gregory J Lehman*[1], Day Deans Buchan[2], Angela Lundy[2], Nicole Myers[2] and Andrea Nalborczyk[2]

Address: [1]Department of Graduate Studies, Canadian Memorial Chiropractic College, Toronto, ON, Canada and [2]Undergraduate Department, Canadian Memorial Chiropractic College, Toronto, ON, Canada

Email: Gregory J Lehman* - glehman@cmcc.ca; Day Deans Buchan - daisyday7@hotmail.com; Angela Lundy - anglundy@hotmail.com; Nicole Myers - myersnicole@hotmail.com; Andrea Nalborczyk - andrea_nal@hotmail.com

* Corresponding author

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Abstract

Background: Exercise beliefs abound regarding variations in strength training techniques on muscle activation levels yet little research has validated these ideas. The purpose of the study is to determine muscle activation level, expressed as a percent of a normalization contraction, of the latissimus dorsi, biceps brachii and middle trapezius/rhomboids muscle groups during a series of different exercise tasks.

Methods: The average muscle activity during four tasks; wide grip pulldown, reverse grip pull down [RGP], seated row with retracted scapula, and seated rows with non-retracted scapulae was quantified during two 10 second isometric portions of the four exercises. A repeated measures ANOVA with post-hoc Tukey test was used to determine the influence of exercise type on muscle activity for each muscle.

Results & Discussion: No exercise type influenced biceps brachii activity. The highest latissimus dorsi to biceps ratio of activation occurred during the wide grip pulldown and the seated row. Highest levels of myoelectric activity in the middle trapezius/rhomboid muscle group occurred during the seated row. Actively retracting the scapula did not influence middle trapezius/rhomboid activity.

Conclusion: Variations in latissimus dorsi exercises are capable of producing small changes in the myoelectric activity of the primary movers.

Background

Working the latissimus dorsi is considered a staple for most weight training programs. Latissimus dorsi exercises are advocated to provide muscle balance to chest and shoulder press exercises. Like many strength training exercises, beliefs persist regarding the influence of exercise variations on muscle recruitment patterns. Anecdotally, two beliefs assert that using a supinated grip during the performance of a pulldown will preferentially activate the biceps brachii over the latissimus dorsi when compared to the traditionally forward grip anterior pulldown. A second belief suggests that performance of the seated row increases activation of the middle trapezius/rhomboids when compared with the lat pulldown. It has also been suggested that the seated row performed with scapulae retraction may alter middle trapezius and rhomboid activity when compared with no scapular retraction. Little research has occurred investigating these claims.

Signoreli et al [1] investigated the influence of grip width and line of pull during the lat pulldown on latissimus dorsi and other muscle group's electromyographic (EMG) activity. The authors found that using a pronated wide grip while pulling anterior to the head resulted in the greatest myoelectric activity of the latissimus dorsi when compared to widegrip pulldowns pulled posterior to the head, pulldowns using a supinated grip and pulldowns using a close grip. This same trend was also found with the triceps muscle. The influence of these exercises on biceps brachii was not investigated.

Scapular retraction is often advocated during the performance of the seated row. It assumed that this position stabilizes the scapula and facilitates optimal shoulder movement. Scapula protraction is thought to tilt the glenoid fossa forward, influencing stability by tilting the glenoid fossa and changing the orientation of the inferior glenohumeral ligament [2,3]. Protraction of the scapula with the addition of the anterior load increases the strain on the inferior glenohumeral ligament [3]. The influence of scapular protraction on muscle activation patterns is unknown. One study [4] has investigated the middle trapezius activity during strength training exercises. The authors found that the one arm row activated the middle trapezius to 79% of its maximum [4] however, the authors did not state whether the subject was encouraged to retract the scapula or allow protraction.

Currently no studies have compared the influence of different shoulder extension/adduction exercises on lattissimus dorsi, biceps brachii and middle trapezius/rhomboid myoelectric activity. This study aims to determine the influence of forearm supination, angle of pull and scapula retraction during common latissimus dorsi exercises on the myoelectric activity of latissimus dorsi, middle trapezius and biceps brachii.

Methods

Subject Characteristics and Inclusion Criteria

Twelve healthy males (average age (standard deviation) 27.09 years(1.23), average height (SD) 179.08 cm(3.75), average weight (SD)78.25 kg (5.23)), with greater than 6 months of weight training experience, with out back pain or upper limb injuries were recruited from a convenience sample of college students. Subjects signed an informed consent form approved by the Internal Review Board of the Canadian Memorial Chiropractic College (CMCC).

Study Protocol

The muscle activation level, expressed as a percentage of a maximum voluntary contraction (MVC), of the Latissimus dorsi (LD), Biceps Brachii (BB) and middle trapezius/rhomboid muscle (MTR) groups during a series of different exercise tasks was quantified. Four different exercise tasks and three normalization procedures occurred during one test session.

Data Collection Hardware Characteristics

Disposable bipolar Ag-AgCl disc surface electrodes with a diameter of one cm were adhered bilaterally over the muscle groups with a centre to centre spacing of 2.5 cm. For the right biceps brachii electrodes were placed on the middle of the muscle belly when the elbow was flexed at 90 degrees. For the latissimus dorsi, electrodes were placed one cm lateral to the inferior border of the right scapula. A pair of electrodes was adhered superiorly to the skin above the middle trapezius and rhomboid minor between the spine of the scapula and the 2nd thoracic spinous process. Raw EMG was amplified between 1000 and 20,000 times depending on the subject. The amplifier had a CMRR of 10,000:1 (Bortec EMG, Calgary AB, Canada). Raw EMG was band pass filtered (10 and 1000 Hz) and A/D converted at 2000 Hz using a National Instruments data acquisition system and collected using EMG acquisition software (Delsys, Boston MA).

Normalization task procedure

Three different maximal voluntary contractions for the three muscle groups studied were collected for each subject. Subjects performed 1–2 practice MVCs before the collection of EMG. For the latissimus dorsi, subjects were required to perform a 3 second maximal isometric Lat pull down against an immovable resistance. For the biceps brachii subjects were required to perform a maximum isometric bicep curl (i.e. attempted elbow flexion) against an immoveable object with the arm at 90 degrees of flexion. The maximum voluntary contraction to recruit the MiddleTrapezius/Rhomboid muscle required the participants to perform a maximum isometric scapular retraction against experimenter provided manual resistance. The muscle activity during the exercise tasks was then subsequently expressed as a percentage of the peak activity found during the previously described normalization tasks.

Exercise tasks

During all exercises subjects used the same weight on a standard lat pulldown and seated row pulley machine. This weight was chosen by the subject based on their perceived ability to perform between 10 and 12 reps until failure for the pronated grip lat pulldown. For each exercise, two repetitions of a ten second isometric contraction were performed. Following each repetition, a three minute rest occurred. The two repetition protocol was then repeated for each exercise. The exercises performed were:

1. Wide grip pull down (WGP): From a seated position with the thighs restricted, subjects used an overhand grip on a straight pull down bar at 150% of the bi acromial distance (BAD). The weight was pulled into an isometric position with the arms at 90 degrees of shoulder flexion and elbow flexion. (Essentially a bar position which finds the bar 1–2 inches above eye level). Subjects held this position for 10 seconds.

2. Reverse grip pull down (RGP): From a seated position with thighs fixed subjects used an underhand grip on a straight bar at 100% BAD. The isometric contraction was held at a position with 90 degrees of shoulder forward flexion and 90 degrees of elbow flexion (Essentially a bar position which finds the bar 1–2 inches above eye level)

3. Seated row, shoulders retracted (SRR): Subjects started from a seated position, arms extended with forearms at a mid pronated position 6 inches apart. The participants pulled the weight to a position where the shoulder was at 0 degrees of flexion and 90 degrees of elbow flexion with maximal scapular retraction. During the isometric portion of the exercise, the subject was asked to approximate the shoulder blades (Retraction).

4. Seated Row, shoulders slack (SRR): Subjects performed the same movement as exercise #3 however the subject was instructed to allow the scapula to roll forward during the isometric hold portion of the exercise.

During all of these exercises the isometric portion (the portion that was analysed) was preceded by a concentric contraction that positioned the subjects arm and then followed by an eccentric contraction where the participant lowered the weight to the stack.

EMG Processing and data analysis

The root mean square (sliding window of 128 ms with an overlap of 64 ms) of the raw EMG during each exercise task and the normalization tasks was calculated using an EMG analysis software package (Delsys, Boston USA). The average activity was then calculated for the middle two seconds of the isometric portion of each exercise and repetition. The average of the two repetitions for each exercise was then calculated for each subject and presented as a percentage of the maximum activity found during the normalization tasks.

Statistical Analysis

Separate repeated-measures ANOVA with post-hoc Tukey tests were then used to determine the influence of exercise type on muscle activity within the latissimus dorsi, biceps brachii and middle trapezius/rhomboids.

Results

Table 1 shows the average activity found for each muscle for the four different exercise tasks. The latissimus dorsi musle activity was higher during the seated row with a protracted scapulae than the activity found during a wide grip pulldown and a reverse grip pulldown. The level of protraction/retraction did not influence latissimus dorsi activity during the seated row exercise. The level of forearm supination had no influence on latissimus dorsi activity during the pulldown exercise. Biceps brachii muscle activity was the same across exercises.

Table 1: Average myoelectric activity (expressed as %MVC) for each muscle studied across 4 different shoulder extension exercises.

Muscle	Exercise Performed			
	Pulldown[1]	Reverse[2]	Slack SR[3]	Retract SR[4]
Lats	26.23 [10.1]	22.37 [9.1]	30.10 [14.9]	37.08 [14.04]
Diff From*:	3	3	1,2	-
Biceps	15.20 [8.05]	19.89 [6.8]	18.21 [7.1]	19.92 [10.7]
Diff from	-	-	-	-
MTR	22.72 [11.5]	20.51 [10.9]	29.77 [11.6]	35.50 [17.6]
Diff from:	-	3	2	-
Ratio Lats:Biceps	175.22 [84.4]	111.48 [53.2]	156.31 [81.0]	186.48 [96.0]
Diff from:	2	1,3	2	-

*This row indicates which exercise [denoted by a superscripted column number [i.e 1 = pulldown exercise] results in statistically significant [p < .05] muscle activity. This only compares across columns [different exercises] for the same muscle group. It doesn't compare different muscle groups within an exercise. Lats=Latissimus Dorsi, Biceps = Biceps Brachii, Ratio Lats:Biceps is the average muscle activation ratio between the latissimus dorsi and biceps brachii for each exercise tested. Pulldown = pronated grip pulldown, Reverse = Supinated grip pulldown, Slack = Seated row allowing scapulae protraction, Retract = Seated row with encouragement to retract the scapulae

During the seated row the act of retracting the scapula did not influence middle trapezius/rhomboid muscle activity. However, performing the seated row with the scapula not retracted resulted in an increased myoelectric activity when compared with the reverse grip pulldown. A trend also existed for increased activity in the middle trapezius/ rhomboids during the seated row with retraction although this was not statistically significant.

Significant differences were found when comparing the ratio between Latissimus Dorsi activity and Biceps Brachii activity across exercises. This ratio is the average ratio for each subject not the ratio of the group average. The wide grip lat pulldown had a siginificantly higher ratio than the reverse grip lat pulldown, as did the seated row with protracted scapula. A large variability was seen across subjects.

Discussion

The belief that a wide grip during the lat pulldown preferentially recruits the latissimus dorsi over the biceps brachii does not appear to be supported. Conversely, a supinated grip does not appear to preferentially activate the biceps. However, there was a statistically significant change in the latissimus dorsi: biceps brachii ratio between the two pulldown exercises. The statistically significant change in the latissimus dorsi to biceps ratio occurred because of the slight non-statistically significant decrease in latissimus dorsi activity when changing from the wide grip to the reverse grip position of the lat pulldown being coupled with the slight non-statistically significant increase in biceps activity when changing from the wide grip to the reverse grip lat pulldown exercise. These results suggest that slight changes occur when changing grip position but these changes are small and may have no weight training significance. To state, as many clinicians and personal trainers do, that the wide grip pulldown preferentially trains the back and the close grip supinated pulldown preferentially trains the biceps is unsupported. While not investigated in this study, differences in strength between the exercises may be due to the different mechanical advantages/disadvantages of one exercise or possibly to differences in the recruitment levels of the forearm flexors which may be most affected by grip position. Additionally, it appeared that the seated row slightly increased Latissimus Dorsi activity without decreasing Biceps Brachii activity as seen by no difference in the Latissimus Dorsi:Biceps Brachii ratio when compared with the wide grip lat pulldown. A related limitation to this study is that only one portion of the latissimus dorsi was studied. Previous research has demonstrated that functional differentiation within the latissimus dorsi exists [5]. However, this study investigated different exercises, it is possible that the muscle activation of the Latissimus Dorsi in our current study merely shifted to another portion of the muscle group when moving from the wide grip lat pulldown to the reverse grip or seated row. This deserves further study.

A second aim of the study was to determine the influence of scapula retraction during the seated row on Middle Trapezius/Rhomboids activity. While the seated row exercise did recruit the Middle Trapezius/Rhomboid to a greater extent than either lat pulldown exercises, actively retracting the scapula did not result in an increase activity of the Middle Trapezius/Rhomboids. This suggests that the Middle Trapezius/Rhomboids is active regardless of the position of the scapulae or another muscle functions to cause scapula retraction. It is possible that deep fibres of the rhomboid may become more active during the scapula retraction and this increased activity was not picked up by the electrodes or the lower trapezius may function to cause scapula retraction. The lower trapezius has been shown to be recruited to 74% MVC during shoulder horizontal extension [4].

A limitation of the study is related to the different amount of weight lifted by each subject. Participants were asked to choose a weight where they would experience muscle failure between 10–12 repetitions. Ten to twelve repetitions was chosen because this represents what is commonly done during many strength training programs. However, at this repetition level, the participant's muscle activity was often less than 30–40 % of the MVC. The moderately low level of muscle activity (30–40% MVC) during this repetition level suggests that large fast twitch fibres (Type II) may not be recruited during this exertion level, especially if fatigue and the associated Type II fibre recruitment is not achieved. Having participants choose their weight for repetitions suggest they may be cautious and underestimate their capabilities. This may carry over to strength training individuals who may underestimate their strength and lift loads at a less than optimum level for recruiting large muscle fibres.

Additionally, it is unknown whether the changes in muscle activation ratios between the latissimus dorsi and biceps brachii occurs at higher levels of muscle activation. Recruitment may be different near maximum exertion levels. It is possible that one muscle may achieve fatigue and maximum activation while the other does not achieve fatigue and is not maximally stressed. It is unknown whether it is the biceps or latissimus dorsi that is the limiting factor during the performance of the lat pulldown or seated row.

Conclusion

The wide grip lat pulldown demonstrated a small but non-significant increase in the activity of the latissimus dorsi compared with the supinated grip pulldown. This same small increase is seen in biceps muscle when using a supinated grip versus the wide grip during the lat pull-down. Due to the small changes in muscle activity there appears to be very little difference in muscle activity between the wide grip lat pulldown and the supinated grip lat pulldown for the biceps and latissimus dorsi muscles.

Additionally, the seated row while recruiting the latissimus dorsi and biceps brachii more or equally effectively as the lat pulldown also recruits the middle trapezius/rhomboid muscle group to a greater extent. Actively retracting the scapula does not appear to increase activation levels of the middle trapezius/rhomboid muscle group. However, from previous research this position does appear to provide superior shoulder stability.

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