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Bench Press at Full Range of Motion Produces Greater Neuromuscular Adaptations Than Partial Executions After Prolonged Resistance Training

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Abstract

Martínez-Cava, A, Hernández-Belmonte, A, Courel-Ibáñez, J, Morán-Navarro, R, González-Badillo, JJ, and Pallarés, JG. Bench press at full range of motion produces greater neuromuscular adaptations than partial executions after prolonged resistance training. *J Strength Cond Res* XX(X): 000–000, 2019—Training at a particular range of motion (ROM) produces specific neuromuscular adaptations. However, the effects of full and partial ROM in one of the most common upper-limb exercises such as the bench press (BP) remain controversial. In this study, 50 recreationally to highly resistance trained men were randomly assigned to 1 of 4 training groups: full bench press (BP_{FULL}), two-thirds bench press (BP_{2/3}), and one-third bench press (BP_{1/3}) and control (training cessation). Experimental groups completed a 10-week velocity-based resistance training program using the same relative load (linear periodization, 60–80% 1 repetition maximum [1RM]), only differing in the ROM trained. Individual ROM for each BP variation was determined in the familiarization and subsequently replicated in every lift during training and testing sessions. Neuromuscular adaptations were evaluated by 1RM strength and mean propulsive velocity (MPV). The BP_{FULL} group obtained the best results for the 3 BP variations (effect size [ES] = 0.52–1.96); in turn, partial BP produced smaller improvements as the ROM decreased (BP_{2/3}: ES = 0.29–0.78; BP_{1/3}: ES = –0.01 to 0.66). After 10-week of training cessation, the control group declined in all neuromuscular parameters (ES = 0.86–0.92) except in MPV against low loads. Based on these findings, the BP_{FULL} stands as the most effective exercise to maximize neuromuscular improvements in recreational and well-trained athletes compared with partial ROM variations.

Key Words: maximum strength, technique, strength reduction, powerlifting, load-velocity

Introduction

The choice of the most effective range of motion (ROM) to produce specific neuromuscular adaptations after a given resistance training (RT) program has been a matter of debate (1,11,18,19,28). In addition to the conventional full ROM exercises, some authors consider training at partial ROM beneficial, since it allows lifting higher loads, decreases the neural inhibition, increases the force produced, and improves the coordination of primary and stabilizing muscles (2,18–20). Also, because lower ROMs allow lifting more weight, since they avoid the sticking region of the movement (16,17), this strategy is commonly used by powerlifting athletes in training and competition (7,8). In contrast to this assumption, a recent and exhaustive research has found that lower ROMs generate limited performance improvements in comparison with full ROMs, besides increments in pain and discomfort after a prolonged RT program in the back squat exercise (24). These results concur with previous findings concluding that full squat maximizes neuromuscular and functional performance both in novice (1) and well-trained athletes (11). Although this evidence has been proven in essential lower-limb RT exercises such as the squat, the effects of training full and partial ROM in the bench press (BP), which is

probably the most common upper-limb exercise, are still under controversy (23).

Only 3 studies have examined the effects of training at different ROM in BP exercise after an RT intervention (3,18,19). Massey et al. (18,19) evaluated the 1 repetition maximum (1RM) strength after 10 weeks of RT in 3 groups, only differing the ROM trained (full, partial, and a combination of both). However, these 2 studies showed contradictory results (18,19). Although the first one found no differences in between-group 1RM improvements in male recreational weightlifters, the second reported greater enhancements (+12.0% 1RM) on female lifters who trained BP with full ROM. For its part, Clark et al. (3) found that a combination of ROMs in the same training session increased the force improvements compared with training only the full ROM both in throw, isokinetic, and isometric BP variants. These controversial findings could be explained by some questionable methodological aspects such as the absence of a control group, the only evaluation of the 1RM parameter instead of the whole load-velocity spectrum, as well as the used of 1RM percentages (%1RM) instead of velocity-based method for programming and control the RT intervention (10), which encourage further research.

In recent years, a valid, reliable, and highly sensitive method based on the barbell velocity (i.e., velocity-based RT) has been developed to (a) determine an athlete's maximum strength without the need to perform 1RM or maximum number of repetitions to failure (nRM) tests (9); (b) determine the %1RM (using the load-velocity

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relationship) that is being used from the first repetition performed at maximal voluntary velocity for a given load (31); (c) estimate the muscle power output production (30); and (d) quantify the neuromuscular fatigue induced by resistance exercise using a noninvasive and objective method (21,22,26,27,29). Taking into account this velocity-based method, a recent study has established the load-velocity relationship for 3 different ROMs in the BP exercise: full bench press (BP_{FULL}), two-thirds bench press (BP_{2/3}), and one-third bench press (BP_{1/3}) (16). This new determination of the load-velocity relationship makes possible an accurate control of the stimulus applied during RT interventions and improves the evaluation of the training effects at different ROMs in BP, as effectively proven in the squat (17,24). Hence, it would be interesting to use evidence-based, advanced monitoring methods to identify the true effects of training at different ROM in one of the most popular exercises such as the BP.

Therefore, based on the data provided by Martínez-Cava et al. (16), the aim of this study was to clear up the effect of full or partial ROMs on neuromuscular adaptations after a prolonged RT program in recreational and well-trained athletes. Despite the fact that previous studies have examined the effect of training at different ROM in BP, it is difficult to suggest a clear hypothesis, since to date, the aforementioned intervention has not been monitored by using velocity-based RT.

Methods

Experimental Approach to the Problem

A randomized controlled experimental design was used. The 3 experimental groups (BP_{FULL}, BP_{2/3}, and BP_{1/3}) trained twice a week (48–72 hours apart) for 10 weeks for a total of 20 sessions, after a progressive RT program (described later in detail; Table 1). The control group was required to fully discontinue any kind of programmed resistance or endurance stimuli other than the normal physical activity of the active life of these young adults during the intervention. Subjects completed a set of neuromuscular evaluations before (the week before; T0) and after training (the week after; T1) in 3 sessions (Monday, Wednesday, and Friday). Each testing day, subjects performed in a randomized and counterbalanced way 1 of the 3 progressive loading tests (BP_{FULL}, BP_{2/3}, and BP_{1/3}). Once a progressive loading test schedule was assigned to each subject in T0, the same order was replicated in T1. Before evaluations, subjects performed 9 familiarization sessions separated by 48–72 hours. The first session was used for body composition assessment, personal data and health history questionnaire administration, medical examination, and identification of the starting position for each of the 3 BP variations analyzed (described later in detail). Then, in random order, each subject performed 3

familiarization sessions for each BP variation and was instructed on how to properly perform the lifts. Some practice sets of light and medium loads were then performed. Subjects were required not to engage in any other type of strenuous physical activity, exercise training, or sports competition for the duration of the present investigation.

Subjects

The required sample size was determined for the primary outcome variable, the BP_{FULL} 1RM. According to similar interventions on subjects with comparable characteristics (19), a clinically relevant change is about 15.0% 1RM increments after a 10-week training. A sample size of 10 subjects can be estimated to detect differences of $15 \pm 15\%$ 1RM with a power of 80% and a significance α of 0.05 using the MedCalc Statistical Software version 18.2.1. Although a maximum loss of follow-up of 20% was assumed, we recruited at least 12 healthy athletes per experimental group meeting the following inclusion criteria: (a) having a 1RM strength/body mass ratio (relative strength ratio [RSR]) higher than 0.75 in the BP_{FULL} and (b) no physical limitations, health problems, or musculoskeletal injuries that could affect training. Fifty resistance-trained men volunteered to participate in this study (mean \pm SD: age 24.0 ± 4.7 years, body mass 73.4 ± 9.9 kg, height 176.2 ± 8.4 cm, and body fat $10.6 \pm 4.3\%$). Their initial 1RM strength for the BP_{FULL} exercise was 71.8 ± 14.2 kg and RSR of 0.98 ± 0.18 (0.75–1.49). In the 6 months preceding this study, subjects completed 2–4 RT sessions per week including the BP exercise as a part of their conditioning. In this period, subjects were instructed in proper technical execution for the 3 BP variations. Subjects were randomly assigned in a counterbalanced way according to their initial BP_{FULL} strength to 1 of 4 groups (3 experimental and 1 control). The experimental groups were classified according to the specific BP ROM performed during the RT intervention: BP_{FULL} ($n = 12$), BP_{2/3} ($n = 13$), and BP_{1/3} ($n = 13$). Members of the fourth group ($n = 12$) were assigned as controls and fully discontinued any kind of physical training program. The study complied with the Declaration of Helsinki and was approved by the Bioethics Commission of the University of Murcia. Written informed consent was obtained from all subjects. No physical limitations, health problems, or musculoskeletal injuries that could affect training were found after a medical examination.

Procedures

Velocity-Load Relationship and One Repetition Maximum Strength Determination. After the familiarization sessions, the

Table 1

Descriptive characteristics of the resistance training program performed by the full bench press (BP_{FULL}), two-thirds bench press (BP_{2/3}), and one-third bench press (BP_{1/3}) groups.*

Scheduled	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10
%1RM	~60	~60	~65	~65	~70	~70	~75	~75	~80	~80
Sets \times reps	4 \times 8	5 \times 8	4 \times 8	5 \times 8	4 \times 6	5 \times 6	4 \times 5	5 \times 5	4 \times 4	5 \times 4
Target MPV (m·s ⁻¹)										
Group BP _{FULL}	0.76	0.76	0.68	0.68	0.61	0.61	0.54	0.54	0.47	0.47
Group BP _{2/3}	0.64	0.64	0.57	0.57	0.51	0.51	0.45	0.45	0.40	0.40
Group BP _{1/3}	0.48	0.48	0.43	0.43	0.38	0.38	0.34	0.34	0.30	0.30

*1RM = 1 repetition maximum; target MPV = maximal intended velocity repetition performed at the end of each session's warm-up to ensure that the load (kg) to be used matched the velocity associated with the intended %1RM.

individual load-velocity relationships were determined by means of a progressive loading test up to the 1RM for the 3 BP variations, performed in a Smith machine (Multipower Fitness Line; Peroga, Murcia, Spain). After the warm-up, initial load was set at 20 kg and was gradually increased in 10-kg increments until the attained mean propulsive velocity (MPV) was $\leq 0.50 \text{ m}\cdot\text{s}^{-1}$ (31). Thereafter, load was individually adjusted with smaller increments (5 down to 2.5 kg), so that the 1RM could be precisely determined. Three repetitions were executed for light ($< 50\%$ 1RM), 2 for medium (50–80% 1RM), and only 1 for the heaviest loads ($> 80\%$ 1RM). Interset recoveries ranged from 3 minutes (low loads) to 5 minutes (high loads) (30). The 1RM was considered as the heaviest load that each subject could properly lift while completing full ROM for each BP variation, without external help. The reliability of this testing protocol has been recently described (5) with excellent reproducibility and repeatability. (Intraclass Correlation Coefficient, ICC = 0.999, 95% confidence interval = 0.999–0.999, Coefficient of Variation, CV = 1.8%).

For the 3 BP variations, subjects lay supine on a flat bench, with their feet resting flat on the floor and hands placed on the barbell slightly wider (5–7 cm) than shoulder width. The position on the bench was carefully adjusted, so that the vertical projection of the barbell corresponded with each subject's intermammary line. Both bench position and grip widths were individually recorded for each subject to be reproduced on every lift. Subjects were not allowed to bounce the barbell off their chests or raise the shoulders or trunk off the bench. With the elbows fully extended and shoulders in contact with the bench (final position), subjects were required to descend in a continuous motion until reaching their previously determined concentric initial position for each BP variation (16):

- Full bench press (BP_{FULL}): descent until the bar contacted the chest, i.e., full ROM.
- Two-thirds bench press (BP_{2/3}): descent until the bar reaches two-thirds of the full ROM.
- One-third bench press (BP_{1/3}): descent until the bar reaches one-third of the full ROM.

The individual ROM for the 3 BP variations was carefully determined during the first familiarization session and subsequently replicated in each training and testing session with the help of 2 telescopic ($\pm 1 \text{ cm}$ precision) bar spotters placed at the left and right sides of the Smith machine (25). This was designed to: (a) precisely control and replicate the individual eccentric ROM between trials and (b) allow subjects to momentarily release the weight of the bar on the spotters for 2 seconds, therefore minimizing the contribution of the stretch-shortening cycle (i.e., rebound effect) and performing a purely concentric action, thus increasing measurement reliability (25).

Subjects were required to perform the concentric phase in an explosive manner (at maximal intended velocity) and the eccentric phase at a controlled mean velocity of $0.45\text{--}0.65 \text{ m}\cdot\text{s}^{-1}$ (25). This protocol was practiced during the familiarization sessions accomplished with the aid of the visual and auditory feedback in real time provided by the linear velocity transducer software, so that subjects could adjust the eccentric velocity to the required range. Repetitions that failed to meet any of these requirements were automatically discarded and repeated after a 3-minute rest.

All testing and training lifts were made using a Smith machine with no counterweight mechanism. A dynamic measurement system (T-Force System, Ergotech, Murcia, Spain; 1,000 Hz) automatically calculated the relevant kinematic parameters of

every repetition, provided auditory and visual velocity feedback in real time, and stored data on disk for analysis. Measures from the following neuromuscular parameters were considered for the analysis: 1RM strength in kg, 1RM to body mass ratio (1RM/BM), average MPV attained against all absolute loads common to T0 and T1 (MPV_{ALL}), average MPV attained against absolute loads lower than 50% 1RM common to T0 and T1 (MPV_{<50% 1RM}, “low” loads), and average MPV attained against absolute loads higher than 50% 1RM common to T0 and T1 (MPV_{>50% 1RM}, “high” loads).

Resistance Training Program. The intervention consisted of a 10-week RT program (2 days a week). The 3 experimental groups (BP_{FULL}, BP_{2/3}, and BP_{1/3}) trained using the same relative loading magnitude (progressively increasing from 60 to 80% 1RM over the time course of the study), interset recoveries (4 minutes), and volume (4–5 sets and 8–4 repetitions) but differed in the BP ROM trained (Table 1). Relative loads were determined from the load-velocity relationship because it has recently been shown that there exists a very close relationship between %1RM and MPV in the 3 BP variations under study (16). Thus, a target MPV to be attained in the first (usually the fastest) repetition of the first exercise set in each session was used as an estimation of %1RM; i.e., a velocity-based training was actually performed, instead of a traditional loading-based RT program (24). After the standardized warm-up and previous to the first RT set, the absolute load (kg) was individually adjusted to match the velocity associated ($\pm 0.03 \text{ m}\cdot\text{s}^{-1}$) with the %1RM that was intended for that session. During training, subjects received immediate velocity feedback while being encouraged to perform each repetition at maximal intended velocity. This procedure ensures that each athlete performed every BP repetition at the programmed load intensity during the training session, thus avoiding the mismatches that typically occur when programming is solely based on the %1RM value measured in T0.

Statistical Analyses

Mean, SD, and SEM were calculated. Assumption of normality was verified using the Shapiro-Wilk test and the homogeneity of variance across groups (BP_{FULL}, BP_{2/3}, BP_{1/3} and CON) using Levene's test. A 4×2 factorial analysis of variance (ANOVA) with post hoc was performed to evaluate changes in the neuromuscular parameters between groups (BP_{FULL}, BP_{2/3}, BP_{1/3} and CON) and time points (T0 and T1). One-way ANOVA was run to compare the percentage of change scores (%) and absolute values ($\text{m}\cdot\text{s}^{-1}$) between T0 vs. T1 in the selected variables between experimental groups. Statistical significance was established at the $p \leq 0.05$ level. Effect sizes (ES) were classified as “small” if between 0.2 and 0.5, “medium” if between 0.5 and 0.8, and “large” if higher than 0.8 (4,14). Statistical analyses were performed using SPSS software version 24.0 (IBM Corp., Armonk, NY).

Results

There was 1 dropout from the BP_{FULL} group due to personal issues not related to the RT intervention, with 49 subjects completing the study. Training compliance was 100% of all sessions. No significant differences between the groups were found at T0 for any of the variables analyzed ($p > 0.05$) (Table 2).

The BP_{FULL} group increased significantly all neuromuscular parameters (Table 2 and Figure 1) for the 3 BP variations ($p < 0.05$; 8.8–21.5%, ES = 0.56–1.96), except the 1RM in BP_{2/3} ($p > 0.05$; ES = 0.52). The BP_{2/3} group obtained the second-best

results with significant enhancements in all neuromuscular parameters ($p < 0.05$, 7.3–11.1%, $ES = 0.59–0.78$), except the 1RM/BM in the BP_{FULL} and BP_{2/3}, the 1RM in BP_{FULL}, and the MPV_{ALL}, MPV_{<50% 1RM}, and MPV_{>50% 1RM} in BP_{1/3} ($p > 0.05$). The BP_{1/3} only improved significantly the MPV_{ALL} in BP_{1/3} ($p < 0.05$; 5.6%, $ES = 0.66$), although small to moderate ES were found in some parameters of the 3 BP exercises ($p > 0.05$; $ES = 0.20–0.59$). For its part, except the MPV_{<50% 1RM} performance, the control group declined on all the neuromuscular parameters, mainly on the MPV_{>50% 1RM} in BP_{2/3} and BP_{1/3} ($p < 0.05$; 8.4–13.2%; $ES = 0.86–0.92$).

Individuals in all 3 training groups improved significantly more at the specific ROM at which they trained (i.e., BP_{FULL} for the BP_{FULL} group, BP_{2/3} for the BP_{2/3} group, and BP_{1/3} for the BP_{1/3} group). However, comparisons between the 3 groups of training (Table 2 and Figure 1) revealed that the greater the BP ROM, the higher the increments in strength (BP_{FULL} > BP_{2/3} > BP_{1/3}).

Discussion

This study aimed to clear up whether training at full or partial ROMs produces different neuromuscular adaptations after a prolonged RT program. The main findings were (a) the group training at BP_{FULL} exercise obtained the greatest neuromuscular improvements in all the performance parameters for the 3 BP variations (BP_{FULL}, BP_{2/3}, and BP_{1/3}) after 10 weeks of RT, (b) individuals from all the 3 BP training groups improved significantly more at the specific ROM at which they trained, and (c) 10 weeks of RT cessation in recreationally and highly trained athletes (control group) significantly reduced the neuromuscular strength, mainly against high loads.

Only 1 previous study supports the recommendation that training at greater ROM (i.e., BP_{FULL}) elicits the greatest neuromuscular

strength adaptations after a 10-week RT program (18). Other studies, in contrast, suggest no differences (19) or even higher improvements by using other strategies such as the combination of ROMs in the same training session (3). Our findings corroborate the first assumption and demonstrate that BP_{FULL} is the best exercise for increasing neuromuscular strength, both at maximal (1RM) and submaximal low (<50% 1RM) and high (>50% 1RM) loads compared with partial BP variations. Similarly, a recent and comprehensive study found that lower ROMs in the back squat exercise generate limited neuromuscular and functional improvements in comparison with full ROMs, besides increments in pain and discomfort after a 10-week RT program (24). It can be speculated that training by using ROMs which have to overcome the sticking region in each lift could generate greater strength improvements than those ROMs that avoid this biomechanical disadvantage (16,17,24).

More importantly, BP training with full ROM lifts produced moderate to high increases in 1RM, 1RM/BM, and MPV on the 3 ROMs variations. In turn, training at restricted ROM, especially in BP_{1/3}, resulted in lower performance increments and the worst transfer to other ROMs. Some authors suggested that greater improvement and adaptations would occur at the specific angle and ROM of training (15,18,19). Our findings partly support this argument by showing the highest increments in neuromuscular performance at each group BP ROM. However, according to our data, the greater BP ROM was, the higher the increments were at all the variations. This means that training at BP_{FULL} produced greater (or at least equal) gains in strength in any of the 3 BP variations (BP_{FULL}, BP_{2/3}, and BP_{1/3}) compared with the other groups.

An innovative aspect of this study is the use of velocity-based RT methods to check that every BP repetition was executed at the programmed load intensity (9). This was possible by using the recently published relationships between relative load (% 1RM) and MPV for the 3 BP variations (16). It is worth noting, as recently pointed out, the 1RM value measured at the beginning of

Table 2
Changes in selected neuromuscular performance variables from before to after training for each BP group.*†

Group	Variable	Exercise/Pre-post								
		BP _{FULL}			BP _{2/3}			BP _{1/3}		
		T0	T1	ES	T0	T1	ES	T0	T1	ES
BP _{FULL} (n = 11)	1RM (Kg)	71.8 ± 15.6	80.7 ± 15.8‡	0.56	83.5 ± 15.9	91.8 ± 16.4	0.52	107.3 ± 16.6	118.7 ± 17.7‡	0.66
	1RM/BM	0.98 ± 0.18	1.14 ± 0.18‡	0.86	1.15 ± 0.18	1.30 ± 0.19‡	0.84	1.47 ± 0.19	1.68 ± 0.15‡	1.17
	MPV _{ALL} (m·s ⁻¹)	0.79 ± 0.06	0.90 ± 0.06‡	1.96	0.72 ± 0.07	0.79 ± 0.09‡	0.91	0.57 ± 0.07	0.62 ± 0.08‡	0.73
	MPV _{<50% 1RM} (m·s ⁻¹)	1.11 ± 0.09	1.24 ± 0.08‡	1.47	1.00 ± 0.10	1.09 ± 0.13‡	0.77	0.80 ± 0.11	0.87 ± 0.12‡	0.65
	MPV _{>50% 1RM} (m·s ⁻¹)	0.46 ± 0.06	0.56 ± 0.07‡	1.62	0.44 ± 0.07	0.50 ± 0.09‡	0.82	0.33 ± 0.04	0.37 ± 0.05‡	0.77
BP _{2/3} (n = 13)	1RM (Kg)	71.3 ± 13.1	76.3 ± 11.9	0.40	83.0 ± 9.5	89.1 ± 8.7‡	0.67	111.2 ± 17.1	123.2 ± 14.8‡	0.75
	1RM/BM	0.96 ± 0.21	1.02 ± 0.19	0.29	1.11 ± 0.20	1.19 ± 0.21	0.43	1.50 ± 0.29	1.66 ± 0.20‡	0.63
	MPV _{ALL} (m·s ⁻¹)	0.81 ± 0.08	0.88 ± 0.10‡	0.78	0.73 ± 0.08	0.80 ± 0.09‡	0.78	0.56 ± 0.06	0.59 ± 0.08	0.40
	MPV _{<50% 1RM} (m·s ⁻¹)	1.12 ± 0.10	1.20 ± 0.12‡	0.78	1.01 ± 0.11	1.10 ± 0.12‡	0.75	0.81 ± 0.09	0.84 ± 0.11	0.29
	MPV _{>50% 1RM} (m·s ⁻¹)	0.50 ± 0.07	0.55 ± 0.10‡	0.59	0.45 ± 0.07	0.50 ± 0.08‡	0.68	0.32 ± 0.05	0.35 ± 0.07	0.47
BP _{1/3} (n = 13)	1RM (Kg)	75.4 ± 18.1	75.2 ± 14.6	-0.01	84.0 ± 19.6	86.3 ± 15.2	0.13	110.4 ± 22.5	117.5 ± 19.8	0.34
	1RM/BM	0.98 ± 0.19	0.99 ± 0.16	0.06	1.11 ± 0.21	1.15 ± 0.17	0.20	1.47 ± 0.26	1.56 ± 0.26	0.36
	MPV _{ALL} (m·s ⁻¹)	0.80 ± 0.07	0.82 ± 0.04	0.45	0.76 ± 0.05	0.78 ± 0.07	0.42	0.58 ± 0.05	0.61 ± 0.05‡	0.66
	MPV _{<50% 1RM} (m·s ⁻¹)	1.13 ± 0.11	1.17 ± 0.06	0.49	1.05 ± 0.08	1.08 ± 0.08	0.33	0.82 ± 0.08	0.86 ± 0.07	0.59
	MPV _{>50% 1RM} (m·s ⁻¹)	0.47 ± 0.06	0.48 ± 0.05	0.20	0.46 ± 0.04	0.48 ± 0.07	0.42	0.33 ± 0.04	0.35 ± 0.05	0.47
Control (n = 12)	1RM (Kg)	68.8 ± 9.9	66.0 ± 12.2	-0.25	81.0 ± 13.2	76.5 ± 13.2	-0.34	110.8 ± 12.9	105.8 ± 15.0	-0.36
	1RM/BM	0.99 ± 0.14	0.95 ± 0.16	-0.30	1.17 ± 0.20	1.10 ± 0.18	-0.36	1.60 ± 0.16	1.53 ± 0.11	-0.54
	MPV _{ALL} (m·s ⁻¹)	0.84 ± 0.11	0.84 ± 0.10	0.00	0.73 ± 0.06	0.71 ± 0.04	-0.27	0.58 ± 0.07	0.56 ± 0.04	-0.43
	MPV _{<50% 1RM} (m·s ⁻¹)	1.13 ± 0.11	1.15 ± 0.10	0.12	1.00 ± 0.08	1.01 ± 0.07	0.15	0.80 ± 0.08	0.80 ± 0.04	0.13
	MPV _{>50% 1RM} (m·s ⁻¹)	0.54 ± 0.11	0.52 ± 0.10	-0.12	0.46 ± 0.06	0.42 ± 0.03‡	-0.86	0.36 ± 0.07	0.31 ± 0.05‡	-0.92

*ES = effect size; BP_{FULL} = full bench press; BP_{2/3} = two-thirds bench press; BP_{1/3} = one-third bench press; 1RM = 1 repetition maximum; BM = body mass; MPV = mean propulsive velocity.

†Data are mean ± SD.

‡Significant differences compared with T0.

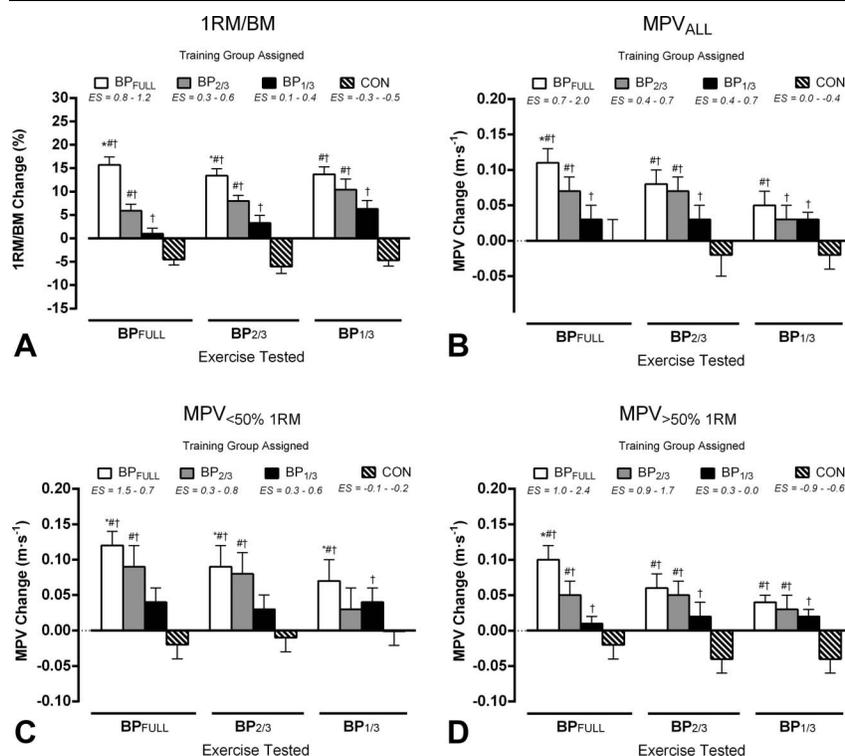


Figure 1. Changes in relative strength ratio (A) and velocity developed against all (B) low (<50% 1RM—C) and high (>50% 1RM—D) loads common to pre-test and post-test. BP_{FULL} = full bench press; BP_{2/3} = two-thirds bench press; BP_{1/3} = one-third bench press; CON = control. *Significant differences when compared with the BP_{2/3} group; #significant differences when compared with the BP_{1/3} group; †significant differences when compared with the CON group. ES = range of effect size for each resistance training group. Data are presented as mean ± SEM.

an RT program (T0) will be considerably altered over the training weeks due to the neuromuscular improvements and/or fatigue processes that occur in the athletes’ functional performance (26). Therefore, the use of velocity-based devices and force-velocity calculations to accurately determine the individual load intensity at each BP lift is a main contribution of this article and encourages future studies to replicate and extend these findings.

Another finding worthy of discussion was that 10 weeks of RT cessation severely decreases upper-limb neuromuscular performance in athletes with different levels of experience in strength training. In particular, we found velocity reductions against both maximal (1RM, ES = -0.25 to -0.36) and submaximal loads (MPV_{ALL}, ES = 0.00 to -0.43). These reductions on upper-body neuromuscular performance are lower than those found in the lower body (back squat exercise) after an identical training cessation intervention, testing procedures, and loads assessed (1RM, ES = -1.01 to -1.21; MPV_{ALL}, ES = -0.52 to -0.83) (24). Also, just like Pallarés et al. (24), the current study found greater strength reductions against maximal loads (1RM) than against submaximal loads (MPV_{ALL}). In relation to this aspect, other studies supported that submaximal strength may be much more rapidly lost than maximal strength, after finding larger reductions on strength performance against light-medium loads than high loads (6,12,13). These contradictory results could be explained by the differences in methodological aspects such as the exercises tested, the durations of the training cessation, or the subjects’ experience.

This study demonstrates that BP_{FULL} is a more effective exercise than partial ROM variations to improve strength

performance in recreational and well-trained athletes after continued training. These findings question the recommendation that greater improvement and adaptations occur at the specific angle and ROM of training. This is particularly interesting for powerlifters since these athletes train and compete at reduced BP ROMs (BP_{2/3} or even BP_{1/3}) generated by different postural modifications (e.g., a pronounced lumbar arch or an accentuated scapular retraction) (7) and wide grips (8). However, although this lower ROM could be more specific to the movement performed in the competition, results found in the current study support the inclusion of BP_{FULL} training sessions to maximize the strength improvements, just like it has been previously suggested by Clark et al. (3).

This is the first study using velocity-based methods for monitoring each repetition and for evaluating changes on neuromuscular performance after a prolonged RT intervention based on different ROMs in the upper limb. The thoroughness of this work encourages future studies to test BP programs using these methods.

Practical Applications

The current study determined the effect of training at different ROMs on BP exercise. Taking into account that the higher the ROM used, the greater improvements, both on the 1RM, as well as on the whole load-velocity spectrum, we encourage trainers and athletes to use a full ROM in BP exercise to maximize the neuromuscular adaptations.

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