Feasibility of the 2-Point Method for Determining the 1-Repetition Maximum in the Bench Press Exercise


Purpose: This study compared the concurrent validity and reliability of previously proposed generalized group equations for estimating the bench press (BP) 1-repetition maximum (1RM) with the individualized load–velocity relationship modeled with a 2-point method. Methods: Thirty men (BP 1RM relative to body mass: 1.08 [0.18] kg·kg⁻¹) performed 2 incremental loading tests in the concentric-only BP exercise and another 2 in the eccentric–concentric BP exercise to assess their actual 1RM and load–velocity relationships. A high velocity (=1 m·s⁻¹) and a low velocity (=0.5 m·s⁻¹) were selected from their load–velocity relationships to estimate the 1RM from generalized group equations and through an individual linear model obtained from the 2 velocities. Results: The directly measured 1RM was highly correlated with all predicted 1RMs (r = .847–.977). The generalized group equations systematically underestimated the actual 1RM when predicted from the concentric-only BP (P < .001; effect size = 0.15–0.94) but overestimated it when predicted from the eccentric–concentric BP (P < .001; effect size = 0.36–0.98). Conversely, a low systematic bias (range: −2.3 to 0.5 kg) and random errors (range: 3.0–3.8 kg), no heteroscedasticity of errors (r² = .053–.082), and trivial effect size (range: −0.17 to 0.04) were observed when the prediction was based on the 2-point method. Although all examined methods reported the 1RM with high reliability (coefficient of variation ≤ 5.1%; intraclass correlation coefficient ≥ .89), the direct method was the most reliable (coefficient of variation < 2.0%; intraclass correlation coefficient ≥ .98). Conclusions: The quick, fatigue-free, and practical 2-point method was able to predict the BP 1RM with high reliability and practically perfect validity, and therefore, the authors recommend its use over generalized group equations.

Keywords: velocity-based training, load–velocity relationship, maximum strength, validity, reliability

The 1-repetition maximum (1RM) is defined as the maximum load that can be lifted just once in a given exercise.¹ The 1RM is one of the variables most commonly reported to assess the efficacy of various training and rehabilitation interventions as it is considered a valid indicator of maximal dynamic strength.²,³ In addition, the 1RM is considered the main reference for prescribing training loads when constructing resistance training programs.⁴,⁵ However, the direct determination of the 1RM from a single maximal lift has been associated with a number of drawbacks such as that it may increase the risk of injury when performed incorrectly or by novice subjects, is time-consuming and maybe impractical for large groups, and it requires the subjects to be fully motivated to reach their true 1RM.⁵–⁸ Furthermore, as the 1RM can change quickly within a resistance training program (especially in novice athletes), it should be assessed frequently to accurately prescribe the relative load (%1RM).⁹ It should be also noted that the frequent performance of maximal lifts may interfere with the athletes’ training goals. To solve these limitations, a number of indirect methods have been proposed to predict the 1RM.⁶,⁹–¹¹

The indirect method that has received the most attention in recent years is to predict the 1RM based on the load–velocity relationship.⁶,⁸,¹²,¹³ Several studies have reported a strong linear relationship between movement velocity and relative load (%1RM) in a variety of resistance training exercises.⁶,¹⁴–¹⁶ The load–velocity relationship of a given exercise has also proven to be very stable regardless of the 1RM value of the subject.⁶,¹⁷ These results have encouraged researchers to propose a use of “generalized group equations” for different basic resistance training exercises (eg, bench press [BP], bench pull, pull-up, squat, leg press, etc) that predict the 1RM from movement velocity as soon as the first repetition with a given load is performed with maximal voluntary velocity.⁵,¹⁴,¹⁶,¹⁸,¹⁹ The first generalized group equations were proposed by González-Badillo and Sánchez-Medina⁶ for the concentric-only BP exercise. These authors found that mean velocity (MV: average velocity from the first positive velocity until the bar reaches maximum height) and mean propulsive velocity (MPV: average velocity from the first positive velocity until the acceleration of the bar is lower than gravity) variables were able to predict the %1RM with a high degree of precision (r² > .97; standard error of the estimate < 4.0%1RM). However, to the best of our knowledge, the cross-validation of these generalized group equations to other populations still remains to be explored. It is also unknown whether the validity of the proposed generalized group equations may depend on the magnitude of the velocity value used for the prediction, as well as whether these equations could be accurate in other BP variants different from the concentric-only BP (eg, eccentric–concentric BP).

In apparent, opposition to the use of generalized group equations could be the results of recent studies that have shown marked between-subjects differences in force–velocity profiles.²⁰–²² Those results

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suggest that the individual assessment of the load–velocity relationship should be recommended for a more accurate prediction of the 1RM. However, the standard test used to determine the load–velocity relationship is based on multiple external loads (usually between 5 and 9), which may be impractical when undertaken on a daily basis.6,9,14 However, as the load–velocity relationship is fairly linear, the addition of intermediate loads to the 2 more distant loads of the relationship should have trivial effects on the final outcomes of the load–velocity relationship.23,24 In this regard, it would be of importance to explore the feasibility of the 2-point method recently proposed by Jaric25 as a quick, fatigue-free, and practical procedure of predicting the 1RM. The 2-point method may allow for the modeling of the load–velocity relationship from the velocity recorded against just 2 different external loads. Finally, as the velocity of the 1RM is quite stable for a given exercise,6,15–17 the load (kg) linked to the velocity of the 1RM obtained from the individual load–velocity relationship could be regarded as the subject’s 1RM. Therefore, it should be elucidated whether the recently developed 2-point method is able to estimate the BP 1RM with higher precision than the generalized group equations proposed by González-Badillo and Sánchez-Medina.5

To address the discussed points, we determined the load–velocity relationship and the actual 1RM in 2 variants of the BP exercise (concentric-only BP and eccentric–concentric BP). Specifically, the purpose of the present study was to examine the concurrent validity and reliability of the generalized group equations proposed by González-Badillo and Sánchez-Medina6 and of the individualized load–velocity relationships modeled through the 2-point method to estimate the 1RM in the BP exercise. We hypothesized that (1) the 1RM estimated by the 2-point method would present a higher level of agreement with the actual 1RM than the generalized group equations due to the existence of individual load–velocity profiles and (2) the direct method would be the most reliable approach to determine the 1RM.

Methods

Subjects

Thirty men with at least 2 years of resistance training experience volunteered to participate in this study (mean [SD]: age = 21.2 [3.8] y; body mass: 72.3 [7.3] kg; body height = 1.78 [0.07] m; body mass index = 22.8 [1.9] kg·m·m−2; BP 1RM relative to body mass = 1.08 [0.18] kg·kg·m−1). Subjects were instructed to avoid any strenuous exercise 2 days before each testing session. They were informed of the study procedures and signed a written informed consent form prior to initiating the study. The study protocol adhered to the tenets of the Declaration of Helsinki and was approved by the University of Granada institutional review board.

Study Design

A repeated-measures design was used to explore the feasibility of generalized group equations and of the 2-point method for determining BP 1RM. Following 2 familiarization sessions, subjects came to the laboratory on 4 occasions, twice a week, with at least 48 hours of rest between them. The 2 sessions with the same BP variant were performed in the same week. The order of the BP variants was randomized. An incremental loading test following the standard procedure proposed by González-Badillo and Sánchez-Medina6 was used during each testing session to determine the BP 1RM as well as the velocity of the barbell against the different external loads applied during the test. Testing sessions were performed at the same time of the day for each participant (±1 h) and under similar environmental conditions (−22°C and −60% humidity).

Testing Procedure

Each testing session began with a 10-minute standardized warm-up, which included jogging, dynamic stretching, arm and shoulder mobilization, and a set of 5 repetitions performed in an explosive manner with an external load of 17 kg (mass of the unloaded Smith machine barbell) in the tested BP variant. Once the warm-up was completed, subjects rested for 3 minutes, and then a standard procedure was used to determine the BP 1RM.6 The initial external load of the incremental loading test was set at 17 kg and was progressively increased in 10 kg increments until the attained MPV was lower than 0.50 m·s−1. Thereafter, the load was progressively increased in steps of 5 to 1 kg until the actual 1RM was directly determined with the completion of a single maximal lift. Three attempts were executed at each lighter load (MPV > 1.00 m·s−1), 2 for the medium (0.65 m·s−1 ≤ MPV ≤ 1.00 m·s−1), and only 1 for the heavier loads (MPV < 0.65 m·s−1). The average number of sets performed with the heavier loads was 4.2 (1.1) for the concentric-only BP and 3.6 (0.9) for the eccentric–concentric BP. Intraset rest was 10 seconds and interset rest was fixed to 5 minutes. Two trained spotters were present on each side of the barbell to ensure safety and to motivate the subject to lift the barbell at the maximum possible velocity.

Subjects performed the BP using the standard 5-point body contact position technique (head, upper back, and buttocks firmly on the bench with both feet flat on the floor). Subjects self-selected the grip width that was measured and kept constant throughout all testing sessions. The specific characteristics of the 2 BP variants are provided below:

Centeric-Only BP. A mechanical brake was used to hold the bar parallel to the subjects’ nipples just above their sternum (=1–2 cm). From the initial position, subjects lifted the bar as fast as possible until their elbows reached full extension.

Eccentric–Concentric BP. Subjects initiated the task holding the bar with their elbows fully extended. From this position, they were instructed to perform the downward and upward phases of the lifting as fast as possible. The bar was lowered until contacting with the subjects’ chest at the level of the sternum, and the concentric action ended when the subjects’ elbows reached full extension.

Measurement Equipment and Data Analysis

Height (Seca 202; Seca Ltd, Hamburg, Germany) and body mass (Tanita BC-418 MA, Tanita Corp, Tokyo, Japan) were assessed in the first familiarization session. A Smith machine (Technogym, Barcelona, Spain) coupled with a linear velocity transducer (T-Force System; Ergotech, Murcia, Spain), which sampled the velocity of the barbell at a frequency of 1000 Hz was used for all testing sessions. The MV and MPV of all repetitions were recorded. The start of the concentric phase for both BP variants was defined as the onset of positive velocity. The acceleration of the barbell was obtained as a time derivative of the velocity data. MV was calculated as the average velocity from the start of the concentric phase (ie, onset of positive velocity) until the barbell reaches maximum height (ie, zero velocity). MPV was calculated as the average velocity from the start of the concentric phase until the acceleration of the barbell dropped below the gravity (−9.81 m·s−2). Note that when heavy loads are lifted in the BP exercise (≥80%