Original Article

Analysis of power output and bar velocity during various techniques of the bench press among women

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ABSTRACT

Background: The aim of the study was to determine the effect of the wide grip bench press (WGBP) and the close grip bench press (CGBP) on power output and bar velocity changes using a variable tempo of movement (6/0/X/0 vs. 2/0/X/0) in a group of female athletes. Objective: Twenty females were enrolled in the study (age 26.6 ± 2.6, body mass 54.4 ± 7.2 kg, RT experience 2.5 ± 0.94 years; CGBP 1RM 55.2 ± 7.5 kg; WGBP 1RM 52.9 ± 6.5 kg). Method: Participants performed two sets of three repetitions of the bench press (BP) at 70% 1RM with different grip widths (WGBP or CGBP) and different tempos of movement (2/0/X/0 or 6/0/X/0). During each test, the following variables were registered: mean power (MP), peak power (PP), mean velocity (MV), and peak velocity (PV). Results: The repeated measures ANOVA showed significant differences between analysed variables for MV, PV and PP. The post hoc Tukey showed significant differences between WGBPSLOW and WGBPFAST for MV ($p < .01$) and PV ($p < .01$), significant differences between WGBPSLOW and CGBPFAST for PP ($p < .05$), MV ($p < .01$) and PV ($p < .05$). Finally, the study showed significant differences between CGBPSLOW and CGBPFAST for MV ($p < .05$). Conclusion: The present research showed that the movement tempo significantly influenced the level of power output and bar velocity during the BP. Furthermore, it was demonstrated that the type of grip width during the BP is not a factor significantly affecting the level of power output and bar velocity.

Keywords: Resistance exercise; Movement tempo; Close-grip; Wide-grip; Strength.

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INTRODUCTION

The bench press (BP) is one of the upper-body exercises most frequently used in resistance training (Baker et al., 2001; Stock et al., 2010; Krzysztofik et al., 2019; Wilk et al., 2019c). The BP is usually performed with an individually adjusted grip width, which was defined by Young et al. (2015) as "the strongest position" also termed a traditional bench press (TBP). However, athletes also often use the wide-grip bench press (WGBP) and the close-grip bench press (CGBP). The WGBP is described as a bench press with a grip width of 200% or more of the biacromial distance (BAD), while the CGBP is defined as a grip width of 95% BAD (Wagner et al. 1992; Barnett et al., 1995; Lockie et al., 2017a; 2017b; Wilk et al., 2019a).

The ability to generate high levels of strength and power output is one of the most significant factors that determines performance in numerous sport disciplines (Cronin and Hansen, 2005; Argus et al., 2014; Gołaś et al., 2017). Previous studies have shown that differences in the level of maximum strength and power output may depend on the width grip used during the BP (Saeterbakken et al., 2017; Lockie et al., 2018). Saeterbakken et al. (2017) showed that the WGBP (165 - 200% BAD) allowed higher maximum external loads compared to the CGBP. The values of 6-RM were 11.1% greater using the WGBP compared to the CGBP. Lockie et al. (2018) showed that peak power output during the WGBP occurred at 50% of 1RM, while for the CGBP at 30% of 1RM. Furthermore, the CGBP resulted in a lower maximal external load one repetition maximum test (1RM), higher peak power output and velocity as well as lower mean force compared to the WGBP (Lockie et al., 2018). The level of power output during the BP depends not only on the width grip used, but also on gender (Bishop et al., 1987; Miller et al., 1993; Amasay et al., 2016) and the level of experience in resistance training (Miller et al., 2019). Miller et al. (2019) indicated that trained females produced peak power output at 50%1RM, while untrained women at 60-70%1RM during the TBP.

What is important is that the level of power output and bar velocity in the BP depend also on the duration of the eccentric (ECC) contraction. A study by Wilk et al. (2019b) showed that a slower ECC cadence (6 s) during the BP had an adverse effect on power output and velocity during the concentric (CON) phase compared to the BP performed with a faster ECC cadence (2 s). Significant decreases were observed for both peak and mean power output as well as for bar velocity Wilk et al., (2019b). However, in that study Wilk et al. (2019b) the width grip was determined not on the basis % BAD, but on the basis of the width of the handle which amounted to 81 cm. Although previous studies have demonstrated that significant differences in power output depend on the grip width used in the BP (Lockie et al., 2017a; 2017b) none of them referred to different movement tempos during the exercise.

The movement tempo is usually described using a sequence of digits (e.g. 2/0/X/0), where each digit determines the duration (s) of a particular phase of the movement. Since there is no standardized method of assigning these digits within the scientific literature, in this paper we adopted a unified description of the movement tempo as follows: eccentric / isometric / concentric / isometric. Previous research has shown that changes in the movement tempo during resistance exercise have an impact on the volume and intensity of effort, and in turn, the resultant adaptive changes in maximum strength, power and hypertrophy (Keeler et al., 2001; Hunter et al., 2003; Gołaś et al., 2017; Wilk et al., 2018a; 2018b).

Despite the fact that training with a controlled movement tempo has become more popular in sports practice as well as in scientific research, there are no available data concerning the influence of the grip width and movement tempos on level of power output and bar velocity changes during the BP. Therefore, the aim of the study was to determine the effects of different grip widths in the BP (WGBP vs. CGBP) performed with different movement tempos (6/0/X/0 vs. 2/0/X/0) on power output and bar velocity in a group of female athletes.

MATERIAL AND METHODS

Participants

Twenty (20) healthy female experienced in resistance training (2.5 ± 0.94 yrs.) volunteered for the study after completing an ethical consent form (age = 26.6 ± 2.6 years; body mass = 54.4 ± 7.2 kg; CGBP 1RM = 55.2 ± 7.5 kg; WGBP 1RM = 52.9 ± 6.5 kg; mean ± SD). All study participants were over 18 years of age and were expected to be able to perform a bench press with the load of at least 100% of their body mass. Participants were allowed to withdraw from the experiment at any moment and were free of any pathologies or injuries. The study protocol was approved by the Bioethics Committee for Scientific Research at the Academy of Physical Education in Katowice, Poland, according to the ethical standards of the latest version of the Declaration of Helsinki, 2013.

Procedures

The experiment was performed following a randomized crossover design, where each participant performed a familiarization session with a 1RM test and four different testing protocols 3-4 days apart. Participants performed the WGBP with a 2/0/X/0 ($WGBP_{FAST}$), and a 6/0/X/0 ($WGBP_{SLOW}$) tempo. They also followed the same exercise procedures with the CGBP using a 2/0/X/0 ($CGBP_{FAST}$) and a 6/0/X/0 ($CGBP_{SLOW}$) tempo. During each experimental session, participants performed one set of 3 repetitions at 70%1RM. The following variables were registered: peak power (PP), mean power (MP), peak velocity (PV) and mean velocity (MV). Participants were required to refrain from resistance training 48 hours prior to each experimental session, were familiarized with the protocol as well as informed of the benefits and potential risks of the study and provided their written consent for participation in the study.

1RM WGBP and CGBP Strength Testing

All testing was performed at the Strength and Power Laboratory of the Academy of Physical Education in Katowice, Poland. Participants arrived at the laboratory between 9:00 and 11:00 a.m. and cycled on an ergometer for 5 minutes, which was followed by a general upper body warm-up and 15 push-ups. Next, participants performed 15, 10, and 5 BP repetitions using 20%, 50%, and 70% of their estimated 1RM, respectively. The 1RM test with the WGBP was performed first. The grip width adopted for the WGBP was 200% BAD (Wagner et al., 1992; Saeterbakken et al., 2017). The grip width was marked on the barbell with athletic tape, and a pronated grip was used. Participants placed their hands on the bar at the same position for each set. Participants executed single repetitions using a volitional cadence with a 3-min rest interval between successive trials. The load for each subsequent attempt was increased by 1.25 - 5 kg, and the process was repeated until failure. No more than five attempts were allowed before the 1RM was determined for each participant. After a 10 min recovery period, participants completed the 1RM test in the CGBP (Lockie et al., 2017a; 2017b). The body position and constraints that determined a successful lift were the same as those for the WGBP, except for the different grip width. The grip width adopted for the CGBP was 95% BAD (Cronin, 2001; Cronin & Owen, 2004; Cronin & Hansen, 2005). Following the established procedures, the warm-up for the second 1RM test began by completing 3–5 repetitions at 85% of the participants' estimated 1RM, and then one repetition with 90%1RM. Afterwards, participants attempted their first 1RM lift following a 3-min recovery period, and this process continued until 1RM was reached. For both the WGBP and the CGBP, absolute strength was taken as the maximum load lifted. An IPF Eleiko bar and weight plates (Eleiko, Sport AB Sweden) were used for both the WGBP and the CGBP.

Experimental sessions

The general and specific warm-up before the experimental sessions was identical to that used during the familiarization session. After the warm up, participants performed one set of the bench press with a particular grip width (WGBP or CGBP) and a specified tempo (2/0/X/0 or 6/0/X/0) with 70%1RM following a metronome guided movement cadence in the eccentric phase (Korg MA-30, Korg, Melville, New York, USA). The concentric phase was performed at the maximal tempo of movement (X). Each experimental set included 3 repetitions. All repetitions were performed without bouncing the barbell off the chest, without intentionally pausing at the transition between the eccentric and concentric phases, and without raising the lower back off the bench. The intervals between experimental sessions were 3-4 days. All familiarization and experimental sessions were recorded by means of a Sony camera (FDR191 AX53). All participants completed the described testing protocol.

Statistical analysis

The statistical analyses were performed using STATISTICA software (StatSoft, Inc., Tulsa OK Oklahoma, USA, 2018 - version 12). Values of power output and velocity were expressed as mean ± SD. Before using the parametric test, the assumption of normality was verified using the Kolmogorov-Smirnov test. The repeated measures ANOVA was used to show differences between collected variables. When significant main effects occurred, post-hoc comparisons were conducted using the Tukey's test.

RESULTS

The repeated measures ANOVA showed significant differences between analysed variables for MV, PV and PP (Table 1). The post hoc Turkey showed significant differences between $WGBP_{SLOW}$ and $WGBP_{FAST}$ for MV ($p < .01$) and PV ($p < .01$), significant differences between $WGBP_{SLOW}$ and $CGBP_{FAST}$ for PP ($p < .05$), MV ($p < .01$) and PV ($p < .05$) (Table 2). Finally, the study showed significant differences between $CGBP_{SLOW}$ and $CGBP_{FAST}$ for MV ($p < .05$) (Table 2).

Table 1. Power output and bar velocity during the various techniques of the bench press.

	$WGBP_{SLOW}$	**$WGBP_{FAST}$**	**$CGBP_{SLOW}$**	**$CGBP_{FAST}$**	***p***
MP [W]	121 ± 35	134 ± 24	131 ± 35	141 ± 46	.92
PP [W]	186 ± 67	196 ± 40	203 ± 60	219 ± 65	.05*
MV [m/s]	0.39 ± 0.07	0.48 ± 0.05	0.46 ± 0.08	0.51 ± 0.05	.05*
PV [m/s]	0.61 ± 0.11	0.72 ± 0.08	0.69 ± 0.17	0.70 ± 0.07	.01*

*All data are presented as mean ± standard deviation; *statistically significant differences p < .05*

Table 2. Differences in power output and bar velocity during the various techniques of the bench press.

Bench press techniques	**MP [w]**	**PP [w]**	**MV [m/s]**	**PV [m/s]**
	p	*p*	*p*	*p*
$WGBP_{SLOW}$ vs. $WGBP_{FAST}$	.88	.97	.01*	.01*
$CGBP_{SLOW}$ vs. $WGBP_{FAST}$	.96	.98	.86	.89
$WGBP_{FAST}$ vs. $CGBP_{FAST}$	.34	.75	.60	.98
$WGBP_{SLOW}$ vs. $CGBP_{SLOW}$	.63	.88	.28	.41
$WGBP_{SLOW}$ vs. $CGBP_{FAST}$	.75	.05*	.01*	.05*
$CGBP_{SLOW}$ vs. $CGBP_{FAST}$	.61	.90	.05*	.98

*All data are presented as mean ± standard deviation; *statistically significant differences p < .05*

DISCUSSION

The main finding of the study was that the movement tempo had a significant effect on power output and bar velocity during the bench press exercise. Significant differences were observed between $WGBP_{SLOW}$ and $WGBP_{FAST}$ for MV, PV, between $WGBP_{SLOW}$ and $CGBP_{FAST}$ for PP, MV and MV, as well as between $CGBP_{SLOW}$ and $CGBP_{FAST}$ for MV. Results of the aforementioned comparisons showed that the level of power output and velocity of movement was significantly higher at the fast tempo of movement compared to the slow tempo of movement. Furthermore, no significant differences were found between wide of grip used during the BP with a constant movement tempo.

To date, several studies have confirmed the effect of the movement tempo on the number of repetitions performed, time under tension and exercise volume (Sakamoto & Sinclair, 2006; Wilk et al., 2018a; 2018b; 2018c; 2019a), but the present study is the first one which analysed both the movement tempo and the width grip. Results of the present study are consistent with previous findings of Wilk et al. (2019), who showed increase level of power output and bar velocity during the BP with fast movement tempo compared to slower one. However, compared to the results obtained by Wilk et al. (2019b), presented study do not showed significant changes in MP for all used techniques. Such differences may result from the fact that in presented study subjects consisted of female athletes, while in the study of Wilk et al. (2019b) study participants were males. Gender differences have a significant effect on skeletal muscle morphology and function (Haizlip et al., 2015), as well as on muscle substrate utilization and neuromuscular activation (Hicks et al., 2001). Previous research suggests that the greater strength of men compared to woman is primarily due to greater muscle fibres levels (Miller et al., 1993) and a higher proportion of type I fibres compared to type II (Staron et al., 2000; Roepstroff et al., 2006; Welle et al., 2006). Furthermore, men produce significantly greater strength as well as absolute and relative peak and mean power during the bench press compared to women (Lovell et al., 2011). In the bench press throw, women achieve peak power output at 30-50%, whereas men at 30% (Thomas et al., 2007). Moreover, another study indicated that men achieved higher mean velocity for light loads, whereas women reported higher mean velocity for heavy loads during the BP on a Smith machine (Torrejón et al., 2018). These data suggest that various training strategies should be used in training for men and women to develop power output.

The main factor influencing differences in power output and bar velocity between the applied tempos of movement was the duration of the ECC phase of movement. In the present study, the duration of the ECC phase in the slow tempo of movement was three times longer than for the fast tempo of movement (ECC_{SLOW} - 6s; ECC_{FAST} - 2s). Therefore, longer duration of effort can lead to greater muscle exhaustion and consequently, premature exercise fatigue. Duration of effort also referred to as time under tension, can be an indicator of exercise volume regardless of the number of repetitions performed (Wilk et al., 2018a; 2018b). Three times longer duration of effort during the slow compared to the fast tempo of movement indicates higher exercise volume which is linked to greater energy expenditure during the longer ECC contraction and greater fatigue, what significantly decreases the value of power output and bar velocity during the BP with the slow compared to the fast movement tempo. The higher value of power output and bar velocity during the faster tempo can be related not only to the duration of effort in the ECC phase of movement, but also to a more effective use of elastic energy generated during the faster ECC contraction, which is released during the CON phase of the movement (Newton et al., 1997; Cronin et al., 2001; Cronin & Owen, 2004;). Previous research has shown decreases in power output and velocity when the slower ECC phase was used, what was partially linked to less efficient utilization of the stretch-shortening cycle (Wilk et al., 2019b). Similar relationships were observed when analysing the effects of post-activation potentiation, which was less effective when slow ECC phases were used (Wilk et al., 2019c).

What is important, the present study is the first which in addition to different movement tempos has also considered different grip widths during the BP. Previous research has confirmed that significant differences in the level of power output and velocity of movement depend on the grip width (Lockie et al., 2017a; 2017b). Studies by Lockie et al. (2017a; 2017b) and van den Tillaar (2012) showed that higher values of power output and bar velocity were achieved in the CGBP compared to the TBP, which was not confirmed in our study. Importantly, the present study showed that power output did not depend on the grip width which contradicts the results of Lockie et al. (2017a; 2017b; 2018), who showed that peak power output, peak velocity, and mean velocity were greater for the CGBP compared to the TBP.

CONCLUSION

The present research showed that the type of grip width during the BP was not a factor significantly affecting the level of power output and bar velocity generated in a group of female athletes. Furthermore, it was demonstrated that the movement tempo significantly influenced the efficiency of resistance exercise. In order to develop a high level of power output during CON contractions, one should strive for maximally dynamic performance of the ECC phase. Therefore, the tempo of movement represents a component of resistance training, which should be controlled and taken into consideration during planning and execution of resistance training programs.

AUTHOR CONTRIBUTIONS

Study concept and design: Mariola Gepfert and Aleksandra Filip; Acquisition of data: Mariola Gepfert, Maciej Kostrzewa and Paulina Królikowska; Analysis and interpretation of data: Aleksandra Filip, Grzegorz Hajduk and Robert Trybulski; Writing—original draft: Mariola Gepfert, Aleksandra Filip and Paulina Królikowska; Writing—review and editing: Aleksandra Filip, Mariola Gepfert and Michał Krzysztofik; Supervision: Michał Krzysztofik.

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DISCLOSURE STATEMENT

The authors state that there are no conflicts of interest.

REFERENCES

Amasay, T., Mier, C. M., Foley, K. K., & Carswell T. L. (2016). Gender differences in performance of equivalently loaded push-up and bench press exercises. The Journal of Sport, 5, 4.

Argus, C. K., Gill, N. D., Keogh, J. W. L., & Hopkins, W. G. (2014). Assessing the variation in the load that produces maximal upper-body power. Journal of Strength and Conditioning Research, 28, 240–244. https://doi.org/10.1519/jsc.0b013e318295d1c9

Baker, D., Nance S., & Moore, M. (1995). The load that maximizes the average mechanical power output during explosive bench press throws in highly trained athletes. Journal of Strength and Conditioning Research, 15, 20–24. https://doi.org/10.1519/00124278-200102000-00004

Barnett, C., Kippers, V., & Turner, P. (1995). Effects of variations of the bench press exercise on the EMG activity of five shoulder muscles. Journal of Strength and Conditioning Research, 9, 222–227. https://doi.org/10.1519/00124278-199511000-00003

Bishop, P., Cureton, K., & Collins, M. (1987). Sex difference in muscular strength in equally-trained men and women. Ergonomics, 30, 675–687. https://doi.org/10.1080/00140138708969760

Cronin, J. B., McNair, P. J., & Marshall, R. N. (2001). Magnitude and decay of stretch-induced enhancement of power output. European Journal of Applied Physiology, 84, 575–581. https://doi.org/10.1007/s004210100433

Cronin, J. B., & Hansen, K. T. (2005). Strength and power predictors of sports speed. The Journal of Strength and Conditioning Research, 19, 349–357. https://doi.org/10.1519/00124278-200505000-00019

Cronin, J. B, & Owen, G. J. (2004). Upper-body strength and power assessment in women using a chest pass. Journal of Strength and Conditioning Research, 18, 401–404. https://doi.org/10.1519/00124278-200408000-00001

Gołaś, A., Wilk, M., Stastny, P., Maszczyk, A., Pajerska, K., & Zając, A. (2017). Optimizing Half Squat Post Activation Potential Load In Squat Jump Training For Eliciting Relative Maximal Power In Ski Jumpers. Journal of Strength and Conditioning Research, 31(11), 3010-3017. https://doi.org/10.1519/jsc.0000000000001917

Haizlip, K. M., Harrison, B. C., & Leinwand, L. A. (2015). Sex-based differences in skeletal muscle kinetics and fiber-type composition. Physiology (Bethesda), 30, 30–39. https://doi.org/10.1152/physiol.00024.2014

Hicks, A. L., Kent-Braun, J., & Ditor, D. S. (2001). Sex differences in human skeletal muscle fatigue. Exercise and Sport Sciences Reviews, 29, 109–112. https://doi.org/10.1097/00003677-200107000-00004

Hunter, G. R., Seelhorst, D., & Snyder, S. (2003). Comparison of metabolic and heart rate responses to super slow vs. traditional resistance training. Journal of Strength and Conditioning Research, 17, 76–81. https://doi.org/10.1519/00124278-200302000-00013

Keeler, L. K., Finkelstein, L. H., Miller, W., & Fernhall, B. (2001). Early-phase adaptations of traditional-speed vs. super slow resistance training on strength and aerobic capacity in sedentary individuals. Journal of Strength and Conditioning Research, 15, 309–314. https://doi.org/10.1519/00124278-200108000-00008

Krzysztofik, M., Wilk, M., Golas, A., Lockie, R., G., Maszczyk, A., & Zając, A. (2019). Does Eccentric-Only and Concentric-Only Activation Increase Power Output? Medicine & Science in Sports & Exercise, 16. (Epub ahead of print). https://doi.org/10.1249/mss.0000000000002131

Miller, A. E. J., MacDougall, J. D., Tarnopolsky, M. A., & Sale, D. G. (1993). Gender differences in strength and muscle fiber characteristics. European Journal Applied Physiology and Occupational Physiology, 66, 254 –262. https://doi.org/10.1007/bf00235103

Miller, R. M., Freitas, E. D., Heishman, A. D., Kaur, J., Koziol, K. J., Galletti, B. A., Bemben, M. G. (2019). Maximal power production as a function of sex and training status. Biology of Sport, 36, 31–37. https://doi.org/10.5114/biolsport.2018.78904

Newton, R. U., Murphy, A. J., Humphries, B. J., Wilson, G. J., Kraemer, W. J., & Häkkinen, H. A. (1997). Influence of load and stretch shortening cycle on the kinematics, kinetics and muscle activation that occurs during explosive upper-body movements. European Journal Appllied Physiology and Occupational Physiology, 75, 333–342. https://doi.org/10.1007/s004210050169

Lockie, R. G., Callaghan, S. J., Moreno, M. R., Risso, F. G., Liu, T. M., Stage, A. A., Birmingham-Babauta, S. A., Stokes, J. J., Giuliano, D. V., Lazar, A., Davis, D. L., & Orjalo, A. J. (2017a). An investigation

of the mechanics and sticking region of a one-repetition maximum close-grip bench press versus the traditional bench press. Sports (Basel), 5, 46. https://doi.org/10.3390/sports5030046
Lockie, R. G., Callaghan, S. J., Moreno, M. R., Risso, F. G., Liu, T. M., Stage, A. A., Birmingham-Babauta, S. A., Stokes, J. J., Giuliano, D. V., Lazar, A., Davis, D. L., & Orjalo, A. J. (2017b). Relationships between mechanical variables in the traditional and close-grip bench press. Journal of Human Kinetics, 60, 19–28. https://doi.org/10.1515/hukin-2017-0109
Lockie, R. G., Callaghan, S. J., Orjalo, A. J., & Moreno, M. R. (2018). Loading range for the development of peak power in the close-grip bench press versus the traditional bench press. Sports (Basel), 6, 97. https://doi.org/10.3390/sports6030097
Lovell, D., Mason, D., Delphinus, E., Eagles, A., Shewrins, S., & McLellan, C. (2011). Does upper body strength and power influence upper body performance in men and women? International Journal of Sports Medicine, 32, 771–775. https://doi.org/10.1055/s-0031-1277206
Roepstorff, C., Donsmark, M., Thiele, M., Vistisen, B., Stewart, G., Vissing, K., Schjerling, P., Hardie, D. G., Galbo, H., & Kiens, B. (2006). Sex differences in hormone-sensitive lipase expression, activity, and phosphorylation in skeletal muscle at rest and during exercise. American Journal of Physiology Endocrinology and Metabolism, 291, E1106–14. https://doi.org/10.1152/ajpendo.00097.2006
Saeterbakken, A. H., Mo, D. A., Scott, S., & Andersen, V. (2017). The effects of bench press variations in competitive athletes on muscle activity and performance. Journal of Human Kinetics, 57, 61–71. https://doi.org/10.1515/hukin-2017-0047
Sakamoto, A., & Sinclair, P. J. (2006). Effect of movement velocity on the relationship between training load and the number of repetitions of bench press. Journal of Strength and Conditioning Research, 20, 523–527. https://doi.org/10.1519/00124278-200608000-00011
Staron, R. S., Hagerman, F. C., Hikida, R. S., Murray, T. F., Hostler, D. P., Crill, M. T., Ragg, K. E., & Toma, K. (2000). Fiber type composition of the vastus lateralis muscle of young men and women. The Journal of Histochemistry and Cytochemistry: Official Journal of the Histochemistry Society, 48, 623–629. https://doi.org/10.1177/002215540004800506
Stock, M. S., Beck, T. W., Defreitas, J. M., & Dillon, M. A. (2010). Relationships among peak power output, peak bar velocity, and mechanomyographic amplitude during the free-weight bench press exercise. Journal of Sports Sciences, 28, 1309–1317. https://doi.org/10.1080/02640414.2010.499440
Thomas, G. A., Kraemer, W. J., Spiering, B. A., Volek, J. S., Anderson, J. M., & Maresh, C. M. (2007). Maximal power at different percentages of one repetition maximum: Influence of resistance and gender. Journal of Strength and Conditioning Research, 21, 336 342. https://doi.org/10.1519/00124278-200705000-00008
Torrejón, A., Balsalobre-Fernández, C., Haff, G. G., & García-Ramos, A. (2018). The load-velocity profile differs more between men and women than between individuals with different strength levels. Sports Biomechanics, 18, 245–255. https://doi.org/10.1080/14763141.2018.1433872
Van den Tillaar, R., Saeterbakken, A. H., & Ettema, G. (2012). Is the occurrence of the sticking region the result of diminishing potentiation in bench press? Journal of Sports Sciencs, 30, 591–599. https://doi.org/10.1080/02640414.2012.658844
Wagner, L. L., Evans, S. A., Weir, J. P., Housh, T. J., & Johnson, G. O. (1992). The effect of grip width on bench press performance. International Journal of Sport Biomechanics, 8, 1–10. https://doi.org/10.1123/ijsb.8.1.1
Welle, S., Tawil, R., & Thornton, C. A. (2008). Sex-related differences in gene expression in human skeletal muscle. PLoS One, 3, e1385. https://doi.org/10.1371/journal.pone.0001385

Wilk, M., Gepfert, M., Krzysztofik, M., Gołaś, A., Mostowik, A., Maszczyk, A., & Zając, A. (2019a). The Influence of Grip Width on Training Volume During the Bench Press with Different Movement Tempos. Journal of Human Kinetics 68, 49-57. https://doi.org/10.2478/hukin-2019-0055

Wilk, M., Gołaś, A., Krzysztofik, M., & Zając, A. (2019b). The effects of eccentric cadence on power and velocity of the bar during the concentric phase of the bench press movement. Journal of Sports Science and Medicine, 18(2), 191–197.

Wilk, M., Golas, A., Stastny, P., Nawrocka, M., Krzysztofik, M., & Zając, A. (2018a). Does tempo of resistance exercise impact training volume? Journal of Human Kinetics 62, 241–250. https://doi.org/10.2478/hukin-2018-0034

Wilk M, Krzysztofik M, Drozd M, Zając A. (2019c). Changes of power output and velocity during successive sets of the bench press with different duration of eccentric movement. International Journal of Sports Physiology and Performance 8, 1–19. https://doi.org/10.1123/ijspp.2019-0164

Wilk, M., Petr, M., Krzysztofik, M., Zając, A., & Stastny P. (2018b). Endocrine response to high intensity barbell squats performed with constant movement tempo and variable training volume. Neuroendocrinology Letters, 39(4), 342-348.

Wilk, M., Stastny, P., Golas, A., Nawrocka, M., Jelen, K., Zając, A., & Tufano, J. (2018c). Physiological responses to different neuromuscular movement task during eccentric bench press. Neuroendocrinology Letters, 39(1), 10 –107.

Young, K. P., Haff, G. G., Newton, R. U., Gabbett, T. J., & Sheppard, J. M. (2015). Assessment and monitoring of ballistic and maximal upper-body strength qualities in athletes. International Journal of Sports Physiology and Performance, 10, 232–237. https://doi.org/10.1123/ijspp.2014-0073