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Article *in* The Journal of Strength and Conditioning Research · September 2016

DOI: 10.1519/JSC.0000000000001651

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Abstract

Farias, DdA, Willardson, JM, Paz, GA, Bezerra, EdS, and Miranda, H. Maximal strength performance and muscle activation for the bench press and triceps extension exercises adopting dumbbell, barbell and machine modalities over multiple sets. *J Strength Cond Res* 31(7): 1879–1887, 2017—The purpose of this study was to investigate muscle activation, total repetitions, and training volume for 3 bench press (BP) exercise modes (Smith machine [SMBP], barbell [BBP], and dumbbell [DBP]) that were followed by a triceps extension (TE) exercise. Nineteen trained men performed 3 testing protocols in random order, which included: (P1) SMBP + TE; (P2) BBP + TE; and (P3) DBP + TE. Each protocol involved 4 sets with a 10-repetition maximum (RM) load, immediately followed by a TE exercise that was also performed for 4 sets with a 10RM load. A 2-minute rest interval was adopted between sets and exercises. Surface electromyographic activity was assessed for the pectoralis major (PM), anterior deltoid (AD), biceps brachii (BB), and triceps brachii (TB). The results indicated that significantly higher total repetitions were achieved for the DBP (31.2 ± 3.2) vs. the BBP (27.8 ± 4.8). For the TE, significantly greater volume was achieved when this exercise was performed after the BBP (1,204.4 ± 249.4 kg) and DBP (1,216.8 ± 287.5 kg) vs. the SMBP (1,097.5 ± 193 kg). The DBP elicited significantly greater PM activity vs. the BBP. The SMBP elicited significantly greater AD activity vs. the BBP and DBP. During the different BP modes, the SMBP and BBP elicited significantly greater TB activity vs. the DBP. However, the DBP elicited significantly greater BB activity vs. the SMBP and BBP, respectively. During the succeeding TE exercise, significantly greater activity of the TB was observed when this exercise was performed after the BBP vs. the SMBP and DBP. Therefore, it seems that the variation in BP modes does influence both repetition performance and muscle activation patterns during the TE when these exercises are performed in succession.

Key Words electromyography, free weights, resistance training

Introduction

The bench press (BP) is a resistance exercise which has been widely used to optimize the performance of the upper extremities with the aim to increase muscle strength, hypertrophy, or athletic performance. The BP can be performed with different equipment such as a traditional barbell, dumbbells, or a Smith machine (8). These BP modes have been examined in prior investigations with respect to different training methods (3,16) and muscle activation patterns (3,19).

Krosshaug (10) conducted a kinetic analysis of the BP exercise using dumbbells and a barbell. The author noted that when using dumbbells, external reaction forces were transmitted through the grip straight downward because of gravitational pull; whereas, when using a barbell, the external reactive forces had a medial-lateral component due to friction. Therefore, the barbell BP (BBP) exercise is influenced by both gravitational force and a lateral force-vector (~25% of the gravitational force), which may require greater triceps brachii (TB) activation (7,19). Using

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31(7)/1879–1887

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dumbbells, the gravitational force vector requires an increase in the internal torque produced by the stabilizing musculature of the shoulder, possibly eliciting greater activation of the long head of the biceps brachii (BB). However, for the BBP, the vertical force is distributed at the midpoint of the bar, requiring less stabilization of the shoulder musculature. Such a condition might be responsible for the increase in muscle activation of the TB (10).

Saeterbakken et al. (19) compared maximal strength and surface electromyographic (SEMG) activity of the pectoralis major (PM), anterior deltoid (AD), BB, and TB for 3 different BP modes (barbell, dumbbell, and Smith machine) in trained men. It was observed that the BBP showed the greatest values for maximal strength. In terms of muscle activity, the BP performed with dumbbells showed lower activation levels for the TB and higher activation levels for the BB. During the eccentric phase, the PM, AD, BB, and TB showed lower muscle activity for the Smith machine.

To our knowledge, the first study to examine different SEMG responses for the BP exercise using different modes was conducted by McCaw and Friday (14). This study aimed to calculate the values of integrated electromyographic activity for the PM, anterior and medial deltoid, triceps, and BB during the ascending and descending phases of the BP. The authors compared low (60%) and high (80%) intensity loads of 1-repetition maximum (RM) when using a free weight barbell or Smith machine. An increase in the integrated SEMG activity was observed in the anterior and medial deltoid muscles when using the free weight barbell for the low load condition. The increased activation during the free weight condition was theorized to be due to greater stabilizing requirements of the shoulder musculature.

Schick et al. (20) analyzed the myoelectric activity of the PM and anterior and medial deltoid muscles during the concentric phase of the BP exercise using a free weight barbell or Smith machine with moderate (70% 1RM) and high (90% 1RM) intensity loads in 12 novice and 14 experienced lifters. The authors found that there was greater activation of the medial deltoid using the barbell, but there were no significant differences for the PM and AD, irrespective of intensity and the training experience level.

In a practical sense, resistance exercise programming is often structured so that 1 or 2 primary muscles are trained during a given workout session (e.g., plan A: chest and biceps or plan B: back and triceps; or plan A: chest and triceps and plan B: back and biceps). Depending on the BP mode used, slightly different force vectors will act during the movement, which may influence the strength performance and SEMG activity not only during the BP but also during a succeeding exercise.

Although there are studies in which different modes of the BP were investigated (19,20,23), a gap exists in the literature regarding the influence of different modes on repetition performance and muscle activation. Additionally, to our knowledge, no studies have examined repetition performance and muscle activation when an exercise such as a triceps extension (TE) is performed immediately after different BP modes. This is often the case in practical scenarios when the objective of a workout session is to train the PM and TB muscles. Therefore, the purpose of this study was to investigate muscle activation, total repetitions, and training volume for 3 BP exercise modes (Smith machine, barbell, and dumbbell) that were followed by a TE exercise performed on a pulley system. We hypothesized that the free weight modes of BP (i.e., barbell and dumbbell) would increase the level of fatigue in the agonist (PM, AD, and TB) and stabilizing musculature (BB) vs. the Smith machine BP (SMBP), and cause a greater decrease in performance during the succeeding TE exercise (2,8).

Methods

Experimental Approach to the Problem

After assessment of 10RM loads for the BP and TE, 3 sessions were conducted with 48 hours between sessions. Each session consisted of 4 sets of a given BP mode followed by 4 sets of a TE performed on a pulley system. The sessions consisted of the following protocols in random order: (P1) SMBP plus TE (SMBP + TE); (P2) BBP plus TE (BBP + TE); and (P3) dumbbell BP (DBP) plus TE (DBP + TE). The total repetitions and volume were recorded for each BP mode in conjunction with the TE; as well as SEMG activity for the PM, AD, TB, and BB.

Subjects

Nineteen healthy men with previous resistance training experience participated in this study (Table 1). All subjects were active in approximately 1–3 hours of recreational resistance training with a training frequency of 3–6 days per week. There was no control over nutritional intake. Subjects

Table 1. Demographical characteristics and 10RM loads.*

Measure	Mean ± *SD*
Age (y)	27.9 ± 4.5
Stature (m)	1.72 ± 0.1
Body mass (kg)	80.3 ± 9.2
BMI ($kg \cdot m^{-2}$)	26.9 ± 1.9
Resistance training experience	7.6 ± 4.6
BBP 10RM load (kg)	81.5 ± 9.9†‡
MBP 10RM load (kg)	74.6 ± 8.1
DBP 10RM load (kg)	70.3 ± 8.5
TE 10RM load (kg)	35.1 ± 4.4

*BMI = body mass index; BP = bench press; DBP = dumbbell BP; MBP = machine BP; TE = triceps extension.
†Significant difference vs. machine BP.
‡Significant difference vs. dumbbell BP.

Table 2. BP repetition performance and volume for each mode.*

	Set 1	Set 2	Set 3	Set 4	Total repetitions	Volume	Fatigue index (%)
BBP	9.2 ± 1.2	7.1 ± 1.1	5.9 ± 1.2	5.4 ± 1.6	27.8 ± 4.8	2,193.4 ± 327.8	58.4 ± 12.2
MBP	10.3 ± 1	7.7 ± 1.5	6.4 ± 1.3	6 ± 1.5	30.5 ± 4.6	2,269.8 ± 377.1	58 ± 14.5
DBP	10.3 ± 1.4	8 ± 1.3†	6.6 ± 1	6.2 ± 1.1	31.2 ± 3.2†	2,265.7 ± 437.4	60.9 ± 12.3

*BBP = barbell BP; DBP = dumbbell BP; MBP = machine BP.
†Significant difference vs. BBP.

were excluded from this study if they had any functional limitations (e.g., orthopedic or cardiovascular) that would be contraindicated by performance of the experimental protocol. The inclusion criteria consisted of the following: being male, age ranging between 20 and 40 years old, and at least 6 months resistance training experience with a frequency of at least 3 times a week.

The University Ethics Committee approved the project and subjects read and signed an informed consent form under the protocol CAE 26604714.4.0000.5020, as Resolution 466/2012 of the National Health Council for research on human subjects. Subjects were instructed to refrain from any additional resistance training targeting the upper body muscles during the data collection.

Ten Repetition Maximum Load Determination

The 10RM load was determined for each subject for the SMBP, BBP, DBP, and TE. The 10RM tests were conducted over 6 sessions, with 48 hours between sessions, and in the following order: sessions 1 and 4–SMBP + TE, sessions 2 and 5–BBP, and sessions 3 and 6–DBP. All machine-based exercises were performed on Life Fitness equipment (Brunswick Company, Franklin Park, IL, USA). During the 10RM testing, a maximum of five 10RM attempts were performed for each exercise on a given day, with a five-minute rest between attempts and a 10 minutes rest between exercises (SMBP and TE) (21). A biacromial distance was adopted to standardize the grip width. During the tests and retests, the body segments (head, shoulder girdle, and hips) remained flat on the bench (19). Because different speeds of movement execution can influence the myoelectric activity, a metronome controlled the movement at a constant pace of 4 seconds per repetition (2 seconds for the concentric phase and 2 seconds for the eccentric phase) (9). Two researchers assisted subjects by lifting the barbell or dumbbells and stabilizing the weight until subjects had fully extended their arms (initial phase). The eccentric phase consisted in lowering the barbell until it touched the chest (eccentric phase) (19).

To minimize possible errors in the 10RM tests, the following strategies were adopted: (a) subjects received standardized instructions on exercise technique, (b) the exercise technique of subjects during all testing sessions was monitored and corrected as needed, (c) subjects received verbal encouragement during testing (12), and (d) the mass of all weight plates, bars (Smith machine and free barbell), and dumbbells used was determined with a precision scale. The sum of the 10RM loads for the Smith machine and barbell was realized through the sum of the weight plates + the barbell weight. For the dumbbell, the sum of the 10RM loads was considered the sum of the 2 dumbbells combined. The heaviest load achieved on either of the test days was recorded as the 10RM.

Exercise Sessions

Forty-eight hours after the last 10RM testing session, subjects performed the first of 3 experimental protocols in a randomized design on nonconsecutive days: (P1) SMBP

Table 3. Triceps extension repetition performance and volume after each BP mode.*

	Set 1	Set 2	Set 3	Set 4	Total repetitions	Volume	Fatigue index (%)
BBP + TE	9.6 ± 1.5	8.9 ± 1.5	8 ± 1.4†	7.6 ± 1.8†	34.4 ± 5.9	1,204.4 ± 249.4†	80.4 ± 16.1†
MBP + TE	9.6 ± 1.3	8.2 ± 1.4	6.8 ± 1.1	6.5 ± 1.5	31.3 ± 4.3	1,097.5 ± 193.0	58 ± 14.5
DBP + TE	9.8 ± 1.5	9.2 ± 1.9†	8.1 ± 1.7†	7.2 ± 1.6†	34.3 ± 5.7†	1,216.8 ± 287.5†	72.2 ± 12.4†

*BBP = barbell BP; DBP = dumbbell BP; MBP = machine BP; TE = triceps extension.
†Significant difference vs. MBP + TE.

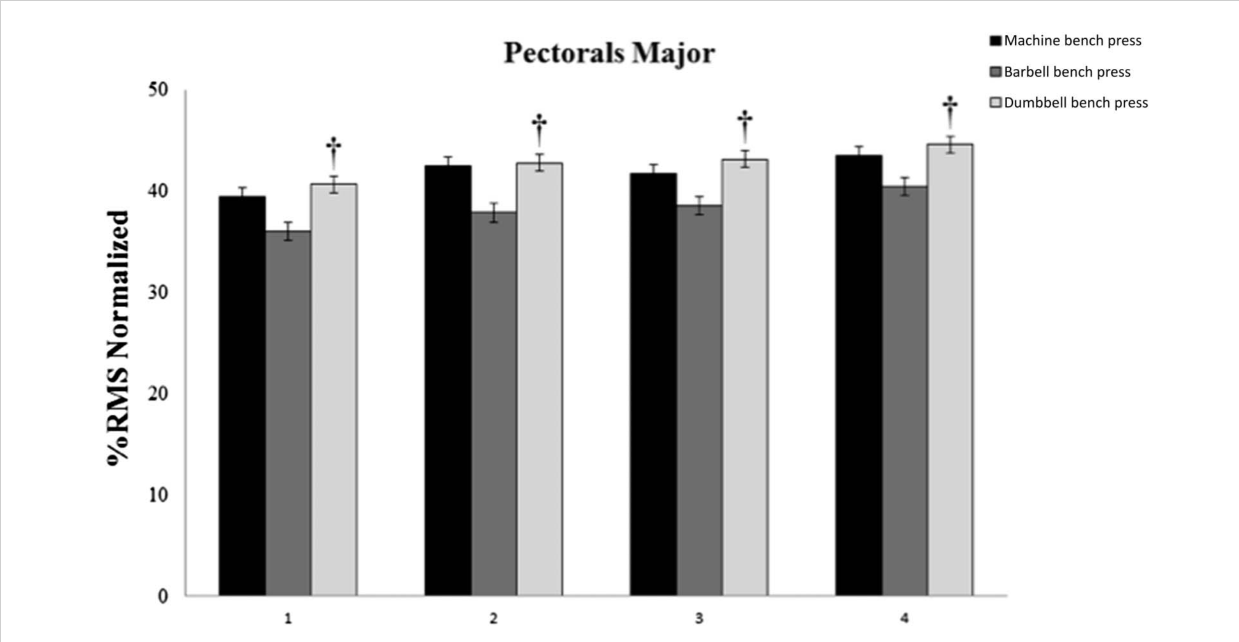

Figure 1. Comparison of pectoralis major activity between BP modes; †significant difference vs. barbell BP ($p \leq 0.05$); BP: bench press.

plus TE (SMBP + TE); (P2) BBP plus TE (BBP + TE); and (P3) DBP plus TE (DBP + TE). A 48-hour rest interval was given between each experimental session. Although Machado et al. (11) reported that a 72-hour recovery interval is required for muscle repair, recovery, and adaptation for trained practitioners who perform multiple RM sets; this study used only 2 exercises for analysis, which involved a smaller total training volume, and we believed that a 48-hour rest interval between protocols provided sufficient recovery.

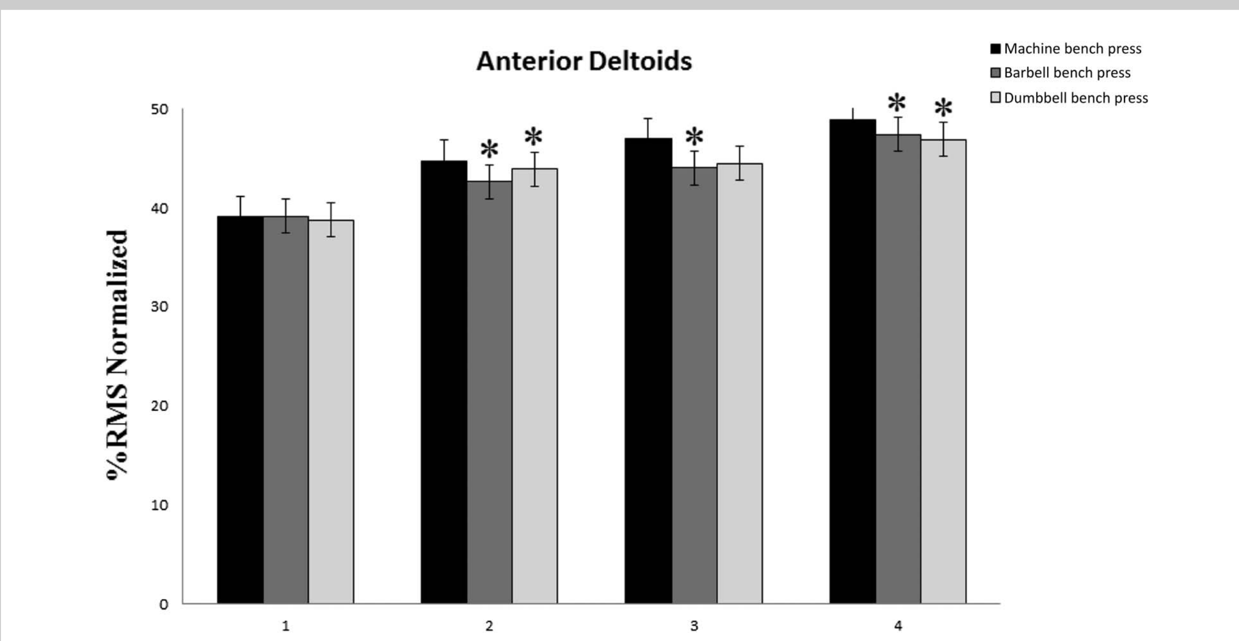

Figure 2. Comparison of anterior deltoid activity between BP modes; *significant difference vs. machine BP ($p \leq 0.05$); BP: bench press.

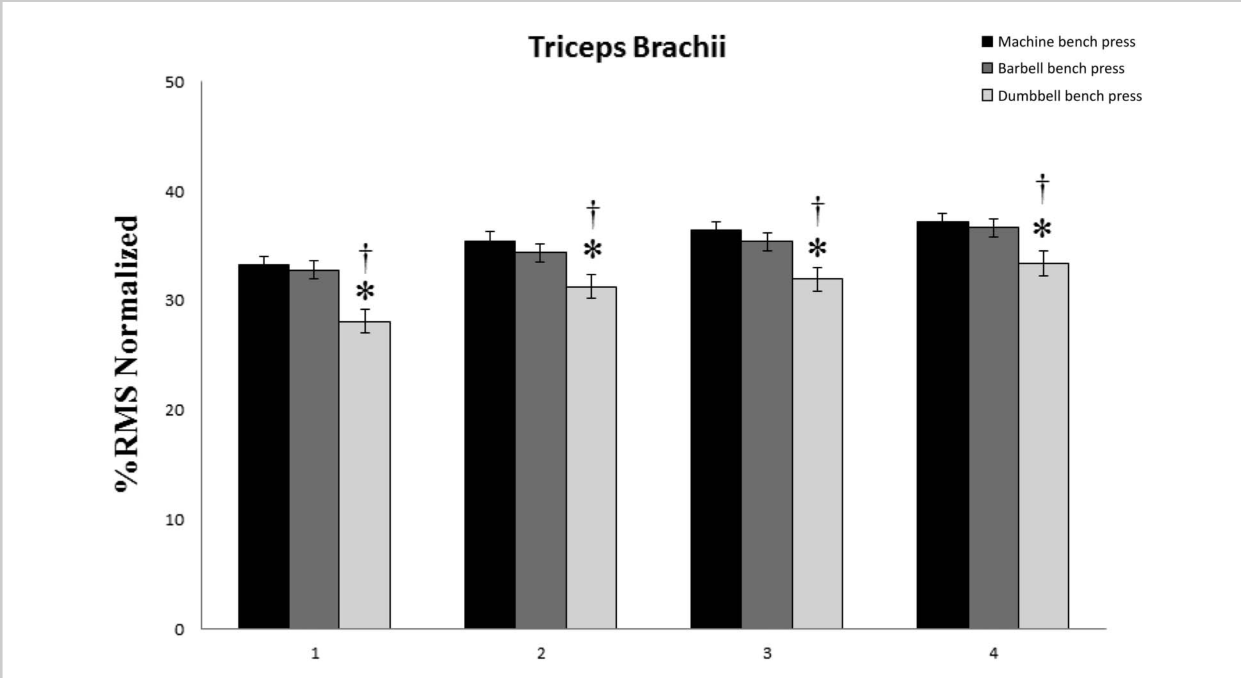

Figure 3. Comparison of triceps brachii activity between BP modes; *significant difference vs. machine BP ($p \leq 0.05$); †significant difference vs. barbell BP ($p \leq 0.05$); BP: bench press.

Each experimental session was preceded by a warm-up set of 20 repetitions at 40% of the 10RM load for the BP mode selected for that day. A 2-minute rest interval was given following the warm-up set and before beginning each experimental protocol. Each BP mode was performed for 4 sets and was followed by performance of 4 sets of the TE. All sets were performed for a RM (muscular failure), using 100% of the 10RM load and with 2-minute rest intervals between sets and exercises. As in the 10RM test, during the exercise sessions, a metronome controlled the movement at a constant pace of 4 seconds per repetition (2 seconds for the concentric phase and 2 seconds for the eccentric phase).

Training Volume

The equation: (set × repetition × load) was used to calculate the training volume for each exercise, set, and protocol. The fatigue index was calculated using the equation proposed by Dipla et al. (6) $F =$ ([repetitions performed on the fourth set/repetitions performed on the first set] × 100), where greater fatigue resistance was indicated by higher percentages.

Surface Electromyography

Before the experimental procedure, the skin was shaved, washed with alcohol, and abraded for the placement of the bipolar surface electrodes (Kendal Medi Trace 200; Tyco Healthcare, Pointe-Claire, Canada). The electrodes were placed on the right side of the body (15). After electrode positioning, impedance was verified and accepted with less than 5 kΩ (22). The impedance was observed between pairs of electrodes using a signal frequency of 25 Hz. For acquisition of muscle activity, surface signals were collected using a MyoSystemTM 1400A with 8 input channels. The EMG signal was filtered with a band pass between 20 and 450 Hz. The sampling rate of the signal was 1,000 Hz. Skin preparation included shaving hair, abrading, and cleaning the surface with alcohol. Elastic tape was applied to ensure electrode and cable placement and provide cable strain relief. Surface electrodes were connected to an amplifier and streamed continuously through an analog-to-digital converter to a windows-compatible notebook computer.

Surface electromyographic data for the PM, AD, TB, and BB muscles were collected during all BP modes and the TE exercise. Electrodes were placed according to the recommendations of Cram, Kasman, and Holtz (5). For the PM, the electrodes were placed midway between the axilla and the areola. For the AD, the electrodes were placed approximately 4 centimeters below the clavicle parallel to the muscle fibers of the AD. For the BB, the electrodes were positioned at the midpoint of the muscle belly, in the longitudinal direction of the fibers. For the TB, the electrodes were placed parallel to the muscle fibers, about 2 cm lateral from the midline of the arm, about 50% of the distance between the acromion and the olecranon processes.

Data Processing

Root mean square of SEMG signal processing was calculated over a 125-millisecond moving window and used on

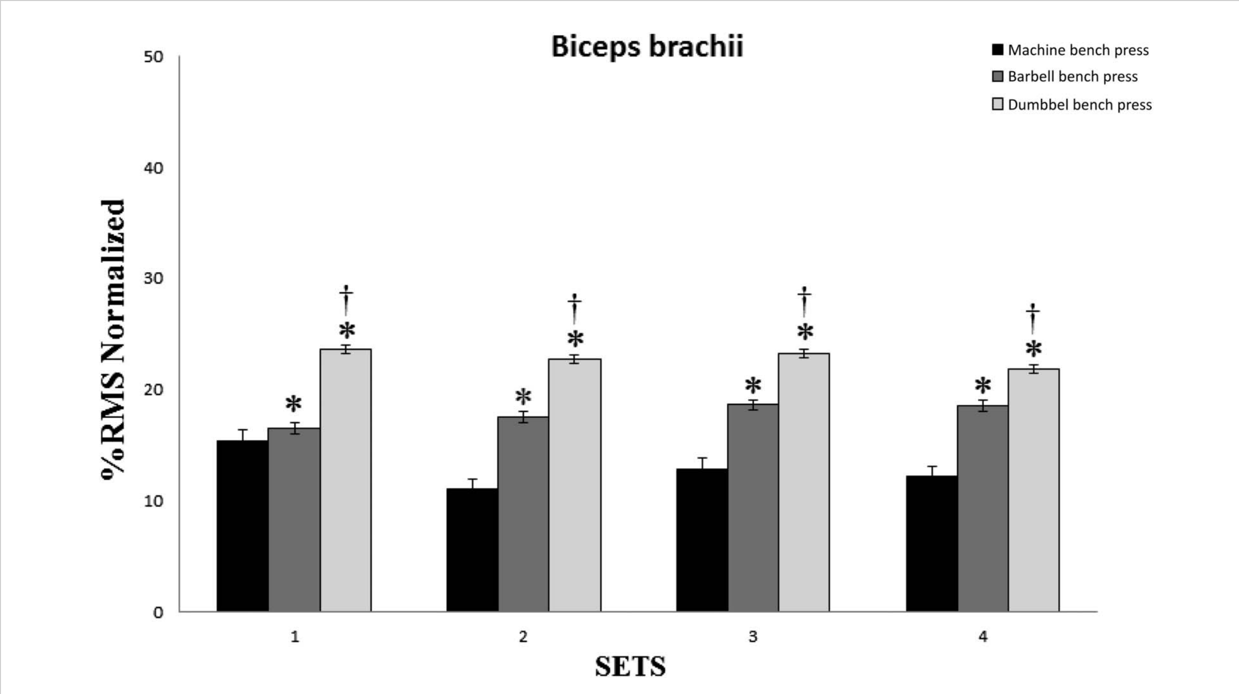

Figure 4. Comparison of biceps brachii activity between BP modes; *significant difference vs. machine BP ($p \leq 0.05$); †significant difference vs. barbell BP ($p \leq 0.05$); BP: bench press.

all SEMG data for the duration of the exercise obtained relative to all exercise modes (PM, AD, BB, and TB), in which the signal amplitude and muscle activity was presented as a percentage of the peak. The myoelectric activity was quantified by the peak of SEMG muscle activity during the performance of each exercise, set, and protocol for each muscle. The SEMG values were determined by an average of the SEMG values of 3 central repetitions of each set. Normalization was performed using the highest peak SEMG value (24).

Statistical Analyses

Test–retest reliability of 10RM loads and EMG spectral parameters were assessed using the intraclass correlation coefficient {ICC = [MSb − MSw]/[MSb + (k − 1) MSw]}, where MSb = mean-square between, MSw = mean-square within, and k = average group size. The Shapiro–Wilk test and homoscedasticity (Bartlett criterion) showed that all variables presented normal distribution and homoscedasticity. Two-way repeated-measures analysis of variance were used to determine whether there were significant main effects or interactions between BP modes in the repetitions per set, total repetitions, volume, fatigue index, and muscle activity. Post-hoc tests using the Bonferroni correction were applied when necessary. The level of statistical significance was set at $p \leq 0.05$ for all tests. The statistical analysis was performed with SPSS version 20.0 (Chicago, IL, USA).

Results

The test–retest ICC of the EMG measures for the 4 monitored muscles ranged between 0.91 and 0.97. Significant differences were noted in 10RM loads between BP modes where the BBP > SMBP > DBP ($F = 12.90$; $p = 0.002$) (Table 1). For the BP, significant main effects were noted between modes in the repetitions per set ($F = 159.21$; $p = 0.0001$) and total repetitions ($F = 3.75$; $p = 0.033$) (DBP > SMBP and BBP). Significantly, higher total repetitions were achieved for the DBP (31.2 ± 3.2) vs. the BBP (27.8 ± 4.8). No difference was noted between SMBP and DBP (Table 2). However, no significant differences were noted between BP modes for the volume and fatigue index.

For the TE, significant main effects were noted in the repetitions per set ($F = 7.30$; $p = 0.002$), total repetitions ($F = 76.91$; $p = 0.0001$), volume ($F = 7.340$; $p = 0.002$), and fatigue index ($F = 5.806$; $p = 0.007$). For the TE, significantly greater training volume and total repetitions was observed when this exercise was performed after the BBP and DBP vs. the SMBP, respectively (Table 3). Fatigue index was significantly higher under following BBP and DBP vs. SMBP, respectively.

The PM muscle presented higher activity under DBP vs. BBP conditions over the 4 sets performed (Figure 1). No difference was noted between DBP and SMBP or between BBP and SMBP, respectively ($p > 0.05$). For AD muscle, the

SMBP showed higher muscle activity vs. DBP and BBP during set 2 and set 4. Thus, greater muscle activity was also noted between SMBP vs. BBP during set 3 (Figure 2).

The TB muscle presented higher activity under BBP and SMBP vs. DBP over the 4 sets performed ($p \leq 0.05$; Figure 3). No difference was noted between BBP and SMBP conditions. For the BB muscle, greater activity was observed under DBP vs. SMBP and BBP over the 4 sets, respectively (Figure 4). Greater BB muscle activity was also noted under BBP vs. MBP condition over the 4 sets.

Considering the TE exercise, greater TB muscle activity was noted under BBP vs. MBP and DBP over the 4 sets performed, respectively (Figure 5). However, the SMBP presented higher muscle activity than DBP condition during set 1, and lower muscle activity than DBP during set 4, respectively. The BB muscle showed higher muscle activity under SMBP vs. BBP over the 4 sets. Thus, the DBP presented greater muscle activity vs. BBP during sets 1, 2, and 3, respectively. No difference was noted between BBP and DBP during set 4.

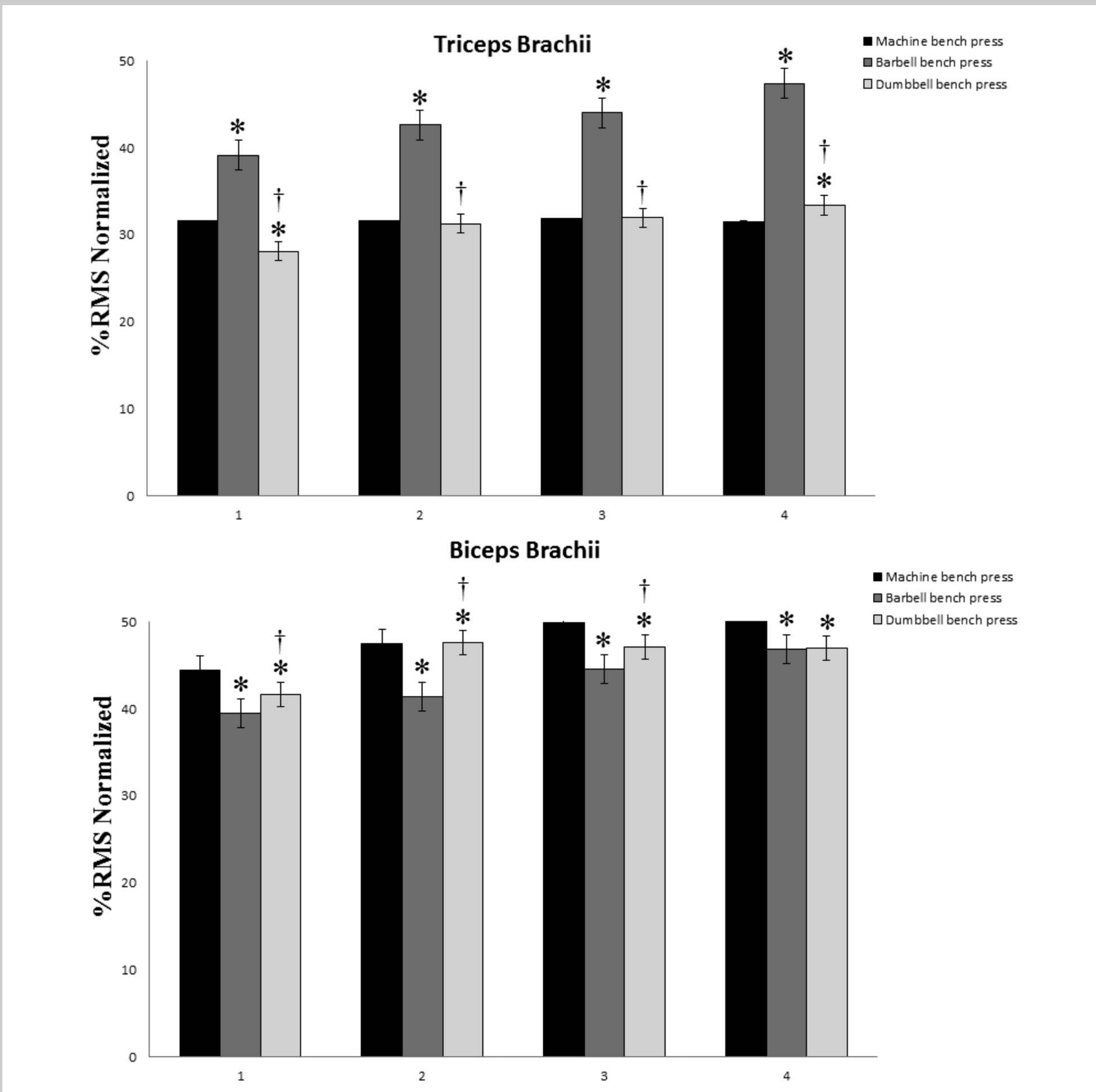

Figure 5. Comparison of triceps brachii and biceps brachii activity during a triceps extension exercise after each BP mode. *significant difference vs. machine BP ($p \leq 0.05$); †significant difference vs. barbell BP ($p \leq 0.05$). BP: bench press.

Discussion

The purpose of this study was to investigate strength performance (total repetitions and volume) and muscle activation for 3 BP modes that were followed by a TE on a pulley system. We hypothesized that the free weight modes of BP (i.e., barbell and dumbbell) would increase the level of fatigue in the agonist (PM, AD, and TB) and stabilizing musculature (BB) vs. the SMBP, and cause a greater decrease in performance during the succeeding TE exercise (2,8). However, our hypothesis was rejected in that the total volume achieved for the TE exercise was significantly greater when following the BBP and DBP vs. the SMBP.

These findings can be explained by the relatively higher activation level of the PM and lower activation level of the TB during the DBP vs. the SMBP. Thus, when the TE was performed after the DBP, the TB was in a lesser fatigued state, enabling greater volume vs. when this exercise was performed after the SMBP. As for the BBP, relatively lower activity of the PM and similar activity of the TB was evident in comparison with the SMBP. Fewer total repetitions and lesser volume were noted during the BBP vs. the SMBP. However, during the succeeding TE, the activity of the TB was significantly greater when following the BBP vs. the SMBP, which may have enabled significantly greater volume.

Regarding the 10RM loads, the BBP was significantly higher vs. the SMBP and DBP. These findings were consistent with Saeterbakken et al. (19) who observed a higher 1RM load when the BP was performed with a barbell vs. Smith machine and dumbbells. Although the DBP presented the lowest 10RM load, surprisingly, this mode showed the greatest total repetitions and fatigue resistance (comparing the repetitions completed on the fourth set vs. the first set). One possible explanation for these results might be the fact that subjects who participated in this study used dumbbells with greater regularity vs. the other BP modes.

The SMBP elicited significantly greater activity of the AD vs. the BBP and DBP; and also significantly greater activity of the TB vs. the DBP. Duffey and Challis (7) observed that during the BP, the lateral force vector transmitted to the bar through the grip accounted for approximately 25% of the load, which would elicit greater elbow extensor torque. Although not assessed in this study, the lateral force vector applied to the bar during the SMBP may have elicited greater activity of the TB. Another explanation for these findings is the single degree of freedom inherent with the SMBP, allowing displacement of the bar in only the vertical direction. At the end of the downward portion of the movement (i.e., the bar must touch the chest), the shoulder joints internally rotate, which may elicit greater recruitment of the ADs (4).

However, the findings of this study were in contrast to McCaw and Friday (14) who found no significant differences in the integrated electromyographic activity of the PM and AD muscles when comparing 80% 1RM for the BP exercise using a barbell or Smith machine. Additionally, Shick et al. (20) found greater activation of the medial deltoid for a BBP, but no significant differences in pectorals major and AD activity vs. a SMBP. However, none of these studies aimed to compare strength performance (total repetitions and volume) as in this study, which would ultimately determine the training outcomes.

The DBP also elicited significantly greater activity of the PM vs. the BBP, and BB vs. the BBP and SMBP. Such findings are consistent with the greater instability inherent for the DBP vs. the BBP and SMBP. Krousshaug (10) found that for the DBP, vertical reactive forces transmitted downward through the handgrip, increase the internal torque requirements of the shoulder stabilizing muscles, thereby promoting greater activation of the BB. The absence of a lateral force vector with the DBP results in lesser recruitment of the TB with the shift in emphasis to the PM (10,17).

As the TE was performed with a pulley and had no variations, the 10RM load remained constant through the protocols (35.1 ± 4.4 kg). For the TE, significant differences were observed in total repetitions and training volumne (TV) when this exercise was preceded by the BBP (total repetitions = 34.4 ± 5.9; TV = 1,204.4 ± 249.4 kg) and DBP (total repetitions = 31.3 ± 4.3; TV = 1,216.8 ± 287.5 kg) vs. the SMBP (total repetitions = 31.3 ± 4.3; TV = 1,097 ± 193 kg). It can be inferred that, since the highest volume among the BP modes was achieved for the SMBP, the TB muscles were pre-exhausted for the succeeding TE. In absolute terms, the SMBP also elicited the highest activity of the TB, which suggests that these muscles may have been fatigued before the onset of the succeeding TE exercise.

Greater antagonistic co-activation was observed when the TE was performed after the SMBP and DBP, as evidenced by the greater activity of the BB and concomitantly lower activity of the TB. The main purpose of antagonistic co-activation is to increase joint stability to prevent injury (18). Antagonistic muscles produce a torque in the opposite direction to the movement performed by the agonist muscles (1). Moreover, a high level of activation of the antagonistic muscles can reciprocally inhibit activity and force production of agonist muscles (13). When the TE was performed after the DBP, significantly greater total repetitions and volume were achieved vs. when the TE was performed after the SMBP. However, during the DBP, there was significantly greater co-activation of the antagonistic BB vs. during the SMBP, which appeared to reciprocally inhibit the TB and facilitate compensatory activity in the PM.

This study was the first to our knowledge to analyze the performance of different BP modes on strength performance and muscle activation in combination with a succeeding TE. Therefore, the results of this study can be readily applied in practical scenarios because the PM and triceps are often trained together in a split routine for the purpose of muscle building. This study demonstrated that different BP modes

(Smith machine, barbell, and dumbbell) result in different patterns of muscle activity and strength performance (PM, AD, TB, and BB), but also elicited different patterns of muscle activity and strength performance during a succeeding TE exercise.

Practical Applications

The results of this study suggest that the best combination of exercises to promote the highest overall training volume was the DBP followed by the TE. From a muscle activation perspective, the DBP elicited the greatest activity of the PM and BB, whereas the Smith machine elicited the greatest activity of the AD and TB muscles. However, if any BP mode is combined with a TE on a pulley, then the BBP might be the preferred choice to elicit greater activity of the TB. It is important to note the exercise sequence when program planning, so that a practitioner can place greater emphasis on the target musculature.

Acknowledgments

Dr. H. Miranda thanks the Research and Development Foundation of Rio de Janeiro State (FAPERJ). The authors thank the Companhia Athletica Manauara and Studio 5 unit and the Norte Fitness gym for releasing the space for data collection and also the Foundation for Research Support of the State of Amazonas (FAPEAM/Brazil) for the master scholarship conceded to D. d. A. Farias.

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