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ORIGINAL ARTICLE

Prediction of one repetition maximum from the maximum number of repetitions with submaximal loads in recreationally strength-trained men

Prédiction de la charge maximale en musculation chez des sujets non spécialistes à partir du nombre maximal de répétitions pour des charges sous-maximales

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KEYWORDS
Linear models;
Maximal test;
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Summary
Objective. — The objective of the present study was to determine and validate five equations used to estimate the corresponding load to one repetition maximum (1RM) from the maximum number of repetitions (MNR) using submaximal loads in bench press, leg extension, lat machine pulldowns, leg curl and arm curl exercises in recreational strength-trained men.
Methods. — The first test conducted was the 1RM test. Following this, the subjects performed the MNR test using loads at 70, 80 and 90% of 1RM for all exercises on different days. To determine each equation, a multiple linear regression model was used in 20 subjects. Two criteria were considered to accept the equation: the adjusted R^2 value ($adjR^2 > 0.80$) and the percent error (PE < 10%). For the cross-validation process, the 1RM value measured and estimated were compared in 10 subjects via Pearson product-moment correlation coefficients and paired *t*-tests.
Results. — For all exercises, the equations achieved the established criteria, except leg extension ($adjR^2 = 0.76$). During the process of cross-validation, the values predicted by the equations did not differ from the measured values ($P > 0.05$) and showed a high correlation (0.869—0.995).
Conclusions. — It can be concluded that determined equation for bench press, lat machine pulldowns, leg curl and arm curl can be used to predict the 1RM load while the equation determined for leg extension cannot be used.

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MOTS CLÉS
Modèles linéaires ;
Charges
sous-maximales ;
Test maximal

Résumé
Objectif. — L'objectif de cette étude était de déterminer et valider cinq équations pour estimer la charge correspondant à une répétition maximum (1RM) à partir du nombre maximal de répétitions (MRN) réalisées à partir de charges sous-maximales. Les exercices retenus ont été le développé couché, l'extension de jambes, le tirage poitrine (prise large en pronation), la flexion des ischiojambiers et la flexion des biceps chez des sujets non spécialistes de l'entraînement en force.
Méthodes. — Nous avons d'abord déterminé la charge correspondant à une répétition maximale (1RM). Suite à cela, les sujets ont effectué un nombre maximal de répétitions (MRN) pour tous les exercices avec des charges correspondant à 70, 80 et 90 % d'une répétition maximale. Les tests étant réalisés des jours différents. Pour déterminer chaque équation, un modèle de régression linéaire multiple a été utilisé à partir des données de 20 sujets. Deux critères ont été considérés pour accepter l'équation : les valeurs de R^2 ajusté (adjR^2 > 0,80) et le pourcentage d'erreur (PE < 10 %). La méthode de validation croisée, a été appliquée en comparant les valeurs des répétitions maximales effectuées avec les valeurs calculées pour dix sujets. Nous avons utilisé le test de corrélation de Pearson et un test *t* avec appariement.
Résultats. — Toutes les équations utilisées ont été en mesure d'établir la charge maximale à partir du nombre maximal de répétitions, sauf pour l'extension des jambes (adjR^2 = 0,76). Les valeurs prédites par les équations ne diffèrent pas des valeurs mesurées (p > 0,05) et ont montré une forte corrélation (0,869 à 0,995).
Conclusions. — Quatre des cinq équations déterminées (développé couché, tirage poitrine, flexion ischiojambiers et flexion biceps) peuvent être utilisées pour prédire la charge maximale á partir du nombre maximal de répétitions réalisé à des charges sous-maximales.

1. Introduction

The present interest in weight training has encouraged the investigation of effective parameters that can be used for its evaluation and application [1]. The one repetition maximum (1RM) test has been used as both a measure of maximum strength and to develop training programs [2—6]. The correct identification of the exercise intensity (percentage of 1RM) enables to achieve specific adaptations and benefits from weight training [7].

To apply this test, subjects performed a specific warm-up for the exercise to be tested, followed by several trials with the estimated maximum load until failure to properly execute the movement. Typically, the value of 1RM is found between three and six attempts [8—12] and the recovery interval between trials is between three and five minutes [8—10,13]. Thus, for a single exercise, performing this test requires about 30 minutes, which could disturb the routine of training [11]. Consequently, this test is not commonly used in clubs and gyms because of the difficulty to implement it, as it is time-consuming and requires additional personnel to conduct the test.

Due to the difficulty of applying this test, the application of training has been conducted with a predetermined number of repetitions (i.e., 8—12 maximum repetitions) associated with a determined intensity (i.e., approximately 70—90% of 1RM). However, for different muscle groups, a difference is observed in the maximum number of repetitions (MNR) performed using the same relative intensity [3,14]. For example, in the study by Hoeger et al. [3], they related that the subjects performed 19 maximum repetitions in leg press, and seven maximum repetitions in the leg curl with the same relative load (80% 1RM). It is therefore important to develop a way to quantify the maximum load (1RM) without having to apply the test itself. In an attempt to attend this goal, studies were conducted to determine 1RM prediction equations based on different variables [11,13,15]. Notable among these are the anthropometric variables [15], the number of repetitions in exercises with fixed loads [11,16], and the MNR from 1RM percentages [13,17,18].

However, of the studies mentioned above, some equations required that the subject performs less than 10 repetitions to guarantee equation accuracy [9,12,13,19,20]. This small range of allowed repetitions (less than 10MNR) becomes a limitation for the application of these equations. When the subject exceeds that limit (10MNR), it is necessary to repeat the test so that accuracy is not compromised. Additionally, there are studies that used a fixed load (225 pounds for bench press), which is very high for non-athletes [10,12,16]. However, many of these equations are worth using because they only need to record the number of repetitions and the load used. Furthermore, basically the bench press has been explored [2,18], and it is known that the equations developed for a single exercise are not valid for other exercises [8,11]. Thus, it would be important to have an equation to predict the 1RM load for exercises related to each major muscle group. This possibility would allow the professional monitoring of training and to use the correct intensity according to the person's objective. Based on the limitations presented in the studies cited above, and considering the absence of specific equations for different exercises, some additional studies are needed to improve the evaluation and application of strength training in training program to improve physical fitness.