


BODY MASS TO PREDICT 4-6 RM OF PECTORAL AND LEG MUSCLES EXERCISES IN BODYBUILDERS


PREDIÇÃO DE 4-6 RM DE EXERCÍCIOS DE PERNA E PEITORAL PELA MASSA CORPORAL


PREDICCIÓN DE 4-6 RM DE EJERCICIOS DE PIERNAS Y PECTORALES POR MASA CORPORAL


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ABSTRACT

Introduction: Submaximal strength testing appears to be valid to prescribe the intensity for strength training protocols that reduce the risk of injuries and testing time. **Objective:** This study aimed to assess the predictive ability of body mass parameters to estimate 4-6 repetitions maximum (4-6 RM) of Leg press 45°, Chest press, and Pull-down exercises. **Methods:** Eleven male bodybuilders (age 38.27 ± 10.48 years) participated in this study. Participants completed an incremental external load up to find the load allowing them to perform 4 to 6 maximal repetitions for each exercise in random order. The starting load was 50% of body mass for chest press and pull-down exercises and 100% for leg press. The load increment after each set was 20 kg for lower limb exercises and 10 kg for upper body exercises. **Results:** Results revealed that body mass had good to optimal relationships with 4-6 RM for all three exercises. Results showed that body mass had a good prediction ability for all three criterion measures. **Conclusion:** The prediction equations suggested in this study may allow coaches to estimate the 4-6 RM of leg press 45°, chest press, and pull-down performances. **Evidence Level IV; Case series.**

Keywords: Predictions and Projections; Muscle Strength; Body Weight.

RESUMO

Introdução: O teste de força submáxima parece ser válido para prescrever a intensidade nos protocolos de treinamento de força, reduzindo o risco de lesões e duração dos testes. **Objetivo:** Avaliar a capacidade preditiva dos parâmetros de massa corporal para estimar o exercício de 4-6 repetições máximas (4-6 RM) nos exercícios de Leg press 45°, Chest press e Pull-down efetuados por fisiculturistas. **Métodos:** Onze fisiculturistas masculinos (38,27 ± 10,48 anos) participaram do estudo. Eles completaram a carga externa incremental até encontrar a carga que lhes permitia realizar de 4 a 6 repetições máximas para cada exercício, em ordem aleatória. A carga inicial foi fixada em 50% da massa corporal para os exercícios de Chest press e Pull-down, e 100% para o de Leg press. O incremento de carga após cada rodada foi de 20 kg para o exercício de membros inferiores e 10 kg em membros superiores. **Resultados:** Os resultados revelaram que a massa corporal apresenta relações satisfatórias com 4-6 RM para todos os três exercícios. Os resultados mostraram que a massa corporal possui boa capacidade preditiva em todas as três medidas. **Conclusão:** As equações de previsão sugeridas nesse estudo podem permitir o uso desses exercícios pelos técnicos para medir a performance a 4-6 RM nos exercícios de Leg press 45°, Chest press, e Pull-down. **Nível de evidência IV; série de casos.**

Descritores: Modelos de Predição; Força muscular; Peso Corporal.

RESUMEN

Introducción: El test de fuerza submáxima parece ser válido para prescribir la intensidad en protocolos de entrenamiento de fuerza, reduciendo el riesgo de lesiones y la duración del test. **Objetivo:** Evaluar la capacidad predictiva de los parámetros de masa corporal para estimar 4-6 repeticiones máximas (4-6 RM) de ejercicios de Leg press 45°, Chest press y Pull-down realizados por fisoculturistas. **Métodos:** Once fisoculturistas masculinos (38,27 ± 10,48 años) participaron en el estudio. Completaron la carga externa incremental hasta encontrar la carga que les permitiera realizar de 4 a 6 repeticiones máximas para cada ejercicio, en orden aleatorio. La carga inicial se fijó en el 50% de la masa corporal para los ejercicios Chest press y Pull-down, y en el 100% para los ejercicios Leg press. El incremento de carga después de cada ronda fue de 20 kg para los miembros inferiores y 10 kg para los miembros superiores. **Resultados:** Los resultados revelaron que la masa corporal tiene relaciones satisfactorias con 4-6 RM para los tres ejercicios. Los resultados mostraron que la masa corporal tiene una buena capacidad predictiva en las tres medidas. **Conclusión:** Las ecuaciones de predicción sugeridas en este estudio pueden permitir a los entrenadores utilizar estos ejercicios para medir el rendimiento a 4-6 RM en ejercicios de Leg press 45°, Chest press y Pull-down. **Nivel de Evidencia IV; serie de casos.**

Descriptorios: Modelos Predictivos; Fuerza Muscular; Peso Corporal.

INTRODUCTION

One-repetition maximum (1-RM) is regarded as a popular test commonly used for muscular testing and conditioning¹ since it is considered a valid indicator of maximal dynamic strength,^{2,3} defined as the maximal weight that an individual can lift with a single repetition.⁴ Chest press and Pull-down for upper body,⁵ and Leg press 45° for lower body,^{6,7} are considered the best exercises to assess the muscle strength in a bodybuilders population. In addition, the 1-RM is considered the primary reference for determining baseline measurements and prescribing training loads when constructing resistance training programs for recreational and professional athletes and especially for individuals who intend to undertake resistance training for the first time.^{3,8} However, the direct determination of the 1-RM from a single maximal lift has been associated with a number of drawbacks. When performed incorrectly or by novice subjects, it may increase the risk of injury, be time-consuming, and be impractical for large groups.^{9,10} Additionally, to obtain an accurate 1-RM, several familiarization and testing sessions for each exercise are needed to establish whether a change occurred due to learning or training.¹¹

Several equations that rely on linear regression modeling are developed to calculate 1-RM indirectly.^{12,13} These prediction equations are derived from multiple repetition maximum or maximal weight that an individual can lift over a specified number of repetitions.¹⁴ The number of repetitions shouldn't exceed more than ten as prediction equations are more accurate when heavier loads are used.¹³ While multiple repetition maximum involves lifting high relative loads during the fatigued state, 4-6 RM or 7-10 RM submaximal strength assessment appears to be valid for prescribing intensity in strength training protocols¹⁵ with no reported symptoms of post-exercise delayed onset of muscle soreness.¹⁶

Recent literature has shown that anthropometric measures can predict 1-RM loads.¹⁷⁻²¹ The body mass routinely used to predict pectoral machine and leg press, particularly correlated to 1-RM performance.^{19,22} It is possible that greater accuracy can be achieved by using a submaximal strength test combined with anthropometric measurements to estimate 1-RM. It should be noted that Whisenant et al.²³ restricted anthropometric measurements to the body height and body mass, which limited their evaluation of the ability of anthropometric measures to reduce prediction error. This seems surprising based on the findings of previous studies showing relatively strong relationships between body mass variables and the expression of strength.^{19,20} Coaches and individuals interested in 'athletes' body strength evaluation^{24,25} may benefit from a reasonably accurate conversion of body mass to estimates of %RM strength exercises, especially for bodybuilders. Bodybuilders are a specific population of athletes whose ultimate goal is to achieve a large muscle mass (MM) with low quantities of fat mass (FM).²⁶ Elevated quantities of fat-free mass (FFM) are crucial in physique sports like bodybuilding, and absolute levels of FFM/MM may be the most significant anthropometric determinant of maximal strength.¹⁹ Although investigations that deal with anthropometric measurement and strength tests to estimate %RM in different sports exist,^{19,20} the efficacy of this approach in bodybuilding is unknown.

Therefore, the purpose of the present study was to examine the predictive ability of body mass to estimate the 4-6 RM in the leg press 45°, chest press, and pull-down exercises. We hypothesized that body mass would explain significant amount of variance in performance for all three exercises at submaximal loads.

MATERIALS AND METHODS

Participants

Eleven senior male bodybuilding voluntarily participated in this study. The participant's body measurements and characteristics are shown in Table 1. All participants had at least ten years of bodybuilding practice,

Table 1. 'Participants' body measurements and characteristics.

Sample size (n =11)	Mean±SD
Age (years)	38.27±10.48
Body mass (kg)	80.05±8.08
Height (m)	1.76±0.08
BMI (kg/m ²)	25.71±0.64
Training experience (years)	16.55±8.18

Note. BMI=Body mass index.

with ~15 training sessions per week routine. Twenty-four hours before and during the study period, participants were asked to avoid medication, alcohol, drugs, and dietary supplements consumption to reduce any interference in the testing. Participants were also free from any injury or pain that would have prevented maximal effort during testing. They all gave their written informed consent to participate in the study after a thorough explanation of the 'study's protocol. The protocol conformed to internationally accepted policy statements regarding the use of human participants in accordance with the Declaration of Helsinki and was approved by the 'Ovidius University's Ethics Committee (292/2021).

Procedures

Body mass was measured using a portable digital scale (Tanita body fat analyzer, model TBF 105) with ± 0.1 kg precision, while body height was measured with an accuracy of one millimeter (Harpden Portable Stadiometer 603 VR, Holtain LTD, Crosswell, UK). Body mass index (BMI) was calculated using the equation: body weight (kg) / [body height (m)]². To determine 4-6 RM for each exercise, participants were evaluated starting with an initial load of 100% body mass for leg press 45° and 50% body mass for chest press and pull-down exercise. When the participant performed 12 repetitions, each exercise was interrupted, and after 5 min of passive rest, the external load of the exercises was increased. The increased load was 20 kg for leg press exercises and 10 kg for chest press and pull-down exercises. According to the protocol described by Brzycki,²⁷ the participants concluded the tests when they reached a maximum number of repetitions ranging between 4 and 6 for each exercise. The load with which the participants were able to perform 4 to 6 correct and complete repetitions was considered 4-6 RM and used for further statistical analyses.

The participants were instructed and supervised by the same assessor who had at least ten years of experience in exercise testing during the testing sessions. Furthermore, before each testing session, the participants performed ~15 min of a warm-up, including circumduction, adduction/abduction, and flexion/extension exercises of the upper and lower limbs with self-selected intensity and dynamic stretching. After the warm-up, the participants rested for ~5 minutes. The participants were asked to avoid any intense effort (i.e., the rate of perceived exertion was less than <6.5/10) in the 72 hours preceding the study. All sessions were performed in the morning to avoid any circadian variations, starting at around 10 am.

Statistical analysis

Data analyses were performed using SPSS version 23.0 for Windows (SPSS, Inc. Chicago, IL, USA). As all variables followed a Gaussian distribution (Kolmogorov– Smirnov test), results were presented as mean ± standard deviation (SD). The Pearson's product-moment correlation coefficient (*r*) and the determination coefficient (*r*²) were used to evaluate the possible correlation between 4-6 RM and body mass for each exercise. For the interpretation of the magnitude of the correlations, the following scale was used:²⁸ trivial (< 0.1), small (0.1-0.3), moderate (0.3-0.5), high (0.5-0.7), very high (0.7-0.9), or almost perfect (> 0.9). The equations and the standard error of estimate (SEE) to predict the 4-6 RM

loads by BM for each exercise were determined using the coefficients obtained by linear regression analyses (LRA). Cohen's f^2 was also calculated as a quantitative measure of the magnitude of the experimental effect (effect size). The following scale was used for the interpretation of the f^2 : small (f^2 0.02), medium (f^2 0.15), and large effect size (f^2 0.35). Finally, the 1-RM of the three exercises was estimated using 4-6 RM load and the respective number of repetitions via Brzycki equation:²⁷ $Lifted\ load \div (1.0278 - (0.0278 \times number\ of\ repetitions))$.

RESULTS

Leg press

The estimated 4-6-RM for the leg press ranged from 270 to 400 kg (324.55 ± 44.80 kg). The results for the leg press indicated that the correlation between body mass and 4-6 RM (Figure 1A) was almost perfect ($r = 0.92$; $r^2 = 84.1\%$; $f^2 = 5.3$).

Using the intercept and slope values of the LRA, it was possible to compute the following equation:

$$4-6\ RM\ (kg)\ for\ Leg\ press = 5.08 \times body\ mass\ (kg) - 82.41$$

$$SEE = 18.81\ kg$$

The estimated 1-RM for the leg press ranged from 295 to 450 kg (364.55 ± 52.56 kg).

Chest press

The 4-6 RM for the chest press exercise ranged from 90 to 150 kg (114.55 ± 16.35 kg). The results indicated that the correlation between body mass and 4-6 RM (Figure 1B) was very high ($r = 0.72$; $r^2 = 51.2\%$; $f^2 = 1.05$).

Using the intercept and slope values of the LRA, it was possible to compute the following equation:

$$4-6\ RM\ (kg)\ for\ Chest\ press = 1.45 \times body\ mass\ (kg) - 1.32$$

$$SEE = 12.03\ kg$$

The estimated 1-RM for the chest press ranged from 98 to 164 kg (125.82 ± 17.92 kg).

Pull-down

The 4-6 RM for the pull-down ranged from 110 to 150 kg (127.73 ± 14.21 kg). The results indicated that the correlation between body mass and 4-6 RM (Figure 1C) was very high ($r = 0.89$; $r^2 = 78.4\%$; $f^2 = 3.63$).

Using the intercept and slope values of the LRA, it was possible to compute the following equation:

$$4-6\ RM\ (kg)\ for\ Pull-down = 1.56 \times body\ mass\ (kg) + 3.17$$

$$SEE = 6.96\ kg$$

The estimated 1-RM for the pull-down ranged from 123 to 169 kg (141.31 ± 15.38 kg).

The scatter plot of the correlation between body mass and 4-6 RM for each exercise is presented in Figure 1. Body mass had very high to almost perfect correlations with 4-6 RM load in all three exercises (leg-press 45°: $r = 0.92$, chest-press: $r = 0.72$, pull down: $r = 0.89$) exercises.

DISCUSSION

This study was designed to explore the feasibility of individualized body mass parameters for determining the 4-6 RM in the leg-press 45°, chest press, and pull-down exercises. Results revealed that body mass had significant correlations with 4-6 RM (range from "very high" to "almost perfect"). Moreover, body mass was a good predictor to estimate 4-6 RM in all three exercises.

Other studies found similar relationships between body mass and bench press 1-RM loads in male powerlifters ($r = 0.49$).¹⁹ Authors conclude that muscle thickness and body mass are the best predictors of strength in upper and lower limbs.^{19,20} Moreover, similar correlations between body mass and bench press 1-RM load were obtained in college football players (r ranged from 0.53 to 0.61).^{29,30} Thus, our results are in line with previous investigations indicating that male athletes routinely demonstrate upper and lower strength, namely that body mass acts as a strong correlate to this criterion. However, it is important to note that, unlike body mass and 1-RM% relationships in the current and previous studies,^{19,20,29} recent findings showed body mass inclusion as an additional independent variable could improve the prediction capacity of multivariate analyses.^{20,22,29} Thus, the inclusion of body mass as a predictor variable is an excellent way to explain the criterion variance because initial determination for submaximal exercises performance (i.e., 4-6 RM) and body mass were good ($r^2 = 51 - 84\%$).^{20,22,29}

Previous studies showed that body composition could increase the amount of explained 4-6 RM variance.^{19,22} For instance, to improve performance, American football athletes in certain playing positions slowly raise their body weight in order to yield higher relative gains in fat mass than fat free mass.^{21,30} Such practices skew body mass 1-RM relationships, as athletes become heavier but not necessarily stronger.³⁰ This, in part, accounts for the inability of body mass to increase the amount of explained variance.³⁰ Mayhew et al.,²³ whose sample was comprised solely of American football players, found out that the poorest relative bench press efforts came from individuals with the higher body mass and fat percentage. High muscle mass (MM) and low fat mass (FM) is even more pronounced in bodybuilders, and indeed assertion of MM improves 1-RM loads. Previous studies confirm a poor relationship between body mass and 1-RM when individuals with high FM are included in testing protocols.^{19,20,30}

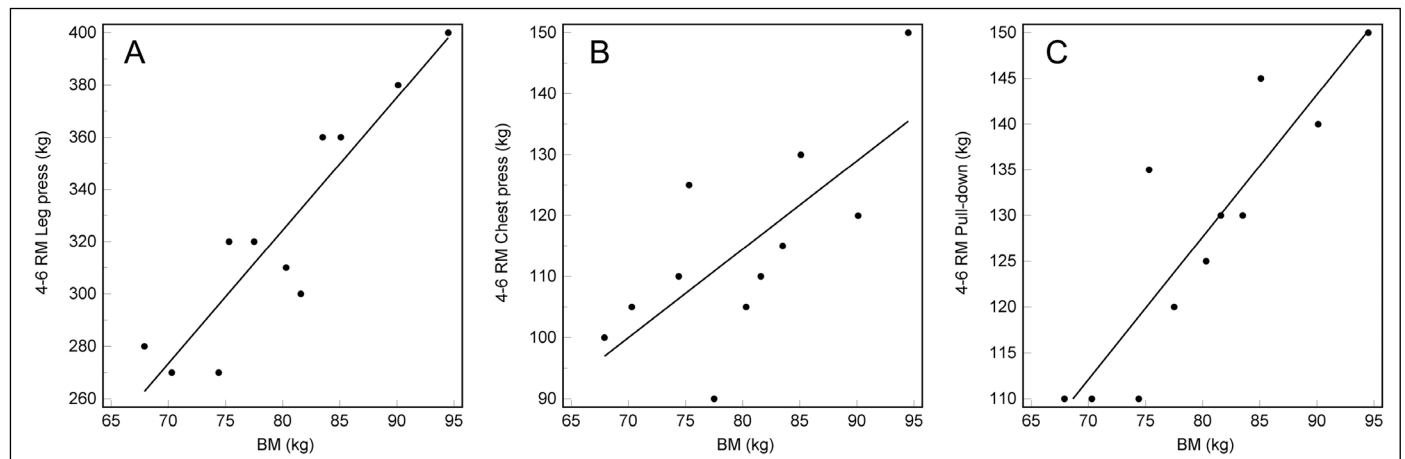


Figure 1. Correlation between body mass (BM) and 4-6 RM on Leg Press (A), Chest Press (B), and Pull-down (C).

CONCLUSION

The prediction equations suggested in this study may allow coaches to use these exercises to measure the 4-6 RM performances, corrected by the following linear regression equation specific for each modality of exercises:

- Leg-press 45° 4-6 RM (kg) = 5.08 × body mass - 82.41
- Chest press 4-6 RM (kg) = 1.45 × body mass - 1.32
- Pull down 4-6 RM (kg) = 1.56 × body mass + 3.17

Knowing the maximum capabilities of athletes is essential to develop and implement a good training process, which is both safe and effective. Future investigations should focus on expanding the range of tested exercises in a different population of athletes and non-athletes. Identifying anthropometric variables that have excellent ability to estimate multiple repetition maximum should be helpful in creating strength and conditioning programs.

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