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The Influence of Grip Width and Forearm Pronation/Supination on Upper-Body Myoelectric Activity During the Flat Bench Press

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Abstract. Lehman, G.J. The influence of grip width and forearm pronation/supination on upper-body myoelectric activity during the bench press. *J. Strength Cond. Res. 19(3):587–591. 2005.*—The myoelectric signal of the sternoclavicular and clavicular portions of the pectoralis major, the biceps brachii, and the lateral head of triceps brachii of 12 healthy men was collected during an isometric hold of 5 different bench press exercises. Grip width (narrow, mid, and wide) and the level of supination/pronation was varied to determine how these factors influence myoelectric amplitude during the flat bench press. A supinated grip resulted in increased activity for the biceps brachii and the clavicular portion of the pectoralis major. Additionally, moving from wide to narrower grip widths increased triceps activity and decreased the sternoclavicular portion of the pectoralis major. However, if the grip was supinated, moving to a narrower grip position did not result in a decrease in muscle activity of the sternoclavicular portion of the pectoralis major. The increase in triceps brachii activity when moving to a narrower grip width was not influenced by the level of supination. Considering the small changes that occur during changes in grip width, the choice of grip position should be determined by the positions athletes adopt during their sport. Sport specificity should supercede attempts to train specific muscle groups.

Key Words. electromyographic, bench press, shoulder stability, pectoralis major, biceps brachii

Introduction

The bench press is a ubiquitous strength-training exercise among recreational and performance athletes. Modifications are often made to the bench press involving grip width and level of body inclinations in attempts to modify the recruitment of the primary movers. Anecdotally, 2 prevalent beliefs are that narrow grips preferentially activate the triceps over the pectoralis major, while an incline bench press will activate the upper or clavicular head of the pectoralis major more so than the "lower" or sternoclavicular head of the pectoralis major muscle. The research is currently conflicting.

Two previous studies have addressed the influence of grip width and bench inclination on the myoelectric activity of the primary movers during the bench press. Barnett et al. (1) evaluated the 2 grip widths (100 and 200% of biacromial distance [BAD]) during decline, flat, and incline bench press in 6 subjects. Subjects were required to lift 80% of a predetermined maximum for each grip width and level of trunk inclination. The study found that the 2 heads of the pectoralis muscle were recruited differently, depending on grip width and level of inclination. Generally, the grip width had no effect on the sternoclavicular portion of the pectoralis major muscle activation except during the incline bench press, when a wide grip elicited greater activity than a narrow grip. For both the narrow and wide grips, the flat bench position produced the greatest activity in the sternoclavicular head of the pectoralis major. For the clavicular portion of the pectoralis major, moving from an inclined to a declined position brought about a decrease in myoelectric activity. This finding is consistent with conventional weightlifting wisdom. For the triceps muscle, again consistent with conventional weightlifting wisdom, the narrow grip produced increased myoelectric activity relative to the wide grip.

Conversely, Clemons and Aaron (3) investigated 4 grip widths all between 100 and 190% of BAD on the muscle activity of the biceps, pectoralis major (sternoclavicular portion), anterior deltoid, and triceps. Participants were required to perform 1 repetition of the bench press at the 4 different grip levels. The subjects lifted the same weight across each grip width. The amount lifted was equivalent to 100% of their maximum at the narrowest grip width. The study found that all prime movers had less activity for narrower grips during the flat bench. Relative to each muscle's maximum electromyogram (EMG) produced during a maximum voluntary contraction (MVC), the triceps had greater activity than the sternoclavicular head of the pectoralis major, regardless of the grip width.

These 2 studies show conflicting results regarding the influence of grip width on the myoelectric activity of the primary movers. To summarize, Clemons and Aaron (3) observed greater activity in all muscles when moving to a wider grip, while the Barnett et al. (1) study had more variable results. Some muscle groups decreased their activity with wider grips (triceps and clavicular head of pectoralis major), while the sternocostal head of the pectoralis major's muscle activity did not change with grip width.

One reason for the differences in the results between the 2 studies may be related to the difference in the amount of weight lifted across exercises between the 2 studies. Clemons and Aaron (3) used the same 1 repetition maximum (1RM) weight (found for the narrow grip) across all grip widths, while Barnett et al. (1) used 80% of maximum load lifted for each different exercise, depending on grip width and level of inclination. Barnett et al. (1) were therefore comparing different loads lifted for the different exercise, suggesting that the load lifted, or even the exertion level (80 vs. 100%), influences the recruitment patterns of the primary movers.

Typically, the bench press is performed with a pronated grip. A common modification is to supinate the forearm while performing the bench press. It is theorized that this action is beneficial for those rehabilitating shoulder injuries, as the supination may result in increased biceps activation, thus resulting in increases in the stability of the shoulder and less superior translation of the humerus. This contention has yet to be tested.

Because of the varying results of previous work and the lack of research investigating the role of supination on upper-limb myoelectric activity during the bench press, the goal of this study was to determine the influence of 3 grip widths and the level of pronation during the flat bench press on the myoelectric activity of the clavicular head of the pectoralis major, the sternocostal head of the pectoralis major, the lateral head of the triceps, and the biceps brachii. The study also investigated whether forearm supination influences muscle activity in the biceps brachii during the bench press and whether grip width modifications can change the muscle activity in the primary movers of the bench press when keeping the same weight across exercises.

Methods

Experimental Approach to the Problem

A within-subject experimental design was used to determine how grip width and forearm supination affected muscle activity during the flat bench press. All volunteers had previous weight-training experience in an attempt to minimize the influence of inexperience on muscle activation levels. Because speed of movement and type of contraction can influence the amount of muscle activity measured, we controlled for this by measuring muscle activity only during an isometric portion of the bench press. During 1 experimental session, each subject performed 5 different types of bench presses. Bench presses were all performed on a flat bench, with an identical weight and with the weight held isometrically at the same distance from the subject's chest. However, different grip widths (narrow, mid, and wide) and forearm supination levels (pronated or supinated) during the flat bench press were used. EMG amplitudes (dependent variable) of the biceps brachii, triceps brachii, sternoclavicular portion of the pectoralis major, and clavicular portion of the pectoralis major were measured during each different bench press style. Differences in EMG amplitudes in each muscle for different grip widths and levels of forearm supination were then determined.

Subjects

Twelve healthy men (average age [*SD*], 26.3 [1.5], average height [*SD*], 176.7 cm [4.99], and average weight [*SD*], 79.6 kg [7.34]) with greater than 6 months of weight-training experience but without back pain or upper-limb injuries were recruited from a convenience sample of college students. Subjects were required to sign an information and informed consent form prior to the study that had been approved by the Institution's Internal Review Board.

Study Protocol

The myoelectric activity of the sternoclavicular pectoralis major, costoclavicular pectoralis major, lateral head of the triceps brachii, and biceps brachii muscles was collected during a 5-second isometric portion of the bench press exercise using 5 different hand positions. The weight lifted was identical across all trials. The subjects chose a weight with which they could perform 12 repetitions using the supinated midgrip width (100% BAD).

Data Collection Hardware Characteristics

Disposable bipolar Ag-AgCI disc surface electrodes with a diameter of 1 cm were adhered bilaterally over the muscle groups with a center-to-center spacing of 2.5 cm following skin preparation (shaving and abrading with alcohol).

A raw EMG was amplified between 1,000 and 20,000 times, depending on the subject. The amplifier had a CMRR of 10,000:1 (Bortec EMG, Calgary, Canada). The raw EMG was band-pass filtered (10 and 1,000 Hz) and A/D converted at 2,000 Hz using a National Instruments data acquisition system.

Exercise Tasks

The goal of this study was to determine the influence of grip width and level of forearm pronation on muscle activation levels during the flat bench press. Subjects performed two 5-second isometric holds during the bench press, at a position where the bar was raised 1 in. above the chest and 5 cm superior to the xiphoid process, for each of the 5 hand positions.

Each movement was identical except for 2 variables: the grip width and whether the forearm was supinated or pronated. Five different hand positions were tested: (a) 100% of BAD with pronated (forward) grip (midforward grip), (b) 100% of BAD with supinated (reverse) grip (midreverse grip), (c) 200% of BAD with pronated (forward) grip (wide forward grip), (d) 200% of BAD with pronated (reverse) grip (wide reverse grip), and (e) pronated/forward grip with 1 hand width distance between the 2 hands (narrow/forward). A supinated grip at the narrow grip position was not used because this position is rarely performed, and preliminary work suggested it was too unstable and unwieldy. Subjects started the exercise with arms extended and lowered the weight 1 in. from the fully flexed position or 1 in. above the chest (2 cm superior to the xiphoid process), holding this position for 5 seconds. The weight was then raised, and this series was repeated 1 more time with the same weight and grip direction. A 3-minute rest occurred, and the same movement was repeated with a different grip width. The order of the movement tasks was randomized.

EMG Processing and Data Analysis

The average root-mean-square (RMS; window of 164 milliseconds, overlap of 82 milliseconds) of the 5-second isometric portion of the bench press was found for each repetition. The average activity for each muscle group was then expressed as a percentage of the RMS average found during the isometric portion of the bench press using a wide grip width (200% BAD) and the supinated/forward forearm position. Normalizing to this task permits comparison across subjects and facilitates comparison between tasks. Normalizing to an MVC may also be performed, although it is not necessary if your element of interest is merely the ratio of activity of the same muscle across different exercises. Normalizing to an MVC and then finding the muscle activation ratios between the dif-

TABLE 1. Clavicular pectoralis major muscle activity (values are expressed as a percentage of the muscle activity found during the forward wide grip bench press).

	Forward grip			Reverse grip	
	Wide[1]	Middle[2]	Narrow[3]	Wide[4]	Middle[5]
Mean	100	99.790	96.878	*127.011	107.590
Standard deviation	0	32.390	44.210	37.939	42.391
Different from*	4	5	4	1,3	2

* This row indicates which other exercise the myoelectric signal for the respective column is statistically different ($p < .05$) from. Columns (grip used) are denoted with a superscript number.

TABLE 2. Sternoclavicular pectoralis major muscle activity (values are expressed as a percentage of the muscle activity found during the forward wide grip bench press).

	Forward grip			Reverse grip	
	Wide[1]	Middle[2]	Narrow[3]	Wide[4]	Middle[5]
Mean	100	82.097	72.804	98.060	97.939
Standard deviation	0	22.613	34.131	35.316	39.937
Different from*	3	—	1,4,5	3	3

* This row indicates which other exercise the myoelectric signal for the respective column is statistically different ($p < .05$) from. Columns (grip used) are denoted with a superscript number.

TABLE 3. Triceps muscle activity (values are expressed as a percentage of the muscle activity found during the forward wide grip bench press).

	Forward grip			Reverse grip	
	Wide[1]	Middle[2]	Narrow[3]	Wide[4]	Middle[5]
Mean	100	157.271	210.507	107.443	154.939
Standard deviation	0	57.097	98.559	40.304	77.673
Different from*	2,3,5	1,3,4	1,2,4,5	2,3,5	1,3,4

* This row indicates which other exercise the myoelectric signal for the respective column is statistically different ($p < .05$) from. Columns (grip used) are denoted with a superscript number.

ferent grip widths would result in identical ratio values between the exercises. The average of the 2 repetitions for each exercise and hand position was calculated for each subject. Since the biceps brachii is not a prime mover in the bench press, a 3-second MVC was performed for the biceps (isometric exertion, elbow flexion at 90°, and fully supinated forearm). For the statistical calculations, the biceps activity was normalized to the average myoelectric activity found during the wide grip bench press, as was done with all other muscle groups. Additionally, to give physiological relevance to the biceps muscle activity during the bench press, we chose to normalize the biceps activity to the average maximum activity found during the 3-second biceps MVC. This would aid in the interpretation of the results.

Statistical Analyses

A repeated-measures analysis of variance with a post hoc Tukey test was used to determine if grip width and hand position caused significantly ($p \leq 0.05$) different activation levels within the 4 muscles.

RESULTS

For the clavicular portion of the pectoralis major, supinating the forearm increased muscle activity relative to a pronated wide grip and pronated narrow grip. Grip width did not influence muscle activity when the forearm position was pronated. With a middle distance grip width (100% BAD), supinating the forearm resulted in an increase in myoelectric activity. No other difference in muscle activity for any hand position was found. Table 1 presents the muscle activation for each grip expressed as a percentage of the muscle activity recorded during the bench press using a forward grip at the widest hand position.

Using a pronated forearm position moving from the widest grip to the narrowest grip resulted in a significant reduction in muscle activity in the sternoclavicular portion of the pectoralis major. The pronated narrow grip width was significantly less than all hand positions except for the pronated middle grip width. Supination did not influence the muscle activity of the sternoclavicular portion of the pectoralis major. Table 2 presents the muscle activation for each grip expressed as a percentage of the muscle activity recorded during the bench press using a forward grip at the widest hand position.

In the triceps muscle, using the narrowest grip with a pronated hand position resulted in the highest amount of muscle activity. Moving from a wide grip to a midgrip position increased muscle activity in the triceps for both the pronated and supinated positions. Supination had no influence on triceps muscle activity. Table 3 presents the muscle activation for each grip expressed as a percentage of the muscle activity recorded during the bench press using a forward grip at the widest hand position.

For the biceps muscle, relative to the activity during a wide grip pronated forearm position, changes in muscle activity were variable. Changing to a midgrip while main-

TABLE 4. Biceps muscle activity (values are expressed as a percentage of the muscle activity found during the forward wide grip bench press).

	Forward grip			Reverse grip	
	Wide[1]	Middle[2]	Narrow[3]	Wide[4]	Middle[5]
Mean	100	84.088	98.737	209.6	122.4
Standard deviation	0	33.275	36.057	98.93	46.5
Different from*	4	4,5	4	1,2,3,5	2,4

* This row indicates which other exercise the myoelectric signal for the respective column is statistically different ($p < .05$) from. Columns (grip used) are denoted with a superscript number.

taining a pronated forearm position brought no change in muscle activity, whereas a substantial decrease in activity was observed when the same change in grip width occurred while in a supinated position. Supinating the forearm resulted in increases in myoelectric activity for both the wide and midgrip positions when compared with the activity observed when using a pronated position of similar width. When expressed as a percentage of MVC, the average activation levels varied from 14.9 to 37.2% of the biceps MVC. Table 4 presents the muscle activation for each grip expressed as a percentage of the muscle activity recorded during the bench press using a forward grip at the widest hand position.

DISCUSSION

The greatest change in muscle activity appeared in the biceps muscle group when moving to a supinated forearm position from a pronated position for both grip widths. One explanation may be related to muscle length changes during biceps supination. Biceps supination causes a decrease in muscle length, which may result in the biceps operating on a suboptimal portion of the force-length curve. Therefore, the increased muscle activity may not have resulted in an increased biceps force production. However, Chang et al. (2) found that the optimal muscle length for the biceps brachii occurred at 107° of flexion in a supinated position when producing elbow flexion torques. Although not directly measured, the elbow angle during the isometric portion of the bench press in this study appears to be between 90 and 120° of flexion. The amount of muscle shortening of the biceps brachii that occurs when moving from a fully pronated to a fully supinated position and how this length change influences the force-length relationship and the subsequent EMG to force relationship are currently unexplained in the literature. Additionally, Sakurai et al. (6) has shown that changes in elbow angle position when fixed in a brace have little influence on biceps EMG activity when flexion torques are produced about the shoulder. Therefore, changes in muscle activity may not be completely due to changes in muscle length. Future work should investigate whether this increased biceps activity occurs at different degrees of arm flexion and possibly different portions of the force-length curve.

The increase in biceps myoelectric activity when using a supinated grip and the trend to increase activity when moving from a midgrip to a narrow grip may be due to the elbow stability requirements imposed by these positions. A narrower grip may be more difficult to balance than the midrange grip, therefore resulting in an increased co-contraction of the biceps muscle with the triceps muscle. This co-contraction of agonist and antagonist, as seen with trunk flexors and extensors to produce adequate spinal stability, may also account for the increases in biceps muscle activity when in a supinated posture. This increased co-activation is supported by the trend for increases in triceps muscle activity during the supinated forearm position at the widest grip width. While the percentage of change in tricep muscle activity was not nearly as great as that observed in the biceps, the increases in force production may have been similar, given that the triceps are a primary mover during the bench press. The triceps are most likely producing forces much closer to their maximum when compared with the biceps. Therefore, similar absolute changes in force production for the 2 muscle groups may have different relative changes in muscle activity.

Last, the increases in myoelectric activity in the biceps brachii when using the wide and supinated grip may be due to the long head of the biceps role in providing shoulder stability. Pagnani et al. (5) showed that the biceps brachii functioned to limit humeral head translation. Supination may facilitate this function. Additionally, Itoi et al. (4) demonstrated that with external rotation (i.e., with a wide and supinated grip), the biceps function to reduce anterior displacement of the humeral head.

Grip width appeared to have no influence on myoelectric activity in the clavicular portion of the pectoralis major muscle when using both forearm positions. This finding is similar to that observed by Barnett et al. (1), although this group did use different weights for the different exercises. Our finding is in contrast to the decreased muscle activity found when moving to a more narrow grip by Clemons and Aaron (3). The reason for the increase in activity in the clavicular head of the pectoralis major when the forearm is supinated is unknown.

A change in muscle activity was not observed in the sternoclavicular head of the pectoralis major when supination of the forearm occurred. Nor were there changes related to grip width when in the supinated position. In contrast to the study by Clemons and Aaron (3), decreasing grip width from 200 to 100% BAD did not statistically change muscle activity, although a trend did exist. However, when moving to the narrowest grip width, statistically significant decreases in muscle activity were observed in the sternoclavicular portion of the pectoralis major. The lack of a change in activity when moving from 200 to 100% BAD is similar to the nonchange found by Barnett et al. (1).

For the triceps muscle, while pronated, moving to a midgrip and to the narrowest grip resulted in increased activation. This finding is consistent with conventional weightlifting wisdom and is in agreement with that of Barnett et al. (1) and yet contradicts the findings of Clemons and Aaron (3), who showed decreased triceps activity when moving to a narrow grip.

PRACTICAL APPLICATIONS

This study supports the conventional wisdom that a narrower grip width will result in an increased activation of the triceps muscle, suggesting the importance of this exercise if an athlete wishes to train this muscle group. The results of this study also indicate that a supinated grip during the bench press increases the recorded myoelectric signal of the biceps without adversely affecting the muscle recruitment of the prime movers. This increased myoelectric activity may translate to an increased force production of the biceps muscle, which can act to stabilize and flex the shoulder joint. Forearm supination during the bench press may be an important component in the functional retraining of injured shoulders.

This study also lends support to the conventional weightlifting wisdom that decreased grip width results in increased activation of the triceps musculature. However, the activation of the sternoclavicular portion of the pectoralis major is decreased. If one wishes to cancel this decrease in activity, supinating the forearm appears to inhibit this myoelectric activity decrease in the sternoclavicular portion of the pectoralis major without adversely affecting the increases in triceps activity.

While small changes in muscle activity occurred during different grip widths, sport- and movement-specific training must still determine the exercises chosen in a training program. These changes in muscle activity are quite small, and attempts to focus on individual muscle groups rather than on movements requiring strength may be less than ideal.

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