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# Comparison of Myoelectric Activity Between Standing and Lying Plate Press Exercises in Recreationally-Trained Participants

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**Abstract**

The plate press is a multi-joint exercise that involves the elbow and shoulder joints and can be performed in two different body positions (lying and standing). The purpose of this study was to evaluate the myoelectric activity between two different plate press exercises (lying and standing) in recreationally-trained men. Fifteen resistance-trained men (26.7 ± 3.2 years, 83.1 ± 6.8 kg, 176.0 ± 6.4 cm) performed one set of 10 repetitions with a standard weight of 10kg for the standing and lying plate press exercises at 60 beats per minute. Surface electromyography was used to measure the myoelectric activity (integrated electromyography, iEMG) of the pectoralis major (PM), anterior deltoid (AD), triceps brachii (TB), and biceps brachii (BB). Two-way ANOVA (2 x 4) with repeated-measures was used to test differences between exercises and muscle groups (PM, AD, TB, and BB) for the iEMG values. There were significant differences between exercises for AD (Standing > Lying: 41.7%, $p=0.05$), TB (Lying > Standing: 51.4%, $p=0.047$), and BB (Standing > Lying: 54.6%, $p=0.001$). In the comparison between muscle groups, TB presented the lowest myoelectric activation for the standing plate press exercise (57.6%, $p<0.05$) and BB presented the lowest myoelectric activation for the lying plate press exercise (48.1%, $p<0.05$). In conclusion, the lying plate press exercise showed a greater myoelectric activation of the TB and the standing plate press exercise showed greater myoelectric activation of the AD and BB. PM showed high myoelectric activation in both exercises but with no difference between exercises.

**Keywords:** Resistance training, strength, performance

## 1 Introduction

Resistance exercise is a key factor to activate specific muscle groups and, when associated with acute load variables (i.e. intensity, volume, frequency, rest intervals), aims to develop chronic adaptations such as hypertrophy, strength, power, and muscular endurance (Brown, 2008; Duchateau et al., 2021; Figueiredo et al., 2018; Floyd, 2021; Haff & Triplett, 2016; Marchetti, 2022; Ratamess et al., 2009; Zatsiorsky et al., 2019). In this way, exercise selection is based on movement specificity and takes into account factors such as the range of motion, number of joints, prime movers, stabilizers, types of routines (Split or Whole body), and periodization phase (Haff & Triplett, 2016; Marchetti, 2022; Ratamess et al., 2009).

The plate press is a multi-joint exercise that involves the elbow and shoulder joints and can be performed in two different body positions (lying and standing). The press plate exercise is performed by practitioners and athletes aiming to stimulate muscles such as the pectoralis major (PM), anterior deltoid (AD), lateral head of the triceps brachii (TB), and biceps brachii (BB). However, the body position adopted in this resistance exercise can influence the level of activity of the prime muscles. Another important factor to be observed in this exercise is the act of squeezing the plate during the entire exercise, which could add an isometric component to the dynamic activity of the pectoralis major muscle.

To the best of the authors' knowledge, no study has analyzed the myoelectric activity between these two different plate press exercises. The rationale for this study is based on the assumption that changes in body position (lying or standing) may modify the myoelectric activity of pectoralis major (PM), anterior deltoid (AD), triceps brachii (TB), and biceps brachii (BB). Therefore, the body position related to the external load may or may not intensify the participation of each prime mover. Understanding the effects of body position on changes in target muscles facilitates the correct selection of these exercises within training or rehabilitation programs. Therefore, the purpose of this study was to evaluate the myoelectric activity between two different plate press exercises (lying and standing) in recreationally-trained men. The main hypotheses are that (1) PM and AD activation are similar between both plate press exercises, (2) TB is more active during the lying plate press exercise, and (3) BB is more active during the standing plate press exercise.

# 2 Methods

## 2.1 Participants

The sample size was justified by a priori power analysis based on a pilot study where the superficial electromyography (vastus lateralis and gluteus maximus), in four recreationally-trained participants, an alpha level of 0.05, and a power ($1-\beta$) of 0.80 (Eng, 2003). Fifteen resistance-trained men were assigned to this study [age 26.7 ± 3.2 years, total body mass 83.1 ± 6.8 kg, height 176.0 ± 6.4 cm]. All participants had 5±3 years of resistance training experience (at least 3 times a week) with hypertrophy-type training and were familiar with the plate press exercise. Participants had no previous surgery or history of injury with residual symptoms (pain) in the upper limbs or spine within the last year. The participants were informed of the risks and benefits of the study prior to any data collection and then read and signed an institutionally informed consent document approved by the Institutional Review Board at the University (IRB # 6.003.724).

## 2.2 Procedures

All procedures were randomized and counterbalanced across participants and experimental conditions. Participants attended one session in the laboratory and refrained from performing any upper body exercise other than activities of daily living for at least 48 hours prior to testing. All participants were asked to identify their preferred arm for writing, which was considered their dominant arm (Maulder & Cronin, 2005). Then, anthropometric data were evaluated (height and weight).

Next, all participants performed a familiarization and specific warm-up for both plate press exercises (lying and standing). The warm-up followed the following procedure: 1 set of 10 repetitions without external load, followed by 1 set of 10 repetitions with 5 kg for each resistance exercise, and a 5-min rest interval was given between sets. To perform the plate press exercise, all participants remained with their elbows extended in line with their shoulders and holding a standard weight of 10 kg plate. The external load was previously defined during a pilot study where the use of a 10 kg plate was a viable external load for performing 10 repetitions in both exercises. The participants started the movement by flexing their elbows and extending their shoulders until the plate touched the sternum region. The participants then performed the opposite movement, returning to the initial position. Participants kept their hands compressing the plate throughout the exercise. No time was given between concentric and eccentric actions. The same movement pattern was used in both exercises but with differences in the body position.

For the lying plate press exercise, all participants laid down on a bench (Figure 1a-b), and for the standing plate press exercise, all participants remained standing (Figure 1c-d). All participants performed 1 set of 10 repetitions for each resistance exercise in a random order and the movement velocity was controlled by a metronome at 60 beats per minute. In the same session, both exercises were performed with a 30-min rest interval. The sEMG electrodes were not removed during both exercises. Participants received similar verbal encouragement during both exercises. All measurements were performed between 9 am and 12 pm and measured by the same researcher (Certified Strength & Conditioning Specialist, CSCS).

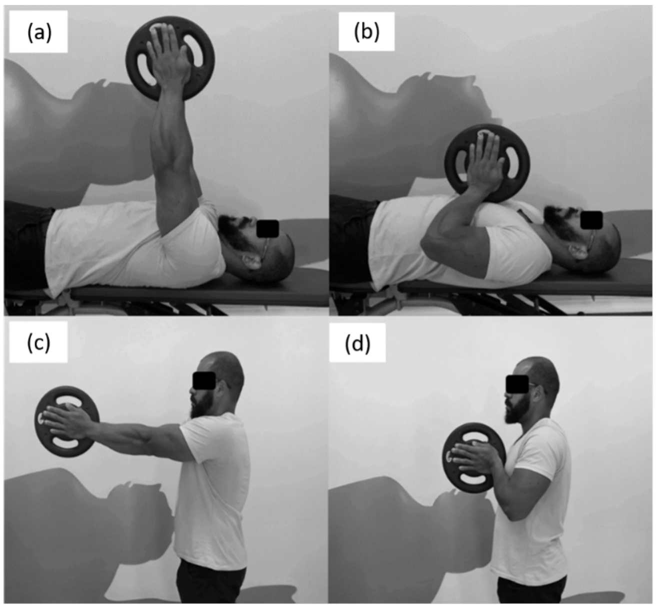


**Figure 1:** Plate Press Exercise in lying body position (a-b) and standing body position (c-d).

## 2.3 Measurements

Electrogoniometry: An electrogoniometer was positioned at the center of the elbow joint and the data were used to define the phases (concentric and eccentric) of each repetition. Data were acquired and synchronized with the sEMG using the same acquisition system and software (EMG832C, EMG system Brasil, São José dos Campos, Brazil) with a sampling rate of 2000 Hz.

Surface Electromyography (sEMG): The participants' body hair was shaved at the site of electrode placement and the skin was cleaned with alcohol before affixing the sEMG electrodes. Bipolar active disposable dual Ag/AgCl snap electrodes spanning 1-cm in diameter for each circular conductive area with 2-cm center-to-center spacing were used in all trials. Electrodes were placed on the dominant upper limb along the axes of the muscle fibers according to the SENIAM/ISEKI protocol (Hermens et al., 2000b): pectoralis major (PM): electrodes were positioned at 50% on the line between the muscular belly and the middle fibers (sternal-costal); anterior deltoid (AD): electrodes were positioned one finger width distal and anterior to the acromion; triceps brachii: lateral head (TB): electrodes were positioned at 50% on the line between the posterior crista of the acromion and the olecranon at 2 finger widths lateral to the line; and biceps brachii (BB): the electrodes were positioned on the line between the medial acromion and the fossa cubit at 1/3 from the fossa cubit, according to the SENIAM reference (Hermens et al., 2000a). The sEMG signals were recorded by an electromyographic acquisition system (EMG832C, EMG system Brasil, São José dos Campos, Brazil) with a sampling rate of 2000 Hz using a commercially designed software program (EMG system Brasil, São José dos Campos, Brazil). EMG activity was amplified (bi-polar differential amplifier, input impedance = 2MΩ, common-mode rejection ratio > 100 dB min (60 Hz), gain x 20, noise > 5 μV), and converted from an analog to digital signal (12 bit). A ground electrode was placed on the right clavicle. The sEMG signals collected during all conditions were normalized to a maximum voluntary isometric contraction (MVIC) against a fixed strap resistance. One trial of five-second MVICs was performed for each muscle with a one-minute rest interval between actions for the dominant upper limb. The first MVIC was performed to familiarize the participant with the procedure. For PM and AD MVICs, the participants were positioned in the supine position with the shoulder joint abducted at 90º, the participants performed a horizontal shoulder abduction against the external load applied at the elbow region. For TB and BB MVICs, the participants were positioned in the supine position with the elbow flexed at 90º and resistance placed at the wrist region. The participants performed elbow extension for TB MVIC and then, elbow flexion for BB MVIC (Boettcher et al., 2008; Criswell, 2011). Verbal encouragement was given during all MVICs. The order of MVICs was counterbalanced to avoid any potential neuromuscular fatigue.

The sEMG and electrogoniometer data were analyzed with a customized Matlab routine (MathWorks Inc., Massachusetts, USA). All sEMG data were defined by the electrogoniometer data, characterizing both the concentric and eccentric phases of each repetition. The digitized angle data were low-pass filtered at 10Hz using a fourth-order zero-lag Butterworth filter. The first and last two repetitions were removed from the data to ensure any body adjustment, neuromuscular fatigue, or change in movement velocity. Then, all six repetitions were used for further analysis. The digitized sEMG data were band-pass filtered at 20-400 Hz using a fourth-order zero-lag Butterworth filter. For each muscle group, the root mean squared (RMS) (250ms moving window, sEMG RMS) was calculated for the MVICs and the sEMG data. The peak MVIC for each muscle (PM, AD, TB, and BB) was used to normalize the sEMG RMS data. Then, for each muscle group, the sEMG RMS was integrated (iEMG) and used for further analysis.

### 2.4 Statistical Analyses

The normality and homogeneity of variances within the data were confirmed by the Shapiro-Wilk and Levene's tests, respectively. Mean, standard deviation, delta percentage (Δ%), and 95% confidence interval (CI95%) were calculated. Two-way ANOVA (2 x 4) with repeated-measures was used to test differences between exercises and muscle groups (PM, AD, TB, and BB) for the iEMG values. Post-hoc comparisons were performed with the Bonferroni test when necessary. Cohen's formula for effect size (d) was calculated, and the results were based on the following criteria: <0.35 trivial effect; 0.35-0.80 small effect; 0.80-1.50 moderate effect; and >1.5 large effect for recreationally-trained participants (Rhea, 2004). An alpha of 5% was used to determine statistical significance. Test-retest reliability was calculated by intraclass correlation coefficient (ICC) for all dependent variables. The test-retest reliability for Lying Plate Press was 0.96 for PM, 0.97 for AD, 0.93 for TB, and 0.94 for BB; and for Standing Plate Press was 0.97 for PM, 0.92 for AD, 0.91 for TB, and 0.96 for BB.

## 3 Results

For iEMG, there was a significant main effect only for exercises ($p = 0.001$) and muscle group ($p = 0.001$). There was significant interaction between exercises and muscle group ($p = 0.002$).

For PM, there was no significant difference between lying and standing plate press exercises [Δ% = 19.4, CI95% = (-61.2 / 25.4), $p = 0.134$], figure 2.

For AD, there was a significant difference between exercises with a higher value observed in the standing plate press [Δ% = 41.7, d = 1.22 (moderate), CI95% = (-75.3 / 0.41), $p = 0.05$], figure 2. For TB, there was a significant difference between exercises with a higher value observed in the lying plate press [Δ% = 51.4, d = 1.47 (moderate), CI95% = (-10.7 / 13.9), $p = 0.047$], figure 2. For BB, there was a significant difference between exercises with a higher value observed in the standing plate press [Δ% = 54.6, d = 1.60 (large), CI95% = (-47.0 / -10.5), $p = 0.001$], figure 2.

There were observed significant differences between PM, AD, and TB vs. BB in the standing plate press exercises ($p < 0.05$) and between PM, AD, and BB vs. TB in the lying plate press exercises ($p < 0.05$) (Table 1).

## 4 Discussion

The main purpose of this study was to evaluate the myoelectric activity between two different plate press exercises (lying and standing) in recreationally-trained men. The main findings include (1) PM presented a similar myoelectric activation between the standing and lying plate press exercises; (2) AD and BB presented a greater myoelectric activation during the standing plate press exercise; (3) TB presented greater myoelectric activation during the lying plate press exercise. To the best of the authors' knowledge, no study has analyzed the myoelectric activity between two different plate press exercises (lying plate press and standing plate press) in recreationally-trained men.

The plate press is considered a multi-joint exercise that involves elbow and shoulder movements. This resistance exercise can be performed in two body positions (lying and standing) with important biomechanical differences when considering the direction of external load (gravity-based force). For the lying plate press, in the starting position (Figure 1a), the external load is vertically aligned with the elbow and shoulder, reducing substantially the external torque in both joints. At this position, there is a low level of muscle effort against the external load to maintain the upper limb position in a vertical direction. During the eccentric phase (Figure 1a→b), in the sagittal plane, the external load remains constantly aligned with the shoulder joint, producing a low external torque. During this phase (descending), the elbow joint moves away from external load increasing external torque in the direction of elbow flexion. Additionally, in the transverse plane, the elbow joint moves away from the external load creating an external torque in the horizontal shoulder abduction direction. During the concentric phase (Figure 1b→a), the opposite effect, in both joints, is observed. Regarding myoelectric activation evaluated in the present study, the PM

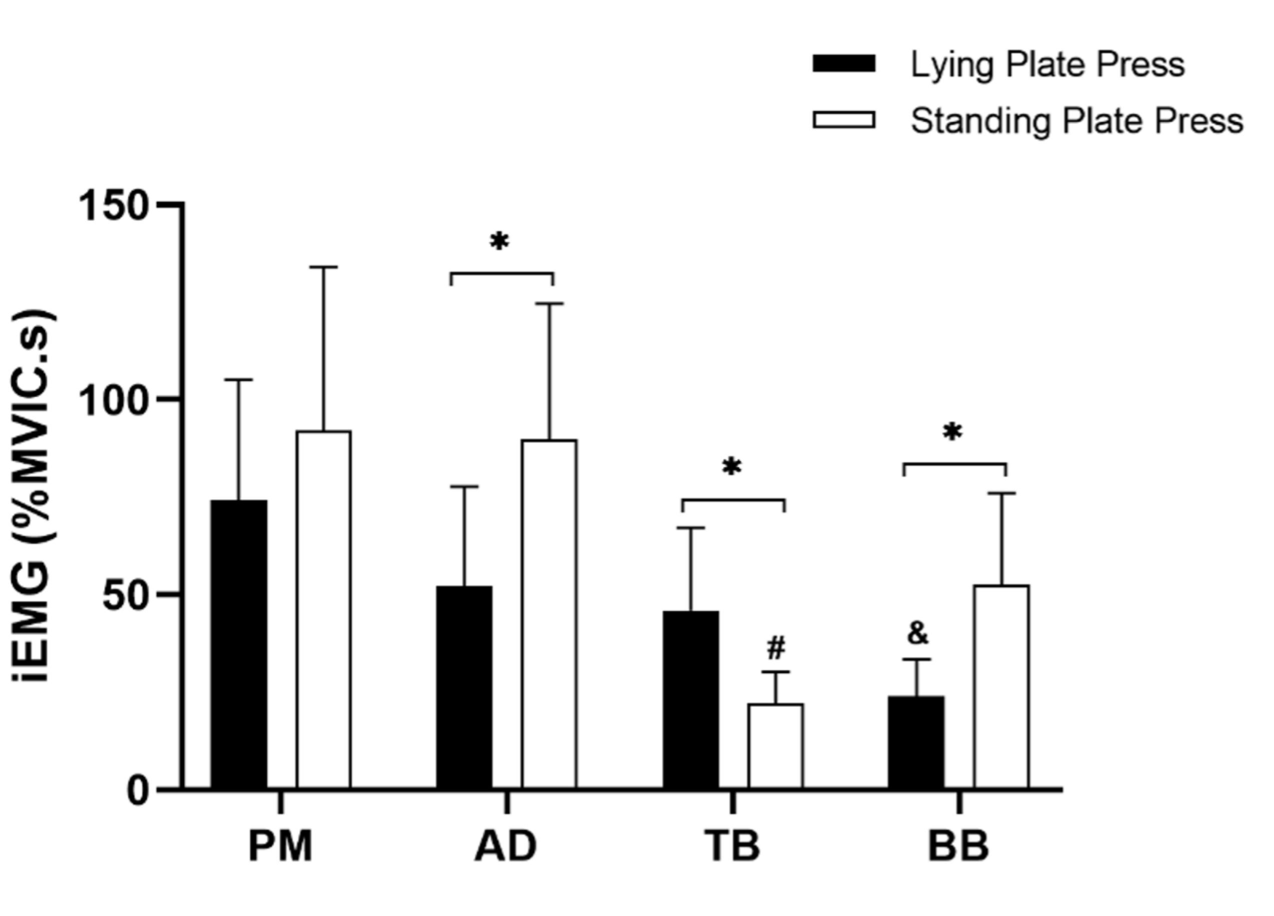


**Figure 2:** Mean ± standard deviation of the myoelectric activation (iEMG) of the pectoralis major (PM), anterior deltoid (AD), triceps brachii (TB), and biceps brachii (BB) for standing and lying plate exercises. Legend: *Significant difference between exercises, $p<0.05$. #Significant difference between TB vs. PM, AD, and BB for Standing Plate Press Exercise, $p<0.05$. &Significant difference between BB vs. PM, AD, and TB for Lying Plate Press Exercise, $p<0.05$.

and AD were active during concentric and eccentric actions and TB showed high activity while BB showed low activity.

On the other hand, for the standing plate press, the direction of the external load changed based on the body position. In the starting position (Figure 1c), the external load is positioned away from both joints (elbow and shoulder) increasing the initial effort. At this position, there is a high level of muscle effort against the external load regarding the large moment arm in both joints (shoulder>elbow). Therefore, from the initial position to the final position (Figure 1c→d), each joint moves in a different pattern. Initially, the external load induces an external torque in the direction of shoulder and elbow extension. In this matter, both AD and PM were active during the eccentric phase in bringing the plate close to the thorax. Additionally, the BB activity (concentric action) was necessary to flex the elbow and keep the plate in a linear horizontal trajectory. Finally, from the final position (Figure 1d) to the initial position (Figure 1c), the external load was moved in a linear horizontal trajectory but in the opposite direction (Figure 1d→c). During this phase, the PM and AD participated concentrically in shoulder flexion. On the other hand, BB showed great eccentric participation in order to control elbow extension and low TB activation in both phases of elbow movement (Knudson, 2007; Marshall & Elliott, 2000; Miller, 1980). Therefore, the observed movement of a segment may have been influenced by external torque, which influences the entire segment (Chapman, 2008; Knudson, 2007).

**Table 1:** Comparison between muscle groups by exercise. Effect size values, 95% confidence interval (95%CI), and percentage delta (Δ%).

| Muscle Groups | p-value | Effect Size ($d$) | 95% Confidence Interval ($CI_{95\%}$) | Delta Percentage (Δ%) |
|---|---|---|---|---|
| Standing Plate Press Exercise | | | | |
| PM > BB | <0.001 | 1.17 (Moderate) | -9.2 / 88.3 | 43% |
| AD > BB | <0.001 | 1.25 (Moderate) | -1.1 / 75.4 | 41.4% |
| TB < BB | 0.009 | 1.74 (Moderate) | -55.1 / -5.6 | 57.6% |
| Lying Plate Press Exercise | | | | |
| PM > TB | 0.001 | 1.07 (Moderate) | -67.8 / 11.1 | 38.2% |
| AD > TB | 0.039 | 0.27 (Trivial) | -43.3 / 30.4 | 12.4% |
| BB < TB | 0.003 | 1.33 (Moderate) | 6.2 / 37.9 | 48.1% |

We hypothesized that PM and AD activation would be similar between both plate press exercises. Both muscle groups play an important role as prime movers in resistance exercises involving shoulder flexion and horizontal shoulder adduction (Campos et al., 2020; Escamilla et al., 2009; Mausehund et al., 2022; Rodríguez-Ridao et al., 2020; Saeterbakken et al., 2021; Stastny et al., 2017). The results of this study partially corroborate the initial hypothesis. For PM, high myoelectric activity was observed in both exercises with a statistically non-significant increase of 19% (standing plate press > lying plate press exercise). This difference may be related to the position of the PM electrode in the sternocostal portion and not in the clavicular portion. For AD, the myoelectric activation was 41.7% higher during the standing plate press exercise when compared to the lying plate press exercise, corroborating the initial hypothesis. This difference might be attributed to a greater moment arm induced by the distance between the external load (external vector) and the shoulder and elbow joints. As well documented in the scientific literature, AD is a very active muscle during shoulder flexion (Botton et al., 2013; Campos et al., 2020; Coratella et al., 2020; Escamilla et al., 2009; Rodríguez-Ridao et al., 2020; Saeterbakken et al., 2021). Finally, consideration should be given to the fact that part of the myoelectric activity recorded from PM and AD, in both exercises, was directed towards maintaining pressure between the hands in order to maintain the position of the plate. This constant isometric action, in both exercises, could not be separated from the dynamic activity in the present study.

We hypothesized that TB would be more active during the lying plate press exercise. The results of this study corroborate this initial hypothesis. The lying plate press exercise produced 50.1% higher myoelectric activation when compared to the standing plate press exercise. Therefore, considering the direction of external load throughout the resistance exercise, a high TB activity would be expected, as observed in other studies with similar movement patterns (Mausehund et al., 2022; Saeterbakken et al., 2021; Stastny et al., 2017). Additionally, TB presented the lowest myoelectric activation when compared to PM (43%), AD (41.4%), and BB (57.6%) for the standing plate press exercise.

We hypothesized that BB would be more active during the standing plate press exercise and the results of this study corroborate this initial hypothesis. The standing plate press exercise produced 54.6% higher myoelectric activation when compared to the lying plate press exercise. This level of activation was expected due to the high external torques produced by the external load on elbow extension during both phases of the exercise. Additionally, the long head of the biceps brachii acts as a shoulder flexor as shown in the study by Landin et al. (Landin et al., 2008). Interestingly, it can be assumed that the BB remained active during the entire movement; with no concentric action due to the type of torque created by the external load (Knudson, 2007; Landin et al., 2017; Marshall & Elliott, 2000; Miller, 1980). Additionally, BB presented the lowest myoelectric activation when compared to PM (38.2%), AD (12.4%), and TB (48.1%) for the lying plate press exercise.

This study has some limitations that should be considered when interpreting the current results. Both resistance exercises were evaluated in the same session. However, both exercises were randomized for each participant and 30-min of rest was sufficient to remove any level of fatigue as observed in the pilot study. We evaluated the pectoralis major in only one region (sternocostal portion). Possibly, the clavicular portion could present a different pattern. However, even knowing that the pectoralis major is a pennate muscle, this position minimizes electrode movement during both exercises. Another limitation was the use of a similar external load (10kg) between subjects and exercises, limiting the study's ecological validity. We also measured only healthy, recreationally-trained men, and, therefore, our findings are not generalizable to other conditions, populations, or women.

## 4.1 Conclusion

In the present study, the plate press is a multi-joint exercise and the body position can affect the myoelectric activity of the PM, AD, BB, and TB. The lying plate press exercise showed a greater myoelectric activation of the TB and the standing plate press exercise showed greater myoelectric activation of the AD and BB. PM showed high myoelectric activation in both exercises but with no difference between exercises. Therefore, when the objective of training or rehabilitation is to increase the myoelectric activity of the TB, the lying plate press exercise is recommended.

## Conflict of Interest

The authors have no conflicts of interest to declare.

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## Ethical Approval

Was obtained from the Human Research Ethics Committee of the University of Sorocaba, under a protocol (#6.003.724), and was written according to the standards established by the Declaration of Helsinki.

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