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RESEARCH ARTICLE

The Effect of Different Incline Angles on the Neuromuscular Activation of the Clavicular Head of the Pectoralis Major Muscle During the Barbell Incline Bench Press Exercise

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ABSTRACT

The bench press is one of the most commonly performed exercises targeting the Pectoralis Major (PM) muscle. However, different inclination degrees of this exercise engage different parts of the muscle. This study aimed to analyze the effect of different incline angles on the neuromuscular activation of the clavicular head of the PM muscle performed on a barbell incline bench press. Twenty young males volunteered to perform 8 repetitions of the barbell incline bench press at 60% of their one-repetition maximum (1RM) at incline angles of 20°, 32°, and 43°. The neuromuscular activation of the PM muscle was recorded via electromyography during the concentric phase of the movement. The root mean square (in mV) was calculated for each repetition and averaged for each angle. The data obtained were analyzed using a repeated-measures ANOVA with Bonferroni post-hoc corrections ($\alpha = 0.017$) to evaluate differences between the angles. The root mean square (in mV) at 20° (0.59 ± 0.29 mV) was statistically significantly lower [$F(2,18) = 5.55$, $p = 0.013$, $\eta^2 = 0.381$] compared to 32° (0.64 ± 0.32 mV) and 43° (0.66 ± 0.34 mV) ($p < 0.05$). Also, the root mean square at 43° was higher than at 32°, although no statistically significant difference was found ($p > 0.05$). Performing the incline barbell bench press at an angle above 32° can lead to significantly higher neuromuscular activation of the clavicular head of the PM muscle, with 43° being the most beneficial.

Keywords: Electromyographic analysis, muscle activation, resistance exercises.

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1. Introduction

One of the most popular upper-body exercises performed at the gym is bench press (BP) (Akagi *et al*., 2014; Coratella *et al*., 2020). Lopez-Vivancos *et al*. (2023) stated that the pectoralis major (PM) muscle plays an important role and acts as a prime mover in bench press. Although BP provokes activation of the whole PM, different parts of the muscle may get more tension and show higher muscle activation depending on the execution (Barnett *et al*., 1995; Cogley *et al*., 2005; da Silva *et al*., 2013; dos Santos Albarello *et al*., 2022; Glass & Armstrong, 1997). Several studies have reported that factors such as hand positions or performing exercises with suspension significantly affect the activation of the PM during push-movement exercises such as push-ups and flat barbell bench presses (Barnett *et al*., 1995; Cogley *et al*., 2005; Coratella *et al*., 2020).

Several studies have investigated the effect of performing BP with different bench positions relative to a horizontal axis, resulting in greater muscle activation of different parts (muscle heads) of the PM muscle (Coratella *et al*., 2020; dos Santos Albarello *et al*., 2022; Trebs *et al*., 2010). In particular, it was demonstrated that the activation of the clavicular head (upper part) of the PM muscle during the concentric phase was significantly higher when BP was performed on a bench inclined at an angle of

44° from the horizontal axis compared to angles of 0° and 28° (Trebs *et al*., 2010). Subsequently, several studies investigated the effects of different degrees of inculcation and declination, demonstrating that various angles also contribute to the activation of the PM heads. Specifically, it was found that performing the incline press movement at a +45° angle resulted in better muscle activation of the clavicular head than at +30° (Coratella *et al*., 2020; dos Santos Albarello *et al*., 2022). However, some studies did not find any positive effects on activation of the clavicular head of the PM muscle when performing inclined or declined BP compared with flat BP (da Silva *et al*., 2013; Saeterbakken *et al*., 2017). Hence, the authors of these studies concluded that flat BP may be the most beneficial, regardless of the head of the PM musclebeing targeted.

From a biomechanical perspective, altering the bench inclination modifies the shoulder joint kinematics and the line of pull of the PM. At steeper inclinations, the clavicular head aligns more directly with the resistance vector, increasing its contribution relative to the sternal head. On the contrary, flatter positions shift the mechanical demand toward the sternal portion. This suggests that moderate inclinations may offer the most efficient recruitment of the clavicular fibers, providing a theoretical rationale for testing specific bench angles (Rodríguez-Ridao *et al*., 2020).

Although previous studies have examined the effect of various inclinations (e.g., 28°, 30° and 45°), there is limited evidence directly comparing moderate, progressively higher inclinations within a practical range. Specifically, the effects of 20°, 32° and 43° have not been systematically examined, despite their common use in strength training programs. Therefore, examining these angles could clarify the inconsistencies in previous research and offer more precise recommendations for targeting the clavicular head of the PM.

Despite extensive research, the impact of different bench inclination angles on the activation of the clavicular head of the PM muscle remains unclear. Therefore, this study aimed to analyze the effect of performing barbell inclined bench presses at 20°, 32° and 43° on activation of the clavicular head of the PM muscle during concentric contraction. It was hypothesized that the greatest muscle activation of the clavicular head of the PM occurs at 32° during the inclined bench press.

2. Materials and Methods

2.1. Participants

Twenty healthy, well-resistance-trained volunteers ($\geq$ 3 times a week for at least 6 months before the tests commenced) participated in the current study. The anthropometric data of the participants and 1RM BP (mean ± standard deviation) are presented in Table I.

Females, athletes with any ailments, upper or lower body injuries, and other contraindications to participation, as well as those with less than six months of resistance training experience or fewer than three resistance workouts per week, were excluded from participation in the study. Before the consent form was signed, all participants were informed about the study procedure, the applied protocol, their opportunity to withdraw from the study at any point because of personal circumstances, and the potential negative consequences associated with the study.

A post hoc analysis was performed using G*power software to calculate the achieved power based on the given sample size of the group (20) and, number of measurements (3) and the effect size was calculated from partial η^2 of 0.286, resulting in an effect size f (U) of 0.63 and an achieved power (1-β err prob) of 0.99. The study was conducted in accordance with the Declaration of Helsinki guidelines (World Medical Association, 2025) and approved by the Ethical Committee of Bioethics.

2.2. Research Design

The current research employed a within-participant design. Muscle activity during inclined BP, measured using electromyography (EMG) sensors, was a dependent variable. The independent variables were the degrees of bench inclination, specifically 20°, 32° and 43°.

TABLE I: Anthropometric Data of the Participants Including Presented as Mean and Standard Deviation (SD) Values

	Number of participants	Age (years old)	Height (cm)	Weight (kg)	Training experience (months)	1RM in BP
Mean value	20	20.7 ± 2.6	178.9 ± 9.2	82 ± 8.5	17.6 ± 9.4	83.25 ± 15.15

Note: RM: maximum repetition; BP: bench press.

2.3. Experimental Procedure

The participants were asked to avoid upper extremity resistance training for at least 48 hours before the test day. Before the start of the tests, all participants performed a 10-minute warm-up that consisted of two parts: general and specific. The general warm-up included a 5-minute rotation of the upper limbs along with static and dynamic stretching of the wrist, elbow and shoulder joint, to warm up the muscles of the rotator cuff and prevent damage to ligaments, tendons, muscle tissue and joints during the tests.

After completing the general warm-up, the participants performed a 5-minute movement-oriented specific warm-up, which involved the following protocol: two sets of barbell bench press on a 45-degree inclined bench, using 30% of their 1RM for eight repetitions and 50% of their 1RM for five repetitions, with a rest period of 1 minbetween the sets. Following the warm-up, all participants rested for at least 5 min, during which they were once again instructed about the testing process according to the commands of the research administrator.

Thereafter, the participant's skin surface was cleared of hair to improve the EMG sensor signal. Next, the skin was wiped with wet tissue immersed in alcohol solution. The sensor was then placed parallel to the muscle in the subclavian region, at the middle of the clavicular head of the PM muscle on the dominant side of each participant (Fig. 1).

During the tests, the participants completed eight repetitions at 60% of their 1RM in a full range of motion at each angle of bench inclination, with a 3-minute rest between trials. The repetitions were performed according to the commands "down" and "up," indicating the moment of lowering the barbell to the chest (negative phase of a repetition) and pressing the barbell up (positive phase of a repetition).

2.4. Electromyographic Analysis

The data were collected using electromyography, and the root-mean-square (RMS) values were obtained. Concentric muscle contractions were detected during testing using a Delsys Tringo Wireless Biofeedback System (Delsys Inc., Natick, USA). The analysis and display of the recorded muscle activity results were performed using Delsys EMGworks Analysis 4.7.3.0 software (Delsys Inc., Natick, USA), which sampled data at 1259.26 Hz with an analogue band-pass Butterworth fourth-order filter at 20–450 Hz. Using this software, the maximum RMS calculations were performed with a window length of 0.125 s and an overlap of 0.0625 s for each repetition at each angle. Subsequently, the mean values of the maximum RMS for each repetition were averaged and compared for each angle. All tests were conducted by the same investigator to ensure consistency and accurate sensor placement.

2.5. Statistical Analysis

Data are presented as the mean ± standard deviation. The Shapiro-Wilk and Levene's tests were used to verify the normality and homogeneity of variance, respectively. To evaluate the differences between the three positions, a repeated-measures analysis of variance (ANOVA) was conducted with Bonferroni post-hoc corrections ($\alpha = 0.017$). Effect sizes were determined by partial η^2 with values of 0.01, 0.06 and 0.14 indicating small, medium, and large effects, respectively. Statistical analysis was performed using IBM SPSS Statistics 26 for Windows (SPSS Inc., Chicago, IL, USA).

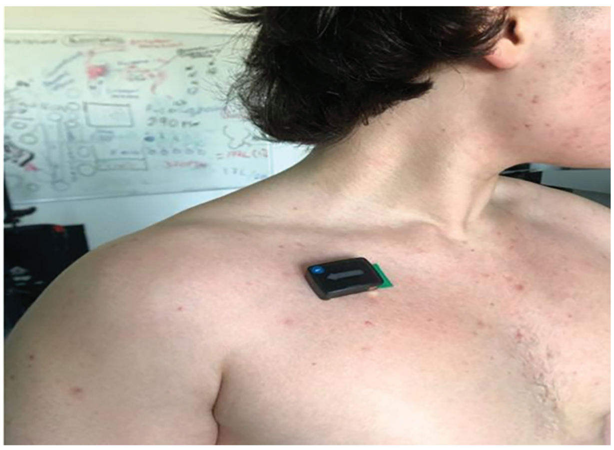

Fig. 1. Delsys EMG sensor set on the clavicular head of the PM muscle.

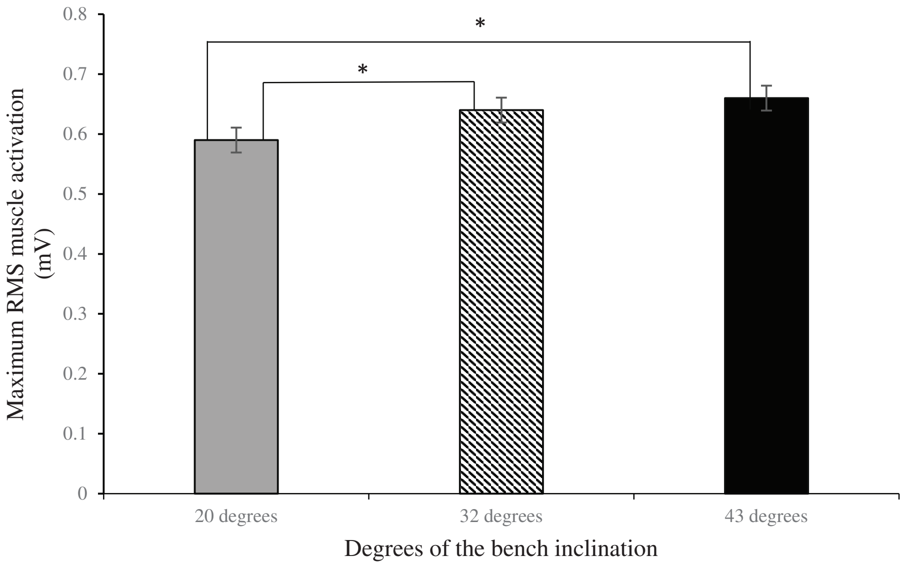

Fig. 2. Mean values of the maximum root mean square (RMS) muscle activation during concentric contraction, demonstrated with standard deviation error bars. *significant difference ($p < 0.05$).

2.6. Findings/Results

The conducted repeated measures ANOVA indicated that the mean of the maximum RMS muscle activation of the clavicular head of PM muscle while performing the barbell inclined bench press on a bench inclined at 20° (0.59 ± 0.29 mV) was significantly [$F(2,18) = 5.55$, $p = 0.013$, $\eta^2 = 0.381$] lower compared to the angles of 32° (0.64 ± 0.32 mV, $p = 0.033$) and 43° (0.66 ± 0.33 mV, $p = 0.009$) (Fig. 2). Meanwhile, performing the inclined barbell bench press at 43°resulted in higher activation of the clavicular head of the PM muscle during concentric contraction compared to 32°; however, a statistically significant difference was not found ($p > 0.05$).

3. Discussion

The current study aimed to analyze the effect of performing the barbell inclined bench press at 20°, 32°, and 43° on activation of the clavicular head of the PM muscle during concentric contraction. The main outcomes of this study demonstrated that muscle activation during concentric contraction of the clavicular head of the PM muscle at 20° was significantly lower than that during 32° and 43° bench inclinations in the inclined barbell bench press. At the same time, muscle activation was greater at 43° than at 32°; however, the difference was not statistically significant. Therefore, consideringthe muscle activation results obtained in this study, it can be stated that performing the inclined barbell bench press on a bench at angles of 32° and 43° can improve training outcomes such as strength, hypertrophy, and overall performance.

The results obtained are consistent with the aforementioned study conducted by Trebs *et al*. (2010), where activation of the clavicular head of the PM muscle was found to be significantly higher when performing the inclined barbell bench press at 44° compared to 28°. In addition, the results obtained in our study support the findings of dos Santos Albarello *et al*. (2022), who showed that performing an inclined bench press at 45° inclination resulted in greater muscle activation of the clavicular head of the PM. This is also in line with the main outcomes of the study conducted by Coratella *et al*. (2020), who found that muscle activation of the clavicular head of the PM during maximum voluntary isometric contraction was significantly higher at 45° on an inclined bench press compared to a flat bench press. Thus, it was concluded that the angle of inclination of the bench at 45° had a significant effect on the muscle activation.

However, the results obtained in our study contradict those of the studies conducted by da Silva *et al*. (2013) and Saeterbakken *et al*. (2017), who found no significant difference in the activity of the clavicular head of the PM muscle when comparing the inclined bench press with flat and declined bench press positions, as well as when comparing muscle activity of the clavicular head of the PM muscle at different angles of bench inclination.

In critically discussing the results of the current study, it is possible to consider that the differences observed may have been influenced by the varying barbell grip widths used during exercise. Research has demonstrated that the grip width during the bench press significantly affects the activation of the different heads of the PM muscle. Therefore, because the participants in the aforementioned studies may have employed different grip widths, this could explain the lack of significant differences in their results (Roy *et al*., 2021; Saeterbakken *et al*., 2021; Turnstedt, 2017).

Despite the absence of a statistically significant difference between the muscle activation values demonstrated by the participants when performing the inclined barbell bench press at 32° and 43°, the results of the present study may still offer practical benefits. The observed difference may provide sufficient justification for choosing either 32° or 43° as the preferred bench inclination angle when personal trainers and coaches design training programs that include aninclined bench press for developing the upper part of the PM muscle.

However, this study did not examine the long-term effect of performing a 43° inclined bench press on strength or hypertrophy development. Simultaneously, the present study included only male participants; therefore, the results may not be generalizable to females. Furthermore, considering the anthropometric data presented above, it can be concluded that all participants belonged to a group of young people. Therefore, the results obtained cannot be applied to the training process of elderly individuals because of the possible effects of aging on different physiological processes. Another limitation was that the sample consisted of trained volunteers, which may introduce selection bias since these individuals are not necessarily representative of the broader population of recreational or novice lifters. Their training experience may also have influenced their neuromuscular responses, limiting the applicability of the findings to less experienced populations. Considering the aforementioned limitations, it is suggested that future research investigate muscle activation of the clavicular head of the PM muscle across more diverse participant groups that vary in age, sex and training background.

The practical implications of the results obtained are significant for the preparation and implementation of training programs by personal trainers, and strength and conditioning coaches for athletes. These findings provide a deeper understanding of how different variations in the inclined barbell bench press impact muscle activation in the clavicular head of the PM muscle. The results obtained when compiling training programs for both professional athletes and beginners will assist in enhancing the effectiveness of the training process to achieve their set goals.

4. Conclusions

This study provides important findings on the impact of bench incline angles on activation of the clavicular head of the PM muscle during the barbell bench press. The results indicate that performing the exercise at 20° resulted in significantly lower muscle activation than at 32° and 43°. These findings emphasize the importance of bench angle selection in strength training programs aimed at enhancing upper-body performance. Personal trainers and coaches can use this information to optimize training regimens for athletes and individuals seeking to improve upper-body strength and hypertrophy.

Conflict of Interest

The authors declare that they do not have any conflict of interest.

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