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PREDICTION OF ONE REPETITION MAXIMUM (1-RM) STRENGTH FROM A 4-6 RM AND A 7-10 RM SUBMAXIMAL STRENGTH TEST IN HEALTHY YOUNG ADULT MALES

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ABSTRACT

PREDICTION OF ONE REPETITION MAXIMUM (1-RM) STRENGTH FROM A 4-6 RM AND A 7-10 RM SUBMAXIMAL STRENGTH TEST IN HEALTHY YOUNG ADULT MALES. **Paula Dohoney, Joseph A. Chromiak, Derek Lemire, Ben R. Abadie AND Christopher Kovacs**. **JEPonline**. 2002;5(3):54-59. The purpose of this investigation was to determine if 1-RM strength could be predicted from a 4-6 RM submaximal strength test with a greater accuracy than the commonly used 7-10 submaximal strength test. Thirty-four healthy males between the ages of 19 and 32 participated in this study. Subjects completed 1-RM, 4-6 RM, and 7-10 RM strength assessments in random order with a minimum of 48 hours between each strength assessment. During each session, subjects performed strength assessments for the bench press, incline press, triceps extension, biceps curl, and leg extension. Multiple regression analysis was used to produce equations for predicting 1-RM strength from 4 to 6 or 7 to 10 repetition maximum tests. The 4-6 RM prediction equations improved the predictive accuracy of 1-RM strength compared to the 7-10 RM prediction equations based on the adjusted R^2 and standard error of estimate. Since no injuries or symptoms of delayed onset of muscle soreness were reported during either the 7-10 RM or the 4-6 RM submaximal strength assessments, the results of this study indicate that when attempting to predict 1-RM strength in healthy, young, males, a 4-6 RM submaximal strength assessment appears to be the more accurate test.

Key Words: One repetition maximum (1-RM), Strength prediction, Submaximal strength.

INTRODUCTION

Weight training is recommended by allied health professionals to enhance physical fitness and overall health (1). However, the methods for testing strength have become increasingly more sophisticated (2). Many studies have been conducted to produce regression equations for predicting 1-RM strength, while other studies have been undertaken to determine the accuracy of such equations. Several studies have extended research in this area by further investigating such aspects as: (a) the predictive accuracy of regression equations with untrained and technique-trained subjects (3,4,5,6), (b) differences in various groups of male subjects (7), (c) differences in male and female performance (8,9,10), (d) the relationship between performances using different types of resistance training equipment and types of strength exercises (11,12), and (e) the validity of repetitions -to-fatigue equations for older adults (13,14,15).

In order to prescribe weight-training programs for a novice weight lifters, an exercise specialist typically determines an individual's maximum lifting capacity. This weight is the maximal amount of weight that can be lifted only one time, and is referred to as the one-repetition maximum (1-RM). Since muscular strength varies depending on the muscle groups involved and the type of lift employed (e.g., bench press, biceps curl), maximal lifting capacity must be assessed for each prescribed exercise. It has been suggested that novice lifters not perform a 1-RM strength assessment, because lifting maximal weight by individuals not accustomed to weight training may induce muscle soreness and increase the risk of more serious muscular injury (6).

In order to minimize the risk of strength assessment, regression equations have been developed to predict 1-RM strength for larger muscle mass exercises for male subjects (16). Prediction of 1-RM strength allows an exercise specialist to assess an individual's maximal lifting capacity without subjecting the novice lifter to the increased risk associated with a 1-RM lift. The majority of studies that have reported prediction equations for 1-RM strength used a 7-10 RM submaximal strength test (4,6,13). The purpose of this investigation was to determine whether 1-RM strength could be predicted from 4-6 RM submaximal strength tests for both large and small muscle mass exercises with greater accuracy than the commonly used 7-10 RM submaximal strength test.

METHODS

Subjects

Thirty-four healthy males between the ages of 19 and 32 years, who had not participated in strength training within the last year, volunteered to participate in this study. Methods and procedures for the study were approved by the institution and informed consent was obtained from participants. Subjects were instructed to refrain from participating in strenuous activity for 24 hours prior to each testing session and to avoid alcohol, caffeine, smoking and the consumption of large meals for at least three hours prior to testing.

Study Design

Body composition analysis included calculating percentage of body fat from the sum of three skinfold measures (16). The sum of three skinfold measures was used to calculate body density, which was used to calculate percent body fat using the Siri equation (17).

Subjects completed 1-RM, 4-6 RM, and 7-10 RM strength assessments in random order with a minimum of 48 hours between strength assessments. During each session, subjects performed strength assessments for the bench press, incline press (28° incline), leg extension, biceps curl, and triceps extension in random order. While being assessed for bench press and incline press strength, subjects lifted a free weight Olympic bar with weighted plates. During the bench press and incline press assessments, subjects laid with their back flat on the bench and their feet in full contact with the floor throughout the lift. Subjects grasped the bar with a thumb-lock grip at a position slightly greater than shoulder width. Trained spotters assisted the subjects in lifting the bar from the support rack, and the subject lowered the bar to the chest and returned the bar to full arm extension.

Strength of the leg extensors was assessed using a Cybex® leg extension machine. Subjects were seated with the resistance bar positioned on a plane with the superior surface of the medial malleolus. Subjects lifted the weight to near full extension of the knee. Biceps curl strength was assessed on a Paramount® preacher biceps curl machine. Subjects sat in the preacher curl machine with the seat adjusted in order to position the upper arm to a 28° angle of elbow flexion. The triceps were flat on the curling pad and subjects' feet maintained full contact with the floor throughout the lifts. Subjects lifted a 22.5 kg free weight bar with additional weight plates using a supine grip at shoulder width. Spotters assisted the subjects in lifting the bar to the proper starting position. Subjects curled the bar to 90° of elbow flexion. Triceps extension strength was assessed on a Body Master® triceps extension press machine. Subjects stood against a backrest. A spotter moved the bar in order to position the resistance bar at 90° of elbow flexion. Subjects used an overhand grip and attempted to extend their arms until near full extension of the elbow was achieved. During all submaximal strength assessments, if subjects could lift the weight greater than the desired number of repetitions indicated by the test protocol, subjects rested for 5 to10 minutes and repeated the lift with additional weight.

Forty-eight hours following the completion of each strength test, subjects were asked the following questions: (1) Did the strength assessment limit your ability to exercise within the last 48 hours?, and (2) Did you experience noticeable muscle soreness within 48 hours of the strength assessment? These questions were asked in order to determine the extent of any muscle injury and the onset of any delayed muscle soreness resulting from the strength assessment.

Statistical Analyses

Stepwise multiple regression analysis was used to generate ten regression equations for predicting 1-RM strength from the 4-6 RM and 7-10 RM submaximal strength tests. Four variables (weight lifted during the submaximal strength test, the number of repetitions completed, the subject's body weight, and the subject's body composition) were initially entered into the stepwise regression equation. The variables selected to predict 1-RM for the exercises from both the 4-6 RM and 7-10 RM submaximal strength tests were the weight lifted during the submaximal strength test and the number of repetitions completed. The degree of relationship between each regression equation for predicting 1-RM strength from either 4-6 RM or 7-10 RM submaximal strength tests and the actual 1-RM was determined using the correlation coefficient (*r*) and adjusted R^2. The adjusted R^2 value equals the explained variance between the correlated values. The standard error of estimate (SEE), between the measured and predicted 1-RM for each exercise, was used as a measurement of accuracy of the prediction equation. The SEE was calculated as Sy/1-R^2, where Sy is the standard deviation of the measured value.

RESULTS

The anthropometric characteristics of the subject population are presented in Table 1. The regression equations for predicting 1-RM from 4-6 and 7-10-RM tests are presented in Table 2. The corresponding correlation coefficients (*r*) between predicted and measured 1-RM strength, the adjusted R^2, standard error of estimate (SEE), and SEE as a percentage of the actual 1-RM are also reported in Table 2.

Table 1. Anthropometric measurements for the sample population (n=34).

Variable	*Mean±SD*
Age (yr)	23.2±3.2
Height (cm)	181.5±5.7
Weight (kg)	84.1±11.5
Body Fat (%)	15.2±1.7

For each exercise, the prediction equation based on a 4-6 RM set was a better predictor of 1-RM strength than the prediction equation based on a 7-10 RM set. For each exercise, the correlation between the predicted and actual 1-RM, the standard error of estimate, and the adjusted R^2 were improved when predicting 1-RM from a 4-6 RM set compared with a 7-10 RM set.

No subjects reported that either the 4-6 RM submaximal strength assessment or the 7-10 RM submaximal strength assessment limited their ability to exercise or caused noticeable muscle soreness. Six (17.5%) subjects reported that the 1-RM strength assessment limited their ability to exercise. Twenty-one (61.2%) subjects indicated that the 1-RM strength assessment created noticeable muscle soreness. If a subject reported that their ability to exercise was limited, or they experienced noticeable muscle soreness, the next strength test was postponed for an additional 48 hours. All of the subjects were able to participate in the strength assessment after the 48 hour postponement.

Table 2. Regression equations for predicting 1-RM from 4-6 and 7-10-RM tests.

Resistance Exercise	*Prediction Equations for 4-6 RM tests*	*r*	*Adjusted R^2*	*SEE*	*SEE/1-RM (%)*
Bench Press	-24.62 + (1.12 x Wt) + (5.09 x reps)	0.97	0.93	11.0	5.6
Inclined Press	-9.85 + (1.02 x Wt) + (5.70 x reps)	0.96	0.90	11.9	6.9
Triceps Extension	6.74 + (0.99 x Wt) + (1.61 x reps)	0.93	0.86	6.4	6.0
Biceps Curl	19.97 + (0.81 x Wt) + (2.31 x reps)	0.89	0.78	6.4	6.3
Leg Extension	82.07 + (0.76 x Wt) + (5.66 x reps)	0.82	0.66	26.3	8.4
Resistance Exercise	*Prediction Equations for 7-10 RM tests*	*r*	*Adjusted R^2*	*SEE*	*SEE/1-RM (%)*
Bench Press	-1.89 + (1.16 x Wt) + (1.68 x reps)	0.95	0.91	13.5	6.9
Inclined Press	12.14 + (1.16 x Wt) + (0.10 x reps)	0.93	0.86	14.3	8.3
Triceps Extension	-9.76 + (1.02 x Wt) + (3.56 x reps)	0.91	0.82	7.2	6.9
Biceps Curl	23.90 + (0.77 x Wt) + (2.16 x reps)	0.84	0.68	7.7	7.6
Leg Extension	95.00 + (0.65 x Wt) + (8.52 x reps)	0.76	0.56	30.1	9.7

DISCUSSION

Many strength prediction equations have been published including generalized equations and exercise specific equations (4,7,12). This paper presents strength prediction equations for five strength training exercises with two different repetition ranges.

For each strength-training exercise, the prediction equation based on a 4-6 RM set was a better predictor of 1-RM strength than the prediction equation based on a 7-10 RM set. The results of this study suggest that the predictive accuracy of the prediction equations is greatest for the upper body exercises, such as the bench press and incline press, compared to lower body exercises, such as the leg extension. Because this study utilized only one lower body test, this outcome may not be true of all lower body exercises. The correlation coefficients were lowest and standard error of estimate greatest for the leg extension strength prediction equations compared with the other four prediction equations in both the 4-6 RM and 7-10 RM sets.

These prediction equations were developed for use on non-strength trained individuals. Studies have revealed that prediction equations are not applicable to strength-trained individuals (6,18) and that proper lifting technique does not necessarily alter maximal and submaximal lifting performance (4). Prediction equations are specific to the training status of the individuals and resistance training has been found to alter the relationship between maximal and submaximal strength (6). However, prediction equations will tend to be most accurate for those individuals who are closest to the mean for the group. For individuals who are capable of lifting heavy weights, the prediction equations will tend to under-predict their 1-RM strength. Typically, a strength-trained individual can complete more repetitions with any given percentage of their 1-RM than an individual who is not strength-trained (19).

Conclusion

This study sought to determine whether 1-RM strength could be predicted from 4-6 RM submaximal strength tests for large and small muscle mass exercises with greater accuracy than the commonly used 7-10 RM submaximal strength test. The 4-6 RM submaximal strength test improved the predictive accuracy of 1-RM strength compared to the 7-10 RM submaximal strength assessment in each of the five assessments of 1-RM strength. Since no injuries or symptoms of delayed onset of muscle soreness were reported during either the 7-10 RM or the 4-6 RM submaximal strength assessment, the results of this study indicate that when attempting to predict 1-RM strength in untrained male subjects with similar characteristics, a 4-6 RM submaximal strength assessment appears to be a more valid and effective test.

Further research could determine the validity of such prediction equations for male subjects with different characteristic means (age, height, weight, % body fat), female subjects, adolescents, the elderly, and other subject groups. The use of such prediction equations to determine 1-RM has practical value for allied health professionals in assessing and prescribing strength training programs.

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