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Abstract

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Keywords

muscle damage, fatigue, range of motion, bench press

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Article

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1. Introduction

Resistance training is the most commonly recommended approach for achieving long-term improvements in strength and muscle mass [1]. Beside the exercise order, volume, intensity, and rest intervals [2], the range of motion (ROM) in an exercise is another variable that influences training adaptations [3]. Thus, acute effects of ROM should be taken into consideration by coaches and athletes participating in resistance training, since changes in exercise ROM may result in exercise-induced muscle damage, leading to impaired muscle function and performance impairment lasting up to several days after the training session [4, 5]. Indeed, participating in intense physical activity that causes damage to the structure of skeletal muscle cells leads to a rise in overall levels of creatine kinase (CK). Thus, the evaluation of blood serum CK activity provides information about the magnitude of muscle damage [4], which may be used as an index to establish sufficient recovery between training sessions.

Although extensive research has already investigated the effects of different exercise ROM on exercise-induced muscle damage [5, 6, 7], most of it was limited to only partial vs. full ROM comparison, and mostly the elbow flexors were investigated. However, in the case of the bench press exercise, the ROM is limited by the barbell which touches the chest while lowering the bar [8]. In consequence, the primary muscles engaged in the bench press movement do not undergo their complete physiological ROM. Nevertheless, since the cambered barbell was designed, this issue seems to be solved. The barbell's U-shape provides extra room for the torso, allowing to achieve a lower bottom position of the lift and a greater stretch of primary muscles when compared to a standard barbell [9, 10]. Previous studies have already investigated differences between a cambered and standard barbell in muscle activity [9], barbell velocities [10, 11], training volume [12] and muscle fatigue [13]. The studies by Krzysztofik et al. [11] and Matykiewicz et al. [10] have demonstrated that the use of a cambered barbell results in an increased range of motion (ROM) during the bench press exercise, leading to higher velocities of the barbell. Hence, the implementation of a cambered bar can be regarded as a supplementary tool in resistance training aimed at enhancing movement velocity, especially with athletes participating in sport disciplines that require explosiveness. Other findings [9] indicated that when comparing the cambered barbell to the standard one during the bench press exercise at 90% of the one-repetition maximum (1RM), it was observed that the cambered barbell elicits increased activation of the anterior deltoid muscles. In contrast, the standard barbell resulted in higher activity of the pectoralis major and triceps brachii long head muscles. A recent study which is a continuation of our previous research [13] indicated no significant differences in neuromuscular fatigue between the cambered and the standard barbell.

Given the benefits of the cambered barbell and that a greater ROM used in a long-term resistance training program results in greater adaptations [14, 15], the main aim of this study was to evaluate the differences between the cambered and the standard barbell used during the bench press exercise in relation to the magnitude of muscle damage assessed by CK activity. We hypothesized that the use of a cambered barbell, which provides a greater ROM during the bench press exercise, would lead to more significant muscle damage.

2. Materials and Methods

2.1. Participants

A group of fourteen well-trained men volunteered for this study (26.3 ± 2.3 years, 88.5 ± 4.9 kg, 178.4 ± 2.8 cm, standard barbell bench presses 1RM = 132.7 ± 12.4 kg, cambered barbell bench press 1RM = 126.3 ± 11.9 kg). The following inclusion criteria were required: free from musculoskeletal injury prior to the study, a minimum of 5 years of resistance training experience, 1RM bench press of at least 100% of own body mass. Moreover, the participants were also required to have at least 5 weeks of previous cambered barbell bench press experience. All participants were familiarized with the study's purpose, methods, benefits and risks and agreed to participate by providing a signed informed consent. The investigation was conducted in the Strength and Power Laboratory of the Academy of Physical Education in Katowice, Poland. All procedures were performed in accordance with the most recent edition of the Declaration of Helsinki, 2013. The study protocol was approved by the Bioethics Committee for Scientific Research of the Academy of Physical Education in Katowice, Poland (KB/14/2022).

2.2. Measures

The participants were divided into two conditions: a) standard (STD), b) cambered (CMB). Both STD and CMB groups performed the bench press training sessions in a randomized crossover design. The first two sessions focused on the one-repetition maximum test (1RM) of the flat bench press with a STD or CMB barbell, followed by two experimental sessions. The focus of the experimental sessions was to evaluate the effects of the STD and CMB bench press exercise protocol on subsequent and delayed muscle fatigue and muscle damage. To do so, the bench press throw as well as creatine kinase activity measures were performed pre-session, 1-h, 24-h and 48-h post- exercise. The experimental procedures contained 5 sets of the bench press exercise against 70% of the standard or the cambered bar bench press 1RM performed to volitional failure. 72 hours of rest was implemented between 1RM tests, and experimental sessions were executed one week apart to avoid fatigue. The participants were also asked not to perform any additional upper-body resistance training during the experiment.

2.3. Design and procedures

The experimental protocol had the same procedures, only differing in the type of the barbell used during the exercise protocol. The procedure required the participants to perform 5 sets of the bench press exercise at 70% of 1RM (STD or CMB barbell) to momentary volitional failure. Cadence of the eccentric phase of the movement was controlled through a metronome and equaled 2s of the eccentric phase and a volitional tempo of the concentric phase of the movement. A 3-min rest interval was established between subsequent sets. To assess the time course of muscle fatigue, changes in peak barbell velocity [16] during the bench press throw (BPT) were analyzed, as several previous studies have shown movement velocity to be a reliable indicator of neuromuscular fatigue [17, 18]. To define the differences in the time course of muscle damage between STD and CMB the activity of serum creatine kinase was analyzed [19, 20, 21]. To achieve these goals, each participant completed a single set of two repetitions of the BPT on the Smith machine at maximum velocity with a load corresponding to 30% of their 1RM for the standard barbell bench press at pre-, 1-h, 24-h and 48-h post session and each post-BPT set was preceded by a standard warm-up on the cycle ergometer for 5min followed by dynamic mobility exercises for the upper body. Similarly, serum samples were collected for creatine kinase activity analysis before and one hour, as well as 24 and 48 hours after each training session. During the BPT attempts, peak velocity was measured, whereas the mean velocity, the number of performed repetitions and the barbell displacement were recorded during each set of the bench press exercise. All measures were conducted using a Tendo Power Analyzer (Tendo Sport Machines, Trencin, Slovakia) [22].

2.4. One-repetition maximum bench press test

The participants visited the laboratory twice for a STD and a CMB 1RM estimation. During both sessions, the participants began with a standardized warm-up specified in a previous study [10]. Subsequently, utilizing either a STD or a CMB, they were subjected to a 1RM bench press test. They were instructed to maintain technical demands during the attempts, e.g. keeping feet on the ground, hips and head in contact with the bench. Moreover, the hand placement was consistent across all attempts and was positioned at 150% of the subject's biacromial width. The tempo of movement was consistent during the trials and matched the recommendation by Wilk et al. [23], i.e. 2s of the negative (lowering) phase of the lift, and a volitional tempo of a positive (raising) phase of the lift, without pausing and bouncing the barbell of the chest. The goal of the sessions was to estimate 1RM within three to five trials, with a 3-min rest interval between sets. The first trial was established at 80% of self-reported 1RM, and if successfully lifted, the load was increased by 2.5kg to 5kg in the next trials until the subjects could not lift a given load. Safety was ensured by two experienced spotters that were present during the sessions.

3. Results

3.1. Statistical analysis

All statistical analyses were performed using SPSS (version 25.0; SPSS, Inc., Chicago, IL, USA) and were shown as means with standard deviations (±SD). Statistical significance was set at $p < 0.05$. The normality of data distribution was checked using Shapiro–Wilk tests, while Mauchly's test was used to test for the assumption of sphericity. The two-way ANOVA or, if the normality was not confirmed, related-samples Friedman's two-way ANOVA by ranks were used to investigate the differences in training variables during standard and cambered barbell bench presses and their influence on the bench press throw performance and creatine kinase activity. When a significant main effect or interaction was found, post-hoc tests with Bonferroni correction were used to analyze the pairwise comparisons. The magnitude of mean differences was expressed with standardized effect sizes. Thresholds for qualitative descriptors of Hedges g were interpreted as ≤ 0.20 "small", 0.21-0.79 "medium", and > 0.80 as "large".

3.2. Bench press performance

Two-way ANOVA indicated that there was a significant interaction ($F = 7.467$; $p < 0.001$; $\eta^2 = 0.365$) and a main effect of a set ($F = 192.302$; $p < 0.001$; $\eta^2 = 0.937$) and condition ($F = 25.560$; $p < 0.001$; $\eta^2 = 0.663$) on the number of performed repetitions. The post-hoc comparisons showed an overall trend of a significant decrease in the number of performed repetitions from the first to the fifth set ($p < 0.002$) with the exception of the first vs. second set during the STD bench press ($p = 0.99$; ES = 0.87) and the fourth vs fifth set during the CMB bench press ($p = 0.065$; ES = 0.0) (Table 1).

Friedman's test (test = 117.195; $p < 0.001$; Kendall's W = 0.93) showed an overall trend of a significantly higher ROM between the corresponding sets during the CMB bench press in comparison to the STD bench press ($p < 0.002$; for all) (Table 1).

Two-way ANOVA indicated that there was a significant interaction ($F = 5.58$; $p = 0.001$; $\eta^2 = 0.300$) and a main effect of a set ($F = 34.205$; $p < 0.001$; $\eta^2 = 0.725$) but not condition ($F = 0.134$; $p = 0.720$; $\eta^2 = 0.010$) on the mean velocity. The post-hoc analysis showed a significantly lower barbell mean velocity in the fourth ($p < 0.001$; ES = 1.29 to 2.32) and fifth set ($p < 0.008$; ES = 1.36 to 2.89) compared to sets from the first to the third one during the STD bench press, while during the CMB bench press, there was a significant overall trend to decrease barbell mean velocity in subsequent sets (first vs other sets $p < 0.01$; ES = 1.07 to 2.67; second and third to fifth ($p < 0.008$; ES = 1.41 and 1.05); third vs. fourth ($p = 0.011$; ES = 1.05) with exception to no significant differences between third and fifth ($p = 0.127$; ES = 0.86) and fourth vs. fifth set ($p = 1.00$; ES = 0.38). Furthermore, a barbell mean velocity was significantly higher in the first set ($p = 0.01$) during the STD compared to the CMB bench press. On the other hand, a higher barbell mean velocity was reported in the fourth set ($p = 0.018$) during the CMB than in the STD bench press (Table 1).

Table 1. Changes in training variables during the standard and cambered barbell bench press sessions. Mean ± SD (95%CI)

	Set 1	Set 2	Set 3	Set 4	Set 5
	Repetitions [n]				
Cambered barbell	13 ± 2 (12 to 14)	10 ± 2 (9 to 11)	8 ± 2 (7 to 10)	6 ± 1 (6 to 7)	6 ± 1 (5 to 6)
Standard barbell	16 ± 2 (15 to 17)	14 ± 3 (13 to 16)	11 ± 2 (10 to 13)	9 ± 2 (8 to 10)	7 ± 2 (6 to 8)
ES	1.46	1.52	1.46	1.84	0.61

	Set 1	Set 2	Set 3	Set 4	Set 5
	Range of Motion [cm]				
Cambered barbell	42.3 ± 1.2 (41.6 to 43.0)	41.8 ± 1.6 (40.9 to 42.7)	41.6 ± 1.6 (40.6 to 42.5)	40.8 ± 2.0 (39.6 to 42.0)	39.9 ± 2.1 (38.8 to 41.1)
Standard barbell	35.7 ± 2.2 (34.5 to 36.8)	34.4 ± 2.2 (33.2 to 35.5)	33.7 ± 2.2 (32.5 to 34.9)	33.0 ± 2.3 (31.8 to 34.2)	32.8 ± 2.6 (31.4 to 34.2)
ES	3.62	3.73	3.99	3.51	2.92
	Mean Velocity [m/s]				
Cambered barbell	0.56 ± 0.04 (0.48 to 0.62)	0.51 ± 0.05 (0.45 to 0.59)	0.49 ± 0.05 (0.40 to 0.58)	0.45 ± 0.04 (0.38 to 0.51)	0.43 ± 0.06 (0.34 to 0.52)
Standard barbell	0.59 ± 0.07 (0.47 to 0.71)	0.50 ± 0.07 (0.41 to 0.65)	0.51 ± 0.07 (0.43 to 0.67)	0.41 ± 0.08 (0.25 to 0.56	0.42 ± 0.04 (0.35 to 0.49)
ES	0.51	0.16	0.32	0.61	0.19

3.3. Bench press throw performance

Two-way ANOVA indicated that there was a non-significant interaction (F = 1.0.25; p < 0.392; η^2 = 0.073) but a significant main effect of a set (F = 12.837; p < 0.001; η^2 = 0.921) and of a condition (F = 8.015; p = 0.014; η^2 = 0.381) on barbell peak velocity. The post hoc analysis showed a significantly higher barbell peak velocity after the CMB compared to the STD condition (p < 0.001; ES = 0.55). Moreover, the barbell peak velocity was significantly lower in post- than in pre- (p = 0.001; ES = 4.39) and post-48 (p = 0.004; ES = 0.73) session (Figure 2).

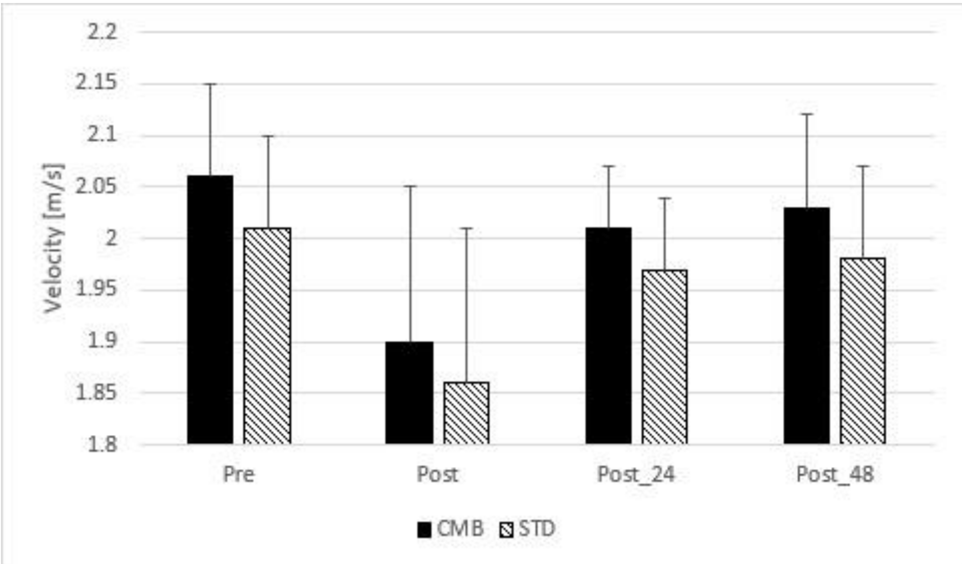

Figure 1. Changes in peak velocity during the bench press throw at pre-, post-, post-24h and post-48h the standard and the cambered barbell bench press session. CMB – cambered barbell bench press; STD – standard barbell bench press

3.4. Creatine kinase activity

Two-way ANOVA indicated that there was a significant interaction (F = 23.417; p < 0.001; η^2 = 0.643) and a main effect of a set (F = 151.837; p < 0.001; η^2 = 0.921) and of a condition (F = 8.015; p = 0.014; η^2 = 0.381) on the CK activity. The post-hoc analysis showed an overall trend to increase of CK activity from pre- to subsequent time points (p < 0.001

for all; ES = 0.95 to 2.27) during the STD condition. Similarly, during the CMB condition with the exception of the post-48, which was higher in comparison to pre ($p < 0.001$; ES = 1.43) and post ($p = 0.002$; ES = 0.88) but not than post-24 ($p = 1.00$; ES = 0.27) (Figure 2).

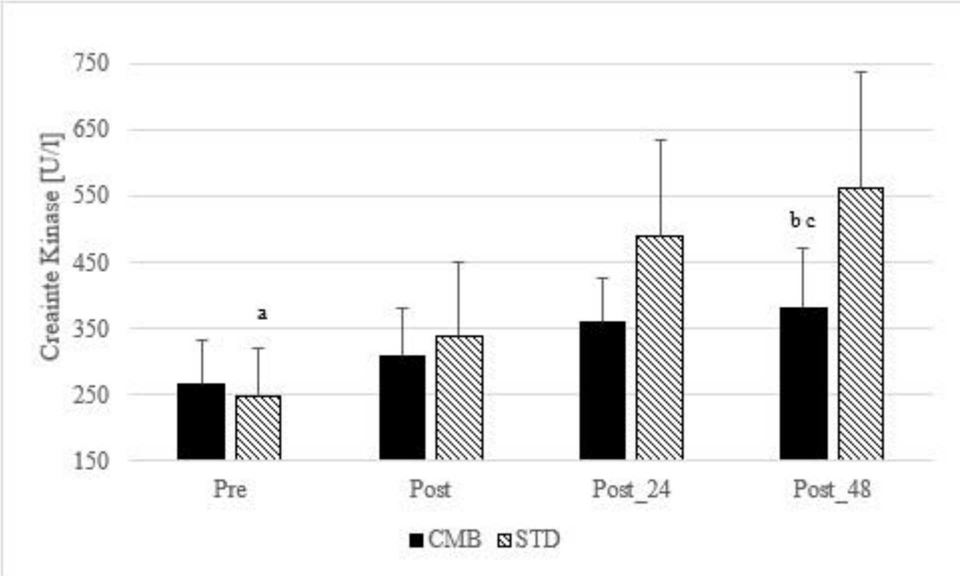

Figure 2. Changes in creatine kinase activity at pre- and post-exercise with the standard and the cambered barbell bench press at different time points. CMB – cambered barbell bench press; STD – standard barbell bench press. a – significantly different in comparison to other time points within the condition; b – significantly different in comparison to pre within the condition; c – significantly different in comparison to post within the condition.

4. Discussion

The main aim of this study was to indicate the differences between the standard and cambered barbells used during the bench press exercise protocol which consisted of 5 sets at 70% of 1RM performed to volitional failure on neuromuscular fatigue assessed by barbell velocity changes during the bench press throw, as well as exercise-induced muscle damage evaluated by creatine kinase (CK) serum activity, evaluated at baseline, as well as 24- and 48-h post exercise. A further objective was to compare the differences in the number of performed repetitions and mean barbell velocities across the exercise protocol between the two conditions. The results indicated that higher peak barbell velocity was reached during the BPT after the CMB when compared to the STD condition. Moreover, interestingly, CK activity showed an overall significant growing trend from baseline to time points following exercise during the STD, whereas the CMB post-48h CK was higher in comparison to pre and post, but not to post-24h. Furthermore, a mean barbell velocity comparison showed a similar velocity decrease across the sets when utilizing both barbells, and the number of performed repetitions decreased similarly across the sets under both conditions. A significantly greater ROM in the corresponding sets during the cambered than the standard barbell bench press was observed.

Despite the long presence of the cambered barbell, and the fact that the bench press exercise is one of the most extensively studied and employed upper-body exercises in training [24], there is limited research exploring its utilization in training [9, 10, 11, 13]. The above-mentioned studies [10, 11] showed a greater ROM during the bench press exercise, as well as higher barbell velocities with the use of CMB. Furthermore, authors [9] found that bench pressing with the CMB at 90% of 1RM elicits increased activation of the anterior deltoid, while the STD resulted in higher activity in the pectoralis major and triceps brachii long head muscles. Nevertheless, to the best of the author's knowledge, the present study is the third to date [12, 13] that presents the effects of a cambered barbell on the number of performed repetitions executed and a barbell velocity comparison in an exercise protocol that closely simulates a bench press training regimen, composed of 5 sets at 70% of 1RM to volitional failure. Furthermore, to our knowledge, the current study is the first designed to compare the impact of a bench press training session performed with a cambered barbell on muscle damage evaluated by CK activity analyzed from baseline up to 48h post exercise.

The influence of exercise ROM on exercise-induced muscle damage has been a matter of debate in previous research [6, 7]. The authors of research [6] indicated that performing 4 sets of 10 repetitions of unilateral elbow flexion on a Scott bench with a full ROM led to a greater muscle damage when compared with partial ROM, even though, similarly to our study, a smaller ROM allowed higher loads to be lifted. Similar results were demonstrated by Fochi et al. [7], who compared full and partial ROM (180° vs. 60°) of elbow flexion on eccentric exercise-induced muscle damage. However, the results were limited only to direct factors, such as peak torque, maximal voluntary isometric contraction torque, muscle soreness, arm circumference and joint ROM. In contrast to the above-mentioned results, the findings of our study showed a longer muscle damage activity after bench pressing with a typical ROM when compared to extended ROM, but this difference did not reach statistical significance. It is known that training frequency is a key variable affecting adaptations in resistance training [2]. Thus, the current study also aimed to investigate whether using a cambered barbell, which allows extending the ROM during the bench press exercise, would lead to a greater fatigue in BPT and muscle damage assessed by CK serum activity, potentially impacting subsequent training sessions. It turned out that a significantly greater decrease in barbell peak velocity was observed after STD than CMB barbell bench press. Moreover, the barbell peak velocity was significantly lower in post than in pre, and 48h post the bench press exercise protocol, with no significant differences between conditions. The final analysis of CK activity showed an overall growing trend from baseline to subsequent time points of recovery during the STD condition. A similar increase during the CMB condition was observed; however, post-48h CK activity was significantly higher in comparison to pre and post exercise, but not post-24h. These results confirm, in connection with the lack of differences in barbell velocities, that utilizing a CMB barbell in upper-body workout might not require a specific training approach, such as different volume or intensity of exercise. Furthermore, considering the analysis of muscle damage, it can be inferred that with the use of a cambered bar, higher training frequency can be applied. Taking into consideration the benefits of a long-term full ROM training on muscle hypertrophy and strength adaptations [3, 25, 26] compared to partial ROM, the need for research on its influence on muscle damage seems to be justified. Nevertheless, this study examined a group of well-trained individuals (minimum of 5 years of resistance training experience) that experience lower increases in CK activity after exercise when compared with untrained subjects [27, 28]. Thus, the results of this study should be generalized with caution.

Additional analysis showed that when utilizing a cambered barbell during a bench press workout, a significantly lower total number of repetitions was achieved when compared to a standard barbell, which was confirmed by previous results [12, 13]. These results are also in line with Vitor Lima et al. [29] study's outcomes, who proved that the lower range of motion, the higher total number of repetitions performed in the bench press exercise. In consequence, an increase in the number of executed repetitions results in a greater frequency of the eccentric-concentric transition phase, leading to a higher peak torque output and increased mechanical stress, which may vary in magnitude to the elicited fatigue and training stimuli [30]. Mean barbell velocity measures indicated a similar decreased trend across the exercise protocol, with no significant differences between STD and CMB bench press. These findings are inconsistent with a previous report by Martínez-Cava et al. [31] that showed significantly lower barbell velocities during bench pressing with a smaller ROM. However, the above-mentioned studies [29, 31] have been limited only to full vs. partial ROM comparison. By contrast, taking into account that CMB allows for extended ROM, studies [10, 11] confirmed greater barbell velocities when CMB was used in the bench press exercise when compared with the STD.

Our study is not without limitations. Firstly, we have compared only two different ROMs in the bench press exercise, which might not translate to other exercises. Therefore, since a cambered barbell has been on the market, future research could compare partial with full and extended ROM. Secondly, even though the same relative load was used in this study (70% of STD or CMB 1RM), a different absolute load was lifted during the experiment. Furthermore, the participants performed 5 sets until reaching voluntary failure, which differs from usual resistance training workouts. Thus, future research could compare bench press training sessions with a predetermined number of repetitions and a consistent load. Thirdly, the BPT performance, as well as CK activity, was only measured up to 48h after exercise, despite the fact that fatigue and muscle damage may last longer.

5. Conclusions

Taking into account no significant differences in mean barbell velocity between the barbells, given that a movement velocity is a reliable indicator of neuromuscular fatigue [17, 18], it can be assumed that the use of a cambered barbell does not require longer rest intervals between sets across a training session. In conclusion, the bench press exercise performed the use of CMB, which allows for a greater ROM might not require specific training approach and even higher training frequency might be applied.

References

1. Stone M, Plisk S, Collins D. Training principles: Evaluation of modes and methods of resistance training – A coaching perspective. Sports Biomech. 2002;1:79–103. DOI: 10.1080/14763140208522788
2. Kraemer WJ, Ratamess NA. Fundamentals of resistance training: Progression and exercise prescription. Med Sci Sport Exerc. 2004;36:674–688. DOI: 10.1249/01.mss.0000121945.36635.61
3. Schoenfeld BJ, Grgic J. Effects of range of motion on muscle development during resistance training interventions: A systematic review. SAGE Open Med. 2020;8:205031212090155. DOI: 10.1177/2050312120901559
4. Clarkson, PM, Hubal MJ. Exercise-induced muscle damage in humans. Am J Phys Med Rehabil. 2002:81:52–S69. DOI:https://doi.org/10.1097/00002060-200211001-00007
5. Nosaka K, Sakamoto K. Effect of elbow joint angle on the magnitude of muscle damage to the elbow flexors. Med Sci Sport Exerc. 2001;33:22–29. DOI: 10.1097/00005768-200101000-00005
6. Baroni BM, Pompermayer MG, Cini A, Peruzzolo AS, Radaelli R, Brusco CM, et al. Full range of motion induces greater muscle damage than partial range of motion in elbow flexion exercise with free weights. J Strength Cond Res. 2017;31(8):2223–2230. DOI: 10.1519/JSC.0000000000001562
7. Fochi AG, Damas F, Berton R, Alvarez L, Miquelini M, Salvini T, et al. Greater eccentric exercise-induced muscle damage by large versus small range of motion with the same end-point. Biol Sport. 2016;33(3). DOI: 10.5604/20831862.1208480
8. Lockie RG, Callaghan SJ, Moreno M, Risso FG, Liu T, Stage A, et al. Relationships between mechanical variables in the traditional and close-grip bench press. J Human Kinetics. 2017;60(1): 19–28. DOI: 10.1515/hukin-2017-0109
9. Krzysztofik M, Golas A, Wilk M, Stastny P, Lockie RG, Zajac A. A comparison of muscle activity between the cambered and standard bar during the bench press exercise. Front Physiol. 2020;11:875. DOI: 10.3389/fphys.2020.00875
10. Matykiewicz P, Krzysztofik M, Filip-Stachnik A, Wilk M. The bench press exercise performed with increased range of motion allows for greater bar velocities. J Phys Educ Sport. 2021;21(4):1737-1743. DOI: https://doi.org/10.7752/jpes.2021.04220
11. Krzysztofik M, Zajac A, Zmijewski P, Wilk M. Can the cambered bar enhance acute performance in the bench press exercise? Front Physiol. 2020;11:577400. DOI: 10.3389/fphys.2020.577400
12. Krzysztofik M, Matykiewicz P, Filip-Stachnik A, Huminska-Lisowska K, Rzeszutko-Belzowska A, Wilk M. Range of motion of resistance exercise affects the number of performed repetitions but not a time under tension. Sci Reports. 2021;11(1):14847. DOI: 10.1038/s41598-021-94338- 7

13. Matykiewicz, P., Krzysztofik, M., Zajac, A. A comparison of basic training variables in the standard and cambered bar bench press performed to volitional failure. Journal of Human Kinetics. 2023:87:201-2010. DOI: https://doi.org/10.5114/jhk/162516
14. Massey, C.D, Vincent, J., Maneval, M., Johnson, J.T. Influence of range of motion in resistance training in women: Early phase adaptations. Journal of Strength and Conditioning Research. 2005:19: 409–411. DOI: https://doi.org/10.1519/R-14643.1
15. Clark, R.A., Bryant, A.L., and Humphries, B. An examination of strength and concentric work ratios during variable range of motion training. J Strength Cond Res. 2008:22: 1716–1719. DOI: 10.1519/JSC.0b013e318173c529
16. Ramos AG, Haff GG, Jimenez-Reyes P, Castilla AP. Assessment of upper-body ballistic performance through the bench press throw exercise: Which velocity outcome provides the highest reliability? J Strength Cond Res. 2018;32(10):2701–2710. DOI: 10.1519/JSC.0000000000002616
17. de-Oliveira LA, Aragao-Santos JC, Heredia-Elvar JR, Da Silva-Grigoletto ME. Movement velocity as an indicator of mechanical fatigue and resistance exercise intensity in cross modalities. Res Q Exerc Sport. 2022:1–7. DOI: 10.1080/02701367.2022.2101603
18. Sanchez-Medina L, Gonzalez-Badillo JJ. Velocity loss as an indicator of neuromuscular fatigue during resistance training. Med Sci Sport Exerc. 2011;43(9):1725–1734. DOI: 10.1249/MSS.0b013e318213f880
19. Brancaccio P, Maffulli N, Limongelli FM. Creatine kinase monitoring in sport medicine. Br Med Bull. 2007:81-82, 209-230. DOI: 10.1093/bmb/ldm014
20. Nosaka K, Newton M, Sacco P. Muscle damage and soreness after endurance exercise of the elbow flexors. Med Sci Sport Exerc. 2005;37(2):248–256. DOI: 10.1097/00005768-200206000-00003
21. Brennecke A, Guimaraes TM, Leone R, Cadarci M, Mochizuki L, Simao R, et al. Creatine kinase and lactate dehydrogenase responses after upper-body resistance exercise with different rest intervals. J Strength Cond Res. 2009;23(3):757–764. DOI: 10.1519/JSC.0b013e3181d8e6b1
22. Drinkwater E, Galna B, Mckenna M, Hunt P, Pyne D. Validation of an optical encoder during weight resistance movements and analysis of bench press sticking point power during fatigue. J Strength Cond Resh. 2007;21(2):510–517. DOI: 10.1519/R-20406.1
23. Wilk M, Golas A, Zmijewski P, Krzysztofik M, Filip A, Coso JD, et al. The effects of the movement tempo on the one-repetition maximum bench press results. J Human Kinetics. 2020;72(1):151–159. DOI: 10.2478/hukin-2020-0001
24. Stastny P, Golas A, Blazek D, Maszczyk A, Wilk M, Pietraszewski P, et al. A systematic review of surface electromyography analyses of the bench press movement task. PLoS ONE. 2017;12(2):e0171632. DOI: 10.1371/journal.pone.0171632
25. Martinez-Cava A, Hernández-Belmonte A, Courel-Ibanez J, Moran-Navarro R, Gonzalez-Badillo JJ, Pallares JG. Bench press at full range of motion produces greater neuromuscular adaptations than partial executions after prolonged resistance training. J Strength Cond Res. 2022;36(1):10–15. DOI: 10.1519/JSC.0000000000003391
26. Pinto RS, Gomes N, Regis R, Cintia EB, Lee EB, Martim B. Effect of range of motion on muscle strength and thickness effect of range of motion on muscle strength and thickness. J Strength Cond Res. 2012;26(8):2140–2145. DOI: 10.1519/JSC.0b013e31823a3b15
27. Vincent HK, Vincent KR. The effect of training status on the serum creatine kinase response, soreness and muscle function following resistance exercise. Int J Sports Med. 1997;18:431–7. DOI: 10.1055/s-2007-972660
28. Fehrenbach E, Niess AM, Schlotz E, Passek F, Dickhuth HH, Northoff H. Transcriptional and translational regulation of heat shock proteins in leukocytes of endurance runners. J Appl Physiol. 2000:89:704–10. DOI: 10.1152/jappl.2000.89.2.704
29. Lima FV, Goncalves Guimaraes D, Diniz RCR. Effect of range of motion in the maximum number of repetitions in the bench press exercise. Brazil J Phys Educ Sport. 2012;26(4):571–579. DOI: 10.1590/S1807-55092012000400004
30. Chapman D, Newton M, Sacco P, Nosaka K. Greater muscle damage induced by fast versus slow velocity eccentric exercise. Int J Sport Med. 2006;27(8):591–598. DOI: 10.1055/s-2005-865920
31. Martinez-Cava A, Moran-Navarro R, Hernandez-Belmonte A, Courel-Ibanez J, Conesa-Ros E, Gonzalez Badillo JJ, et al. Range of motion and sticking region effects on the bench press load-velocity relationship. J Sport Sci Med. 2019;18(4):645–652.

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