

# The Effect of 12 Variations of the Bench Press Exercise on the EMG Activity of Three Heads of the Pectoralis Major

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## ABSTRACT

This study compared the activation of the clavicular, sternocostal and abdominal heads of the pectoralis major (PM) and the long portion of the triceps brachii during the execution of the bench press with several inclinations, grip types, and grip widths. Thirteen healthy men with more than a year of resistance training experience participated in this study. The subjects performed 6 repetitions of various variations of the bench press at angles of  $-15^\circ$ ,  $0^\circ$  and  $30^\circ$  with grip width of 100% and 200% of their biacromial width in both pronation and supination with a load equivalent of their respective 12RM for each movement. EMG, bar acceleration and shoulder angle were recorded during each repetition. Activation of the clavicular head of the PM was, compared to a wide pronation at  $0^\circ$ , significantly higher at a close pronation at  $0^\circ$  and  $30^\circ$ ; during a close supination at  $30^\circ$  and during a wide supination at  $30^\circ$ . Activation of the sternocostal head of the PM was, during a wide pronation at  $0^\circ$ , significantly higher than during a close supination at  $0^\circ$ ,  $30^\circ$  and  $-15^\circ$ ; during a wide supination at  $30^\circ$ ; during a wide supination at  $0^\circ$  and  $30^\circ$  and at close pronation at  $30^\circ$  and  $-15^\circ$ . Activation of the abdominal head of the PM was significantly better with wide pronation at  $-15^\circ$  and  $0^\circ$  compared to all positions at  $30^\circ$ . Triceps brachii were better solicited during close pronation at  $0^\circ$  and  $-15^\circ$  compared to supinated grip at  $0^\circ$  and  $30^\circ$ . Results from this study show that the bench press exercise performed with a wide pronation grip at  $0^\circ$  can maximize the activation of the three heads of the PM.

**Keywords:** Muscle Recruitment; Muscle Development; Positions Comparisons

## INTRODUCTION

Resistance training is one of the most popular forms of exercise to improve the overall fitness of an individual or athlete such as strength, power, endurance and/or muscular hypertrophy (5). In addition, some studies have proposed the idea that within a muscle, neuromuscular compartments could exist, meaning that the body could recruit different muscle heads depending on the chosen exercise (3, 11). For example, changes in the recruitment of the clavicular and sternocostal heads of the pectoralis major can be brought about by the variation of the incline of the bench during the bench press (2, 14) as well as by a change in the width or type of grip (4, 10). In this case, Lehman (10) demonstrated that adopting a supinated grip during horizontal bench pressing ( $0^\circ$ ) allowed for a better recruitment of the clavicular head of the pectoralis major than a pronated grip. However, no studies to date have analyzed supinated grip during decline and incline bench press. Also, Barnett et al. (2) and Glass and Armstrong (6) demonstrated that the clavicular head would be equally well worked at decline ( $-18^\circ$  and  $-15^\circ$  respectively) and at incline ( $+40^\circ$  and  $+30^\circ$  respectively) while recruitment of the sternocostal head would be diminished in an inclined position compared to a declined position. However, the involvement of the abdominal head was not taken into account in any study in which the inclinations

of the bench were varied. In terms of grip width, studies show variations in muscle recruitment, but none of them correlated the width of the grip with the shoulder angle of the subjects. Because the pectoralis major attaches to the humerus and is influenced by the angle of shoulder abduction, data from studies examining the differences in muscular recruitment between multiple grip widths in the bench press can therefore be misleading and misinterpreted in the absence of this essential value.

In order to develop muscle mass or strength, the degree of activation of a muscle or muscle region is paramount. Consequently, it would be interesting to understand the influence of different inclinations, grip types and widths (with a correlation to the shoulder's angle) during a bench press on the activation of the pectoralis major, specifically on the clavicular, sternocostal and abdominal heads of the muscle. From a practical point of view, this will demystify or confirm certain claims in strength and conditioning such as dominance of the clavicular head during the incline bench press and the dominance of the abdominal head in the decline bench press. The purpose of this study was to determine the effects of a variation of trunk inclination ( $-15^\circ$ ,  $0^\circ$  and  $+30^\circ$ ), width of grip (100% and 200% of biacromial width with control of the shoulder angle during movement) and type of grip (supinated and pronated) during various bench press exercises on the stimulation of the abdominal, sternocostal and clavicular heads of the pectoralis major as well as the long head of the triceps brachii in male subjects who have been training for more than a year.

## METHODS

### *Approach to the problem*

#### *12RM estimation procedures (first session)*

After a warm-up consisting of 2 sets of 6 repetitions with 50% of the starting load estimated by the subject, the subject settled on the bench (decline, horizontal or incline). The indexes of each hand were positioned directly on the marks indicated on the barbell according to their biacromial width (100 or 200% of the biacromial diameter) when the forearms were in pronation. With a supinated grip, it is the auricular fingers that were then positioned on the marks. Also, the type of grip used, for both supinated and pronated grip, in regard to the thumb was in a closed position (thumb secured around the bar). The subjects performed the lifts in a controlled

manner with a tempo of 3-1-1-0, ie. 3 seconds in eccentric, 1 second pause at 2 cm of the chest, 1 second in concentric and no pause between the repetitions. This tempo was dictated aloud by the tester who was following a stopwatch.

Exercise order was randomized for all subjects and was repeated during the second session. Subjects completed their 12 RMs for each of the 12 exercises. To do this, a load was predetermined by the subject according to his resistance training experience. Next, the subject had to complete as many repetitions as possible with this load in order to estimate their 12RM using the Percentage Chart from Beachle et al. (1). For example, if a subject completed 8 repetitions with 60 kg, the estimated 12RM was 54 kg (1), which is the load that would be used at the second session. Only one set per exercise was completed, ie. 12 sets in total, with 3 minutes of rest between each set. For a repetition to be considered valid, the subjects had to perform a full extension of the elbows.

### *Electromyographic measurements*

The EMG signals of the pectoralis major (clavicular, sternocostal, abdominal) and triceps brachii (long portion) heads were pre-amplified at the electrode source ( $\times 1000$ ). Two electrodes were placed above each muscle with a distance of 1 cm between the electrodes and parallel to the muscle fiber. The electrode sites were prepared by shaving, abrading with sandpaper and disinfecting with alcohol to reduce the skin's resistance. The spinning of each preamplified electrode was attached to the skin by adhesive tape to prevent delamination caused by traction on the wire and also not to interfere with movement (attachment to the upper trapezius muscle). Subsequently, the signals were sent to a converter that transforms analog data into digital data (Measurement Computing™) and processed by DASYLAB® 11 (National Instruments, USA). Once the raw data was displayed on the computer screen, a bandwidth of 20-350 hertz was applied, followed by a signal rectification and filtering of the curve with a 6 Hertz filter (second-order Butterworth filter). Each EMG signal for each test was visually analyzed to remove any artifact. The data were normalized (in percentage) according to the highest EMG value obtained during the exercises and/or the maximum voluntary isometric contraction for each muscle, respectively.

### *Maximal voluntary isometric contraction (MVIC) assessment*

For each of the MVIC attempts (two), the participant was asked to provide maximal force against manual resistance for a five-second duration and completed two MVIC attempts for each movement (one before and one after EMG recording to assess muscle fatigue). Strong verbal encouragement was provided to the subject during each of the MVIC attempts. Two minutes of recovery was provided following each MVIC attempt. For the pectoralis major MVIC, the participant was asked to horizontally abduct with the shoulder and elbow flexed at 90°. The participant provided maximal force while attempting to horizontally adduct the arm by pushing each hand together. During the triceps brachii MVIC, the participant was asked to flex the elbow to 90° and put the forearm on a table. The participant was then asked to provide maximal force attempting to extend the elbow while resistance was provided (pushing on table).

### *Subjects*

Data were collected from 13 male subjects (age =  $31.1 \pm 6.3$  years, height =  $179.5 \pm 10.2$  cm, weight =  $88.8 \pm 14.4$  kg, biacromial width  $41.9 \pm 2.0$  cm, training experience =  $12.2 \pm 6.0$  years) who volunteered to participate in this study. One subject was, however, forced to leave the study for medical reasons. The remaining subjects were injury-free at the time of assessment and had no history of joint and muscle issues. Prior to data collection, the subjects were informed of the purpose and procedures of the study through a consent form and then completed the document. The approval of the UQAM ethics committee was also received before the start of the study.

### *Procedures*

The subjects visited the laboratory on two different occasions. During the first visit, the subjects became familiar with the procedures of the study (tempo used, explanations and 12 positions that would be analyzed) and a 12RM test was measured for each of the 12 positions. The rest periods between each test was three minutes and all participants used a different order protocol (the sequence of the exercises was different for all participants with some beginning with the decline bench press and others with the incline bench press, for example) to minimize the impact of accumulated fatigue during the results analysis. Furthermore, a maximal voluntary isometric

contraction (MVIC) with recorded EMG was performed during the second visit before and after the performance of the 12 bench press exercise variations to evaluate potential accumulated fatigue. Therefore, during the second visit and the first MVIC, subjects performed a single set of 6 repetitions at each of the positions using a respective load of 12RM. The order in which the series were performed was randomly distributed and counterbalanced. During each set and for the MVIC, the EMG activity was recorded on the three heads of the pectoralis major (clavicular, sternocostal and abdominal) as well as on the long portion of the triceps brachii.

In order to determine whether the angle of the bench inclination, the width of the grip and the type of grip during the bench press influence the activation of the agonist muscles, a random order of exercises was assigned to each of the subjects. The 3 angles evaluated are: -15° below the horizontal (decline), 0° (horizontal) and 30° above the horizontal (incline). The type of grip was either pronated or supinated and the width was either 100% or 200% of the biacromial width. A total of twelve exercises were analyzed corresponding to four variants per inclination: (a) close grip and wide grip in supination and (b) close grip and wide grip in pronation. Six repetitions, using a 70% load of 1 repetition maximum (RM) (or equivalent to 12RM) for each of the positions, were performed on each of the 12 exercises. The electromyographic (EMG) activity of the clavicular, sternocostal and abdominal heads of the pectoralis major and the long portion of the triceps brachii were recorded, and later analyzed, for each of the positions. Subjects were instructed to refrain from training their upper body for at least 48 hours before the evaluation period. Preamplified electrodes (DELSYS, Bagnoli™ surface EMG sensor, Ag, 10mm) were used to record surface EMG at four sites: on the muscular belly of the pectoralis major in a vertical line below the mid-clavicle, ie. above the 1st (clavicular head), the 3rd (sternocostal head) and the 5th intercostal space (abdominal head).

General instructions given during the first session (eg. marks on the bar, tempo, etc.) were the same during the second session. Once the subject was ready, the tester began his countdown procedure for the tempo. The camera was turned on just before the start of the movement, followed by activation of the light and electromyogram. The shoulder opening was visually detected by the tester so that the shoulder was <45° when the grip was close and >45° when the grip was wide. If necessary, verbal instructions were given to the subject to readjust the

position of the elbows. No contact between the bar and the electrodes was allowed. In addition, three minutes of rest were given to the subject between each EMG recording to minimize fatigue.

### Statistical analysis

A three-factors repeated measures ANOVA was used to determine the effects of inclination (3 trunk positions), grip width (2 distances) and type of grip (pronation and supination) on the electrical activity of each muscle. Post hoc Bonferroni tests revealed the source of the significant results. Statistical significance was set at  $p \leq 0.05$ .

## RESULTS

### Loads

Table 1 illustrates the mean estimated 1 Repetition Maximum (RM) in kilograms for each bench press variations.

### Bar Acceleration

No difference in bar acceleration between subjects and for the same subject was observed. Mean accelerations (g) of the bar was  $0.56 \pm 0.25$  (close pronated grip),  $0.44 \pm 0.27$  (wide pronated grip),  $0.46 \pm 0.12$  (close supinated grip) and  $0.37 \pm 0.08$  (wide supinated grip) for the horizontal bench press ( $0^\circ$ );  $0.50 \pm 0.18$  (close pronated grip),  $0.44 \pm 0.20$  (wide pronated grip),  $0.48 \pm 0.16$  (close supinated grip) and  $0.40 \pm 0.16$  (wide supinated grip) for the incline bench press ( $+30^\circ$ ); and  $0.44 \pm 0.12$  (close pronated grip),  $0.33 \pm 0.11$  (wide supinated grip),  $0.40 \pm 0.25$  (close supinated grip) and  $0.38 \pm 0.13$  (wide supinated grip) for the decline bench press ( $-15^\circ$ ), respectively.

### Shoulder angles with wide and tight grip

No significant difference was observed between the shoulder angles with a close pronated grip between the three inclinations and also with a wide pronated grip between the three inclinations. Table

**Table 1.** Estimated 1RM\* for each bench press variation

Inclination	Type of grip	Grip width	1RM (kg)
Horizontal ( $0^\circ$ )	Pronation	Close	$79,7 \pm 16,3$
		Wide	$84,9 \pm 15,9$
	Supination	Close	$65,8 \pm 12,0$
		Wide	$67,2 \pm 11,7$
Incline ( $+30^\circ$ )	Pronation	Close	$68,1 \pm 18,2$
		Wide	$72,1 \pm 21,8$
	Supination	Close	$57,1 \pm 11,1$
		Wide	$59,6 \pm 14,0$
Decline ( $-15^\circ$ )	Pronation	Close	$81,4 \pm 15,5$
		Wide	$84,9 \pm 16,3$
	Supination	Close	$68,6 \pm 17,2$
		Wide	$72,1 \pm 20,1$

\*1RM = 1 repetition maximum Mean ( $\pm$ SD)

**Table 2.** Mean shoulder angle of subjects when bench press in three different inclinations ( $-15^\circ$ ,  $0^\circ$ ,  $+30^\circ$ )

Width Grip	Shoulder Angle
	Mean $\pm$ Standard Deviation
Close Grip	$33.6 \pm 2.1$
Wide Grip	$67.9 \pm 3.3$

\*All presented values are in degrees ( $^\circ$ ). No significant difference between width grip in all inclinations

2 illustrates the average shoulder angles for both types of grip width.

#### Clavicular head of the pectoralis major

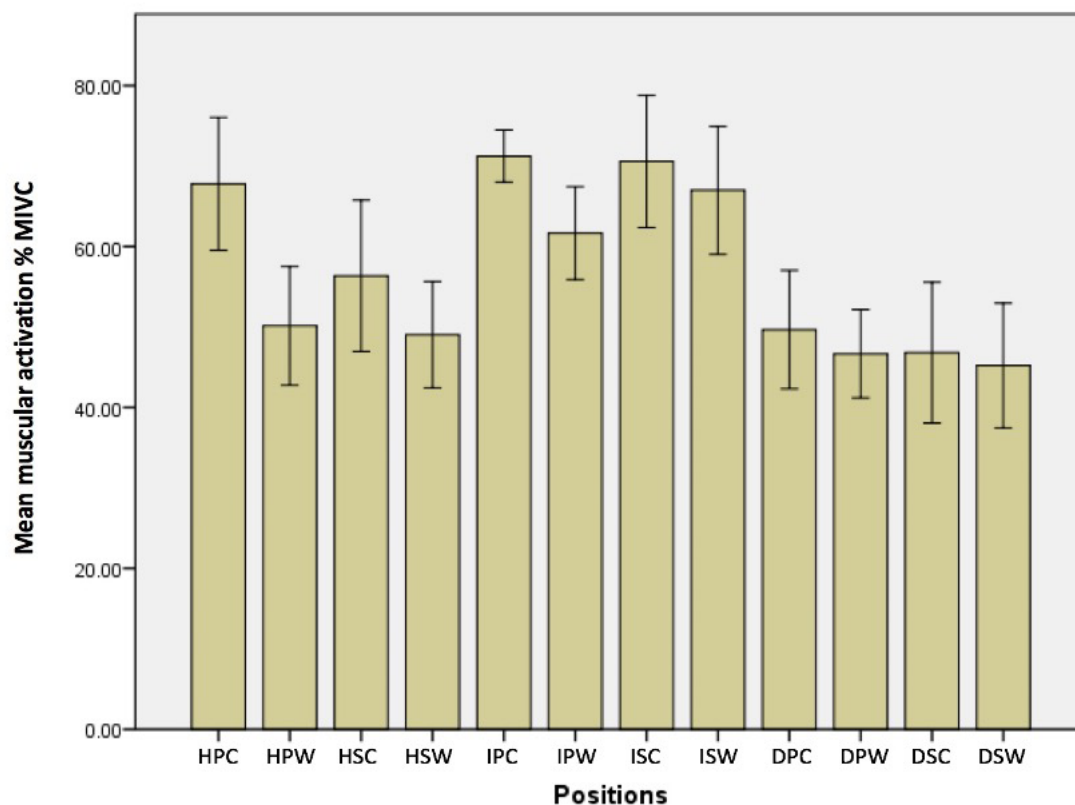
For the following section and for figures 1, 2, 3 and 4, note that abbreviations on the X axis are presented as follows: Inclination [ $H = \text{Horizontal } (0^\circ)$ ;  $I = \text{Incline } (+30^\circ)$ ;  $D = \text{Decline } (-15^\circ)$ ] / Type of grip [ $P = \text{pronated}$ ;  $S = \text{supinated}$ ] / Width of the grip [ $C = \text{Close}$ ;  $W = \text{Wide}$ ]. For example, the HPC position means the horizontal movement [ $H$ ] in pronation [ $P$ ] and with close grip [ $C$ ].

Figure 1 illustrates the results for the activation of the clavicular head of the pectoralis major in the 12 exercises, and the significant differences ( $p \leq 0.05$ ) are presented as follows: HPC elicited higher activation of the clavicular head of the pectoralis major than the HPW, HSW, DPC, DPW, DSC and DSW; IPC elicited higher activation of the clavicular head of the pectoralis major than HPW, HSW, DPC, DPW, DSC and DSW; IPW elicited higher activation of the clavicular head of the pectoralis major than the DSW; the ISC elicited higher the clavicular head of the pectoralis major more than HPW, HSW, DPC, DPW, DSC and DSW; ISW activates more the clavicular head of the pectoralis major than HPW, HSW, DPC,

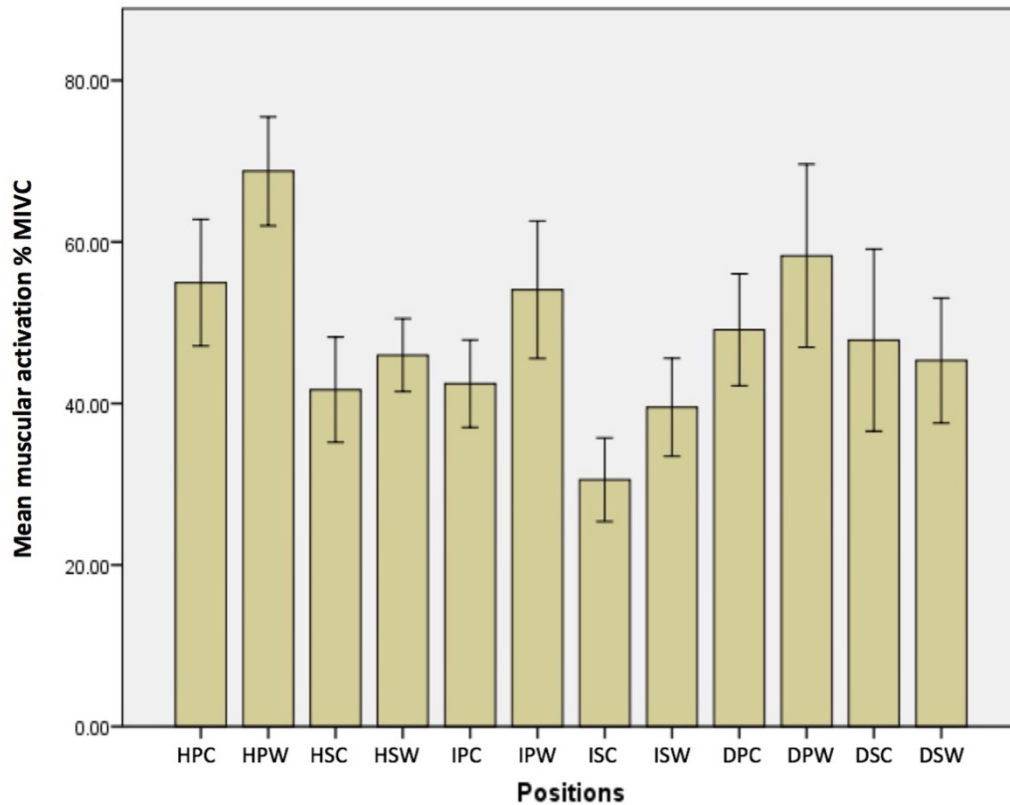
DPW, DSC and DSW. As a result, the best positions in the bench press for a greater muscle activation of the clavicular head of the pectoralis major are therefore HPC, IPC, ISC and ISW.

#### Sternocostal head of the pectoralis major

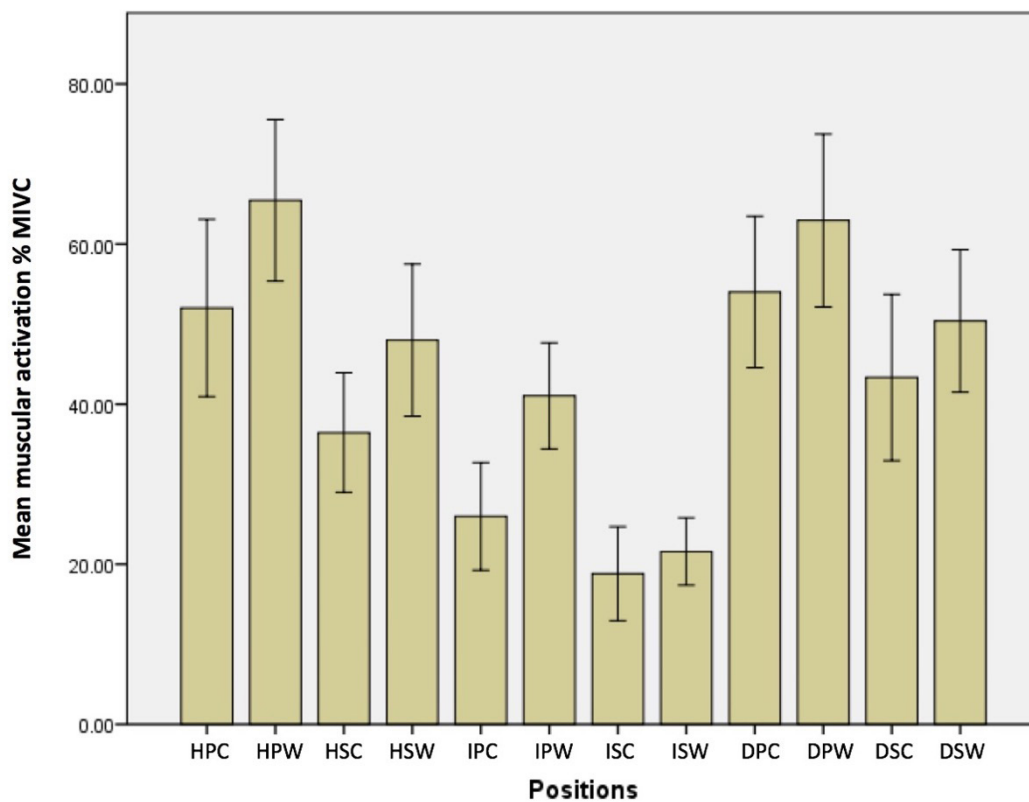
Figure 2 illustrates the results for the activation of the sternocostal head of the pectoralis major in the 12 exercises and the significant differences ( $p \leq 0.05$ ) are presented as follows: the HPC elicited higher activation of the sternocostal head of the pectoralis major than the ISC; HPW elicited higher activation of the sternocostal head than the HSC, HSW, IPC, ISC, ISW, DPC, DSC and DSW; the IPW elicited higher activation of the sternocostal head of the pectoralis major than the ISC; the DPC elicited higher activation of the sternocostal head of the pectoralis major than the ISC; DPW elicited higher activation of the sternocostal head of the pectoralis major than the ISC and ISW; the DSC elicited higher activation of the sternocostal head of the pectoralis major than the ISC. As a result, the best position in the bench press for the activation of the sternocostal head of the pectoralis major is therefore HPW.



**Figure 1.** Effects of trunk inclination ( $-15^\circ$ ,  $0^\circ$ ,  $+30^\circ$ ), grip width (wide vs close), and type of grip (pronation vs. supination) on the EMG activity of the clavicular head of the pectoralis major.



**Figure 2.** Effects of trunk inclination (-15°, 0°, +30°), grip width (wide vs close), and type of grip (pronation vs. supination) on the EMG activity of the sternocostal head of the pectoralis major.



**Figure 3.** Effects of trunk inclination (-15°, 0°, +30°), grip width (wide vs close), and type of grip (pronation vs. supination) on the EMG activity of the abdominal head of the pectoralis major.

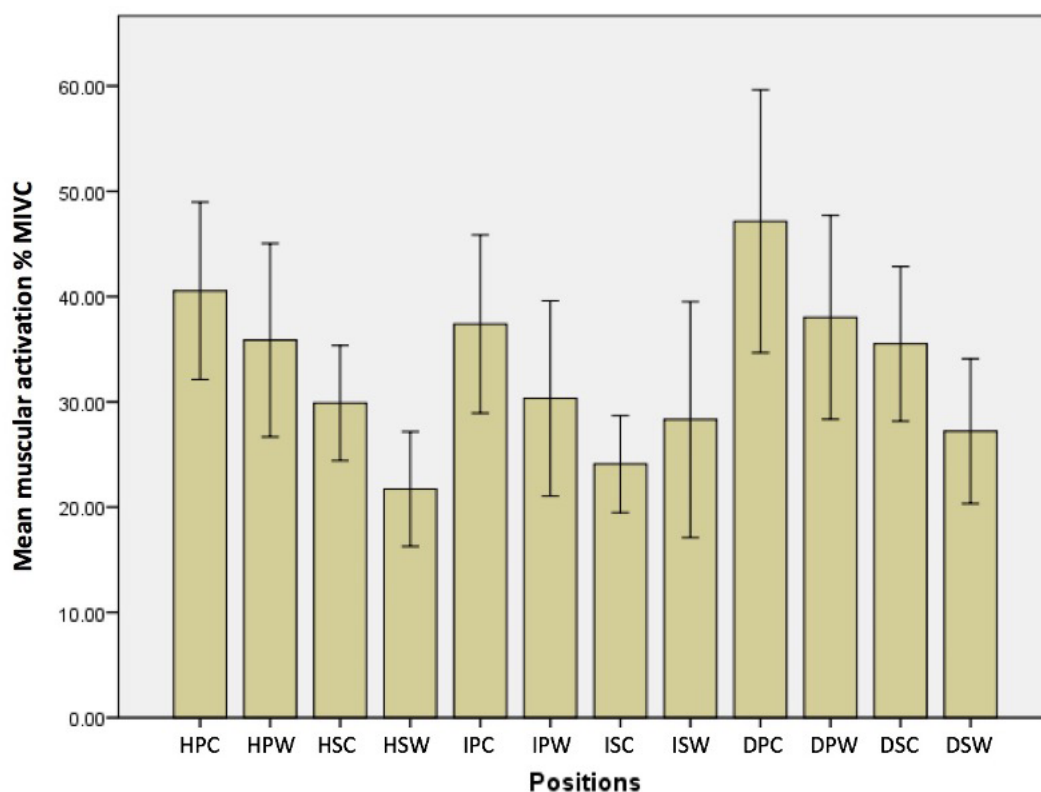
### Abdominal head of the pectoralis major

Figure 3 illustrates the results for the activation of the abdominal head of the pectoralis major in the 12 exercises and the significant differences ( $p \leq 0.05$ ) are presented as follows: the HPC elicited higher activation the abdominal head of the pectoralis major than the IPS, ISC and ISW; HPW elicited higher activation the abdominal head of the pectoralis major than HSC, IPC, IPW, ISC, ISW and DSC; HSW elicited higher activation the abdominal head of the pectoralis major than the IPC, ISC and ISW; the IPW elicited higher activation the abdominal head of the pectoralis major than the ISC and the ISW; DPC elicited higher activation the abdominal head of the pectoralis major than the IPC, ISC and ISW; DPW elicited higher activation the abdominal head of the pectoralis major than HSC, IPC, IPW, ISC, ISW and DSC; the DSC elicited higher activation the abdominal head of the pectoralis major than the ISC

and the ISW; the DSW elicited higher activation the abdominal head of the pectoralis major than the IPC, ISC and ISW. As a result, the best positions in the bench press for the recruitment of the abdominal head of the pectoralis major are therefore HPW and DPW.

### Long head of the triceps brachii

Figure 4 illustrates the results for the activation of the long head of the triceps brachii in the 12 exercises and the significant differences ( $p \leq 0.05$ ) are presented as follows: the HPC elicited higher activation the long head of the triceps brachii than the HSW; DPC elicited higher activation the long head of the triceps brachii than HSW, ISC and DSW. As a result, the best positions in the bench press for the recruitment of the long head of the triceps brachii are therefore HPC and DPC.



**Figure 4.** Effects of trunk inclination ( $-15^\circ$ ,  $0^\circ$ ,  $+30^\circ$ ), grip width (wide vs close), and type of grip (pronation vs. supination) on the EMG activity of the abdominal head of the triceps brachii

## DISCUSSION

The clavicular head of the pectoralis major elicited higher activation, according to the present study, with the horizontal bench press (0°) with a close grip as well as in almost all the positions (3/4) during the incline bench press (+30°). As a result, these data are consistent with Barnett et al. (2) who demonstrated better activation on the clavicular head of the pectoralis major during a close grip horizontal bench press compared to a wide grip bench press.

In contrast, Lehman (10) found no significant difference between wide (200% of the biacromial width) and close (100% of the biacromial width) pronated grip in clavicular head recruitment. Four points can explain this difference: (a) First, Lehman did not control the abduction at the shoulder for both grip widths, so that the participants could simply keep the angle to the shoulder identical in both types of movements. Knowing that the clavicular head is also involved in flexion of the shoulder (8), a close grip with controlled shoulder angle would cause more flexion (<45° as performed in this study) which may explain this difference; (b) Secondly, Lehman had subjects perform an isometric pressing movement for 5 seconds instead of performing repetition with full range of motion; (c) Thirdly, no data is mentioned as to the positioning of the electrodes on the muscle in addition to the fact that “the electrodes of the clavicular and sternocostal head are distant by 2.5 cm” making the comparison difficult; (d) Finally, the load used was identical for all the positions analyzed, contrary to the present study which used the respective 12RM for each of the analyzed positions.

For the variation of the inclination of the bench, no significant difference was observed between the horizontal (0°) bench press and the inclined (+30°) bench press with a large pronated grip for the clavicular head of the pectoralis major. This data is consistent with the results of previous studies (2, 9, 13). In addition, there was no significant difference between the declined (-15°) and inclined (+30°) bench press with a wide pronated grip in our study. This data is consistent with the results of Glass & Armstrong (6), Trebs et al. (14) and Lauver et al. (9), but is potentially contrary to those of Barnett et al. (2). In the study by Barnett et al. (2), grip widths similar to this study were used, ie 100% and 200% of the biacromial width. On the other hand, the inclinations used were different between this study and that of Barnett et al. (-15° vs -18°, +30°

vs +40°, respectively). Interestingly, Trebs et al. (14) demonstrated a significant difference in clavicle head recruitment between the horizontal position (0°) and inclined position at +44°, but not significant when compared to a position at +28°. Thus, the difference between the angles analyzed (45° difference between -15° and +30° in the present study compared to 58° difference between -18° and 40° in that of Barnett et al. (2)) could explain the difference in clavicular head activation. In addition, Barnett et al. (2) did not mention the grip width that resulted in the best muscle activation. It was simply mentioned that the inclined position elicited higher activation of the clavicular head than the position declined. However, the present study demonstrated a better activation of the clavicular head of the pectoralis major during an incline bench press with a close pronated grip compared to the same grip placement, but in a declined bench press. These results would then agree with Barnett et al. (2) if the authors had specified the width of the grip.

Concerning the supinated grip, the results of this study showed no significant difference between the supinated and pronated grip during the horizontal bench press. In fact, a close pronated grip elicited higher activation of the clavicular head than the other two supinated grip widths during the horizontal bench press (0°). As a result, these results disagree with those of Lehman (10) who demonstrated superior activation between a wide (200% of the biacromial width) supinated grip horizontal bench press (0%) versus the same exercise but performed with a pronated grip. The conclusions are also the same when Lehman (10) compared the close supinated grip (100% of the biacromial width) compared to the same exercise performed with a pronated grip and the same weight. The explanation for this difference is based on the load used between the two studies (Lehman's study and our study). Lehman (10) used the 12RM of the close supinated grip as a general load to hold isometrically for 5 seconds in all positions. Since use of a supinated grip is not common in resistance training and can be inherently dangerous, it is very likely that individuals were uncomfortable with this movement and therefore used a very small load compared to their actual capacity in the pronated bench press. In light of this comparison, the supinated grip can have more risks than benefits and should be avoided.

As a result, electromyographic analysis in pronation was potentially submaximal and would have resulted in inferior recruitment of the clavicular head, thus giving a false advantage to supination. In the present



study, participants had a strength difference of almost 18 kg between pronated and supinated grips. Since the electromyographic signal (EMG) is related to the number of recruitment of muscle fibers and a larger load increases the recruitment of fibers and therefore the EMG signal, a submaximal load (as in the study of Lehman (10)) thus underestimated the real muscle involvement of the clavicular head of the pectoralis major when the movement performed with a pronated grip with the same weight of a supinated grip.

For the sternocostal head of the pectoralis major, it was better activated, according to the present study, by the close grip horizontal bench press (0°) as well as in all the positions (3) using a wide pronated grip (-15°, 0°, +30°). There was, however, no significant difference between the close grip and the wide grip within the same inclination, which is consistent with the results of Lehman (10) and Barnett et al. (2). For the inclination of the bench, the present study showed no significant difference in activation of the sternocostal head between the three inclinations in both close and wide pronated grips, which is consistent with the results of Lauver et al. (9), Glass and Armstrong (6) and Trebs et al. (14). When examining the differences compared to a wide pronated grip in the horizontal (0°) bench press, all supinated grips (6) in all three inclinations (HSC, HSW, ISC, ISW, DSC, DSW) stimulated significantly less the sternocostal head of the pectoralis major.

The declined position favored the abdominal head of the pectoralis major compared to the inclined position and the wide horizontal grip improves the recruitment of the abdominal head compared to all inclined positions (4). These results are consistent with those of Glass and Armstrong (6), Barnett et al. (2) and Trebs et al. (14) for which the sternocostal

head mentioned by these studies must be compared with the abdominal head of this study (above the 5th intercostal space). No significant difference ( $p=1.000$ ) was observed between the decline and the horizontal positions when using a wide grip.

In addition, the results of the present study support that the activation of the long head of the triceps brachii was not different in a wide grip compared to a close grip, and this, for all inclinations and the type of grip (HPC vs HPW, DPC vs. DPW, IPC vs. IPW, HSC vs. HSW, DSC vs. DSW, ISC vs. ISW). However, these data do not agree with Lehman (10) and Barnett et al. (2) who noted an increase in triceps brachii recruitment when the grip is closer. In the study by Lehman (10), the electrode was placed on the lateral head of the triceps and not on the long head as in this study and that of Barnett et al. (2). In addition, the shoulder abduction angles were not measured in both studies cited above and thus be the main reason for this difference. As a result, failure to control the shoulder abduction angle may result in a different torque at the elbow when using a wide grip and a close grip. For example, if a participant maintains an identical 70° shoulder angle in a bench press with a close grip or a wide grip, the force generated by the triceps will be totally different compared to a participant who moves his or her elbow depending on the width of the grip (as in our study). In the first case, with a close grip, the participant will have the hand over his shoulder and the elbow will be on the side creating a high moment arm at the elbow, and consequently a higher recruitment of triceps brachii. Conversely, if the elbow remains close to the body during a close grip (angle of abduction of the shoulder <45°), the elbow will end up under the hand, thus minimizing the torque at the elbow and less difference in the recruitment of the triceps brachii. During the EMG

**Table 3.** Effects of trunk inclination, width grip and type of grip on EMG activity when bench pressing

Muscles	Positions with Maximum Muscle Activation	Positions with Minimum Muscle Activation
Clavicular Head of Pectoralis Major	HPC, IPC, ISC, ISW	HPW, HSW, DPC, DPW, DSC, DSW
Sternocostal Head of Pectoralis Major	HPW	ISC, ISW
Abdominal Head of Pectoralis Major	HPW, DPW	IPC, IPW, ISC, ISW
Triceps Brachii	HPC, DPC	HSW, ISC, SW

The abbreviations above mean: Inclination [H = Horizontal (0°); I = Incline (+30°); D = Decline (-15°)] / Type of Grip [P = Pronated; S = Supinated] / Width of Grip [C = Close; W = Wide]. For example, the HPC position means the horizontal movement [H] in pronation [P] and width grip close [C]

recording, no participant has moved their elbows outside of the 45° zone tolerated for each grip during both test periods. In summary, the main effects of trunk inclination, width grip and type grip on EMG activities (maximum and minimum) of the pectoralis major (all heads) and the long head of triceps brachii during the bench press are presented in table 3.

## PRACTICAL APPLICATION

Individuals who undergo resistance training often use a variety of training methods such as varying the width of the grip, varying the type of grip and varying the inclination to try to activate or recruit different heads of a muscle. These individuals target the same muscle group in hopes of stimulating growth and/or strength of these specific muscles. Since the pectoral muscles are a major focus of interest in most training programs, several variations of the bench press exist to target this muscle group. In this study, twelve variants of the bench press were analyzed to specify the impact and use of each of them. Results demonstrated that during a bench press of moderate intensity and without fatigue, activation of the motor units was specific to the type of bench press variation performed. It appears that the muscular heads of the pectoralis major (clavicular, sternocostal and abdominal) activated during the bench press are dependent on the relative trunk inclination in which the muscle works to move the humerus (taking into account the angle at the shoulder). Here are the important considerations:

1. The incline bench press (+30°) with a wide pronated grip does not recruit the clavicular head of pectoralis major more than the horizontal (0°) and declined (-15°) using the same grip. The close pronated grip in the horizontal (0°) and inclined (+30°) bench press with a shoulder angle of less than 45° as well as the wide and close supinated grip during an inclined bench press (+30°) further promote the recruitment of the clavicular head of the pectoralis major.
2. The decline bench press (-15°) does not recruit the abdominal head of the pectoralis major more than the horizontal bench press (0°). The horizontal (0°) and declined (-15°) positions with a wide or close grip recruit this muscle head in a similar way.
3. The width of the grip significantly affects the activity of the clavicular head of the pectoralis major in the horizontal bench press (0°), which means that a closer grip leads to a better recruitment. Otherwise, using a wide or close

grip does not result a significant difference in the recruitment of the sternocostal and abdominal heads of the pectoralis major and the long portion of the triceps brachii.

4. The activation of the triceps brachii does not vary according to the width of the grip. In fact, if the elbow is placed below the hand, regardless of the width of the grip used, the recruitment of the triceps will remain approximately the same. However, if the hand is placed further away from the elbow, the recruitment of the triceps will increase.
5. Use of a supinated grip does not add value in the recruitment of the sternocostal and abdominal heads of the pectoralis major and triceps brachii. It is of interest only in the inclined position (+30°) in order to increase the recruitment of the clavicular head of the pectoralis major although other positions (pronated close grip at 30° and 0°) will achieve similar muscular recruitment. Therefore, use of a supinated grip is not necessary nor suggested.
6. For a bodybuilding athlete wanting to achieve overall growth of the entire pectoralis muscle, the combination of a pronated close grip and a pronated wide grip at 0° on the bench press will be sufficient to achieve the best overall hypertrophy effect.
7. For classic strength/power athletes such as throwers, rugby and combat athletes who may not have the time to do 12 different positions of bench press, the combined use of a pronated close grip and a pronated wide grip at 0° should be achieved to maximize their strength in a time efficient manner. Moreover, varying the inclination of the bench press could allow athletes to express their strength in angles that can be specific to their sport.

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