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The Use of Incremental, Decremental or a Random Order of Loads does not Affect Peak velocity Values during Bench Press Throw Load-Velocity Relationships

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ABSTRACT

The aim of this study was to assess the influence of the load order used (i. e. incremental, decremental or random loads order) during the bench press throw load-velocity profile on peak velocity achieved against four different loads (20–40–60–80% of one repetition maximum [1RM]). Both intraclass correlation coefficient (ICC) and coefficient of variation (CV) were calculated to assess the reliability of the measures. A repeated measures ANOVA was used to assess differences between protocols. A linear regression analysis was performed to assess the load-velocity relationships among the different protocols. Peak velocity showed good to high ICC values independently of the load used (ICC = 0.83–0.92). CV scores showed good reliability (ranging between 2.2 and 6.2 %). No significant differences in peak velocity attained at each load were found between the three testing protocols ($p > 0.05$). In addition, peak velocity at each load was very large to almost perfect, correlated between protocols ($r = 0.790–0.920$). The linear regression model showed a significant relationship between testing protocols ($p < 0.001$; $R^2 = 0.94$). In conclusion, due to some ICC scores below 0.9 and R^2 below 0.95, the indistinct use of different load-order protocols to assess load-velocity relationships in the bench press throw exercise is not recommended.

Introduction

The ability of the neuromuscular system to apply force (F) is considered a crucial factor for athletic performance in many sport disciplines (e. g. tennis, baseball, rugby) [1]. In particular, ballistic performance is determined by the ability to accelerate a mass (e. g. system, implement) as much as possible in a short period of time. This ability is closely related to the athletes' maximal power output [2, 3]. Resistance training is the most effective method to improve muscular force and power production [4]. Specifically, the bench press exercise is one of the most commonly exercises used to increase upper-body strength and power values. Compared to a traditional bench press, the use of a ballistic movement (i. e. bench press throw) caused significantly greater velocities, which is explained by the lack of a deceleration phase of the bar during the

last part of the movement [5, 6]. Due to the continuous acceleration during the whole range of motion, concentric force, power, and muscle activation use to be also greater during ballistic than traditional exercises [5, 6]. As a consequence, several research studies have shown greater improvements in athletic performance after a training intervention based on ballistic vs traditional resistance exercises [6, 7]. Therefore, ballistic exercises are usually recommended by researchers and coaches during training programs aimed at improving muscular power [7].

One of the most important variables influencing the adaptations to resistance programs is training intensity [8]. This training intensity is usually quantified and prescribed based on the individuals' maximal dynamic strength, represented by the one repetition maximum (1RM) [9]. However, in the last years, direct 1RM assessment

has lessened some popularity in favor of 1RM prediction, which is calculated based on the well-established load-velocity relationship [10, 11]. The aim of measuring movement velocity against a sub-maximal load is not only to predict 1RM, but to assess the load-velocity relationships, and to monitor within-session training intensity (e. g. velocity losses) [11]. This load-velocity assessment also allows researchers to identify different performance characteristics and may detect individual qualities (e. g. maximum and relative strength) and weakness areas (e. g. strength deficits) that can be used as indicators of athletic performance [12]. The assessment of the load-velocity relationship requires the athletes to perform a series of maximal intended velocity repetitions in a given exercise (e. g. bench press throw) against different external loads. When using this multiple load approach, most research have used an incremental protocol, where loads are increased on a set-to-set basis [13, 14]. However, other authors have used a decremental protocol [15], or a protocol using a random order of loads [16, 17]. As neuromuscular performance, including rate of force development and maximal power output, may be affected by previous muscle history (i. e. prior sets) [18, 19], the load-velocity assessment could be influenced by the order of the loads used for testing. This may lead to an incorrect interpretation of the load-velocity relationship and the consequent problems in training prescription. However, to date, no studies have investigated the influence of the load order during the protocol of load-velocity relationship on the performance outcomes (i. e. movement velocity). As different loads-order protocols have been employed in different studies [14–16], there is a need to assess whether the results might be affected by the protocol used, and, consequently, whether these results can be interpreted together.

The aim of the present study was thus to compare the effect of the loads order (i. e. incremental, decremental, and randomized) during the load-velocity assessment on the performance outcomes obtained (i. e. peak velocity against the different loads). The authors hypothesized that, the use of a complete and intense warm-up will optimize subsequent performance [20, 21]. Consequently, the authors expect no differences in the peak velocity obtained with the different loads when using either load order.

Materials and Methods

Participants

Seventeen males (age = 22.9 ± 2.9 years; height = 1.77 ± 0.06 m; body mass = 78.2 ± 6.9 kg; bench press 1 repetition maximum (1RM) = 100.0 ± 15.2 kg; 1RM/BM = 1.28 ± 0.16) with at least two years' experience in resistance training took part in the study. To be included in the study, participants had to show a 1RM/BM superior to 1.0 and to be familiarized with the bench press throw exercise. Before participation, each participant provided a signed written informed consent according to the Declaration of Helsinki and approved by the Ethics Committee of the University.

Design

Each participant attended four testing sessions separated by 48 hours each. The first session was used to evaluate the 1RM bench press. During the second, third and fourth sessions, the load-velocity

relationship in the bench press throw exercise was measured, using a different protocol in each session: incremental loads (20, 40, 60, 80 % RM), decremental loads (80, 60, 40, 20 % RM) and randomized loads (60, 20, 40, 80 % RM). The order of the different sessions was randomized.

1RM bench press assessment

The 1RM bench press evaluation started with a general warm-up, including 5 minutes of low-intensity jogging, dynamical stretching and core exercises. Then, participants performed a specific warm-up consisting of a single set of 10 repetitions with absolute loads of 10 and 25 kg. After this specific warm-up, the 1RM test was assessed using a standardized protocol that requires participants to increase the load lifted across attempts until a maximum load is achieved. During these attempts, participants were asked to perform two maximal intended repetitions. The increases in the load mobilized were guided by the proximity to 1RM estimated by the linear position transducer. The maximum number of sets performed to 1RM assessment was five. Interset rest interval was at 3 minutes to avoid the effects of fatigue. The test was performed in a Multipower M953, Technogym, Gambettola, Italy. During each repetition, the participants were instructed to lower the bar until the chest was lightly touched approximately at nipple height, and to perform the concentric phase of the movement as fast as possible. A spotter certified by the NSCA as a strength and conditioning specialist (CSCS) was positioned behind the subjects to ensure safety during the exercise. Bouncing the bar against the chest was not allowed.

Load-velocity relationships

After the same general warm-up performed during the first day, participants performed a specific warm-up consisting of a single set of 8, 6, 4 and 2 repetitions at 20, 40, 60 and 80 % 1RM, respectively. Once this specific warm-up was completed, participants carried out the load-velocity relationship assessment. During this assessment, participants performed three repetitions of the bench press throw exercise against each load (i. e. 20, 40, 60 and 80 % 1RM) (adapted from García-Ramos and Jaric [22]) with a 3-minute rest interval between sets. During this protocol, a linear position transducer (Speed4Lift) was attached to the bar and was used to record the kinematic data. The validity and reliability of this linear position transducer has been previously published during a concentric-only bench press exercise [23]. However, the reliability of this device has been shown to be lower during other exercises (e. g. squat and hip thrust) [24]. Therefore, its reliability should be studied further. The peak velocity (PV) of each repetition was recorded, using the highest value at each load for further the analysis. PV was used because previous research have shown this variable as a variable showing the lowest within-subjects variability (e. g. coefficient of variation [CV]) [25]. Further, Pestaña-Melero et al. [26] suggested that, in particular, PV should be reported when assessing ballistic performance.

Statistical analysis

Data were analyzed using the statistical package SPSS 25.0 (IBM). To assess relative reliability, intraclass correlation coefficients (ICCs) were calculated, while absolute reliability was calculated using the

CV. The 95 % confidence intervals were also included. ICC values between 0.8 and 0.9 were considered as good, and above 0.9 as high [27]. After confirming data normality through the Shapiro-Wilk test, a repeated measures ANOVA was used to compare PV values between the three different protocols used. Statistical significance was established at $p < 0.05$. Pearson's r correlation coefficients were calculated to assess the relationships between the PV attained at each load during the three protocols and interpreted as good (0.8–0.9) and high (> 0.9) [27]. Finally, linear regressions were used to analyze the load-velocity relationship for each subject.

Results

Reliability data are shown in ► **Table 1**. Both relative (ICC) and absolute (CV) scores showed good to high reliability scores.

The levels of association of PV achieved at each load between the different protocols used are shown in ► **Table 2**. All variables showed a good-to-high (from 0.80 to 0.92) significant relationship.

The data of PV with the different loads during the three different protocols are shown in ► **Fig. 1**. No significant main effect of the protocol was found at 20 % 1RM ($p = 0.113$), 40 % 1RM ($p = 0.529$), 60 % 1RM ($p = 0.458$) or 80 % 1RM ($p = 0.553$).

Finally, the linear regression model showed a significant relationship ($p < 0.001$; $R^2 = 0.94$) between the individual load-velocity profiles obtained through the different testing protocols.

Discussion

The aim of the present study was to assess the influence of the loads order during the evaluation of the load-velocity relationships on the peak velocity obtained against different loads. The main finding of the study was that peak velocity values obtained against four different loads (20–40–60–80 % 1RM) did not significantly differ between protocols using an incremental, decremental or a randomized order of loads. In addition, reliability analysis showed good-to-high ICC scores and good CV values. Peak velocity values during

the three different protocols against all loads also showed a good-to-high correlation.

With the aim of optimizing training strategies and monitoring performance adaptations, it is necessary to implement reliable tests [28]. In this vein, the load-velocity relationship in the bench press throw exercise had previously shown good-to-high reliability scores when using an incremental loads protocol (ICC = 0.86 to 0.93; CV = 1.80 to 3.55 %) [25], but low reliability values were found when using randomized loads protocol (ICC = 0.55 to 0.81; CV = 7.68 to 10.98 %) [29]. Cuevas-Aburto et al. [29] showed acceptable reliability only with light to moderate loads, while the ICC values for heavy loads were below 0.7. Although showing better reliability scores, the present study also reports that absolute reliability is greater with lower loads (i. e. CV = 2.2 and 6.2 % at 20 and 80 % 1RM, respectively). As a result, strength and conditioning coaches should be aware of this slightly worse reliability scores when using heavy loads. To the best of the authors' knowledge, only Alcazar et al. [15] have used a decremental loads protocol, providing results that were not significantly different than an incremental protocol (CV < 5 %). The results of the present study expand on these previous findings, as the good-to-high values of ICC and the good CV values suggested that load-velocity relationship is reliable even with protocols using incremental, decremental or randomized loads order. Although speculative, it can be suggested that the considerably intense warm-up protocol used in the present study, where all the loads used for testing were also used to warm-up, is responsible for the good-to-high reliability scores shown independently of the protocol used. In addition, correlation analysis of the PV values obtained against different loads between the different protocols also showed a good-to-high relationship (r ranged from 0.80 to 0.92; see ► **Table 2**). However, due to the magnitude of within-subjects variation between protocols, especially with heavy loads (i. e. CV values), it is recommended to keep constant the protocol used to assess the load-velocity relationships. The consistency in the protocol used should lead to better reliability scores, helping coaches to track performance changes over time.

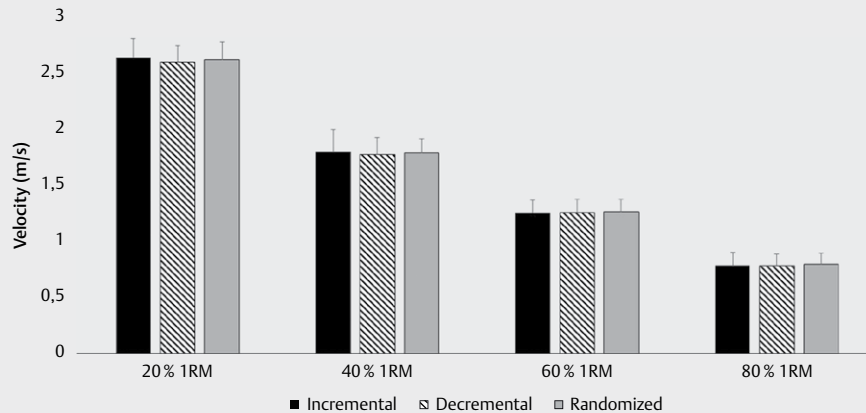
The repeated measures ANOVA showed a non-significant effect of the protocol on the PV values achieved against the range of loads used in the study (see ► **Fig. 1**). These results confirm that the load-velocity profile assessment is not affected by the order of the loads used in the testing protocol. Despite previous research showing that neuromuscular performance (e. g. movement velocity, power output) can be affected by previous muscle history (i. e. prior sets) [30], the present study suggested that this is not the case in the load-velocity assessment. It can be argued that the relative low volume of repetitions performed during the protocol is not enough to provide an optimal stimulus for a post-activation performance enhancement [29]. Further, post-activation performance enhancements usually take place after long resting periods (e. g. 8 minutes) following the conditioning activity. As the load-velocity relationship assessment used a 3-minute rest between attempts, it can also be suggested that this short time does not allow to maximize performance enhancements caused by the previous activity [30]. As a result, due to the specific characteristics of the protocol used for the load-velocity profile, including low repetitions volume and short between-effort rest intervals, potential performance en-

► **Table 1** Reliability of peak velocity at each percentage of 1RM.

	ICC	CV (%)
PV 20 % 1RM	0.88	6.3
PV 40 % 1RM	0.87	6.0
PV 60 % 1RM	0.77	10.1
PV 80 % 1RM	0.84	13.6

► **Table 2** Correlations between peak velocity at each percentage of 1RM for all protocols.

	Incremental with Decremental	Incremental with Randomized	Decremental with Randomized
PV 20 % 1RM	.891 **	.886 **	.839 **
PV 40 % 1RM	.907 **	.901 **	.890 **
PV 60 % 1RM	.854 **	.868 **	.910 **
PV 80 % 1RM	.729 **	.863 **	.785 **
** = significant correlation ($p < 0.001$)			



► **Fig. 1** Peak velocity data with the different loads during the incremental, decremental and randomized loads-order protocols.

► **Table 3** Linear regression analysis obtained from the individual load-velocity profiles using the different loads-order protocols.

	Estimate	SE	95% Confidence Interval		p-value
			Lower	Upper	
Intercept	3.107	0.029	3.051+	3.163	<.001
%RM	-0.030	0.000	-0.031	-0.029	<.001
Equation: $Y = 3.107 - 0.03b$					

hancements derived from previous muscle history are negligible. In addition, these protocol characteristics aid in avoiding potential performance decrements caused by neuromuscular fatigue. Finally, the regression model analysis showed a significant relationship between the load-velocity profiles obtained through different testing protocols ($R^2 = 0.94$, $p < 0.001$; see ► **Table 3**). Despite this being an acceptable value, it should be highlighted that scores over 0.95 are recommended for considering different protocols interchangeable. Therefore, based on the results of the present study, where some reliability and correlational scores found values below 0.9, and the regression model reported a $R^2 < 0.95$, coaches are encouraged to be consistent with the protocol used during the load-velocity profile assessment.

The present study is not without limitations. The sample size was relatively small, which may have influenced reliability scores. All the results should be interpreted with caution, as they were obtained from the use of a particular linear position transducer, which has previously been considered valid and reliable, but it is not the gold standard device. Finally, the authors speculate about the influence of the comprehensive warm-up protocol used in the study. Further studies should be conducted to elucidate whether different warm-up protocols might influence the load-velocity relationships.

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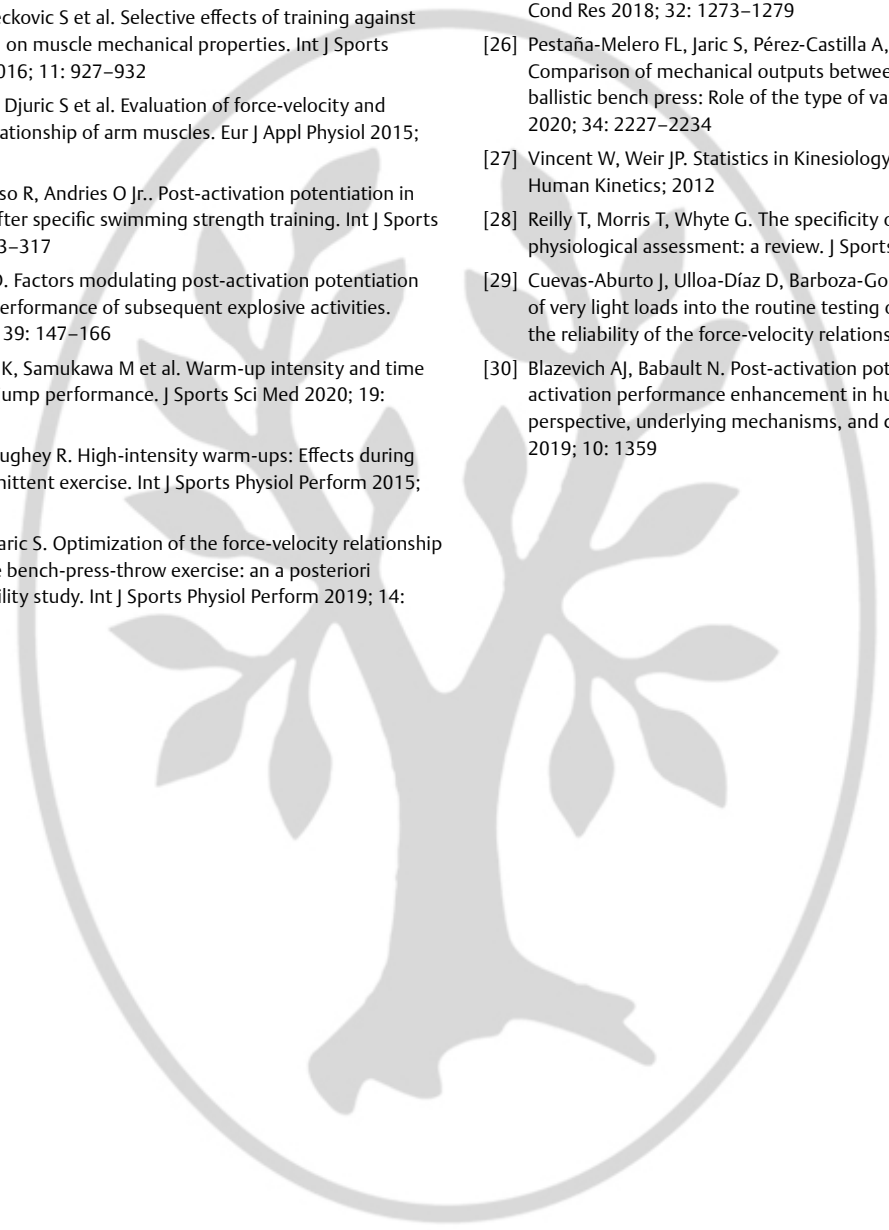
The authors declare that there is no conflict of interest. No funding was received to carry out this study.

Conflict of Interest

The authors declare that they have no conflict of interest.

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