A Modified YMCA Bench Press Test as a Predictor of 1 Repetition Maximum Bench Press Strength

PAUL S. KIM,1 JERRY L. MAYHEW,1,2 AND D. FRED PETERSON¹

¹Department of Physiology, Kirksville College of Osteopathic Medicine, Kirksville, Missouri 63501; ²Human Performance Laboratory, Truman State University, Kirksville, Missouri 63501.

ABSTRACT
This study evaluated the influence of cadence on the Young Men's Christian Association (YMCA) bench press test for predicting 1 repetition maximum (1RM) bench press test performance. Fifty-eight medical students (37 men, 21 women) were evaluated for anthropometric variables (age, height, weight, fat-free mass, and percent fat), 1RM bench press, and 2 cadence tests of muscular endurance performed at cadences of 30 and 60 repetitions per minute (reps·min⁻¹). Each test was performed on a separate day, with 5 days rest in between. There was no significant difference among the number of repetitions performed at each cadence by men, whereas women performed significantly more repetitions at the slower cadence. Repetitions at either cadence were good predictors of 1RM bench press in both genders (men: 30 reps·min⁻¹, \( r^2 = 0.757 \), standard error of the estimate \( \text{SEE} = 8.0 \) kg; 60 reps·min⁻¹, \( r^2 = 0.884 \), \( \text{SEE} = 8.2 \) kg; women: 30 reps·min⁻¹, \( r^2 = 0.754 \), \( \text{SEE} = 3.1 \) kg; 60 reps·min⁻¹, \( r^2 = 0.816 \), \( \text{SEE} = 2.7 \) kg). The addition of anthropometric dimensions to the regression equations did not improve predictive accuracy. Using both fast and slow cadences, the YMCA bench press test can provide a valid estimation of 1RM performance in untrained young men and women.

Key Words: muscular strength, muscular endurance, fitness testing


Introduction
The 1 repetition maximum (1RM) test is widely recognized as the reference standard for the evaluation of muscular strength (7). This technique requires an individual to lift the heaviest load possible once through a full range of motion. Although the occurrence of injury may be minimal among experienced weight trainers (21), novice exercisers are at greater risk of injury when unaccustomed to handling heavy loads. Additionally, the apprehension of lifting these heavy loads could compromise the performance of inexperienced individuals, causing underestimation of their actual strength. Furthermore, the 1RM is time consuming and requires a considerable amount of equipment (11). Whereas an accurate measure of maximal strength may be necessary to design training programs for athletes and serious weight lifters, alternative methods to the 1RM that provide reasonable estimates would be useful in evaluating strength in a general population of subjects.

A popular approach to estimate the 1RM has been the use of muscular endurance repetitions. Such a procedure can use an absolute or a relative load to evaluate muscular endurance. A relative muscular endurance load is an amount of weight based on some proportion of the 1RM (1, 18, 20) or body weight (15). The correlations between 1RM strength and the number of repetitions completed with a relative load are typically poor (\( r = 0.40 \) to 0.44) but can be effective in estimating 1RM when used in conjunction with the load lifted (17, 19, 25). An absolute muscular endurance load represents a constant amount of weight to be lifted for every individual being evaluated, with the load being dependent on several factors including level of training (2, 19) and occupational demand (10). The correlations between 1RM strength and the number of repetitions completed with absolute loads are usually high (\( r = 0.74 \) to 0.93) (2, 4, 11, 19, 24), indicating that those with greater strength levels have higher absolute muscular endurance.

An absolute endurance test that is widely used throughout the United States for evaluating muscular strength is the Young Men's Christian Association (YMCA) bench press test of muscular endurance (5, 8). This test involves pressing a constant weight at a fixed cadence of 30 repetitions per minute (reps·min⁻¹) while lying supine on a flat bench. Golding et al. (8) neither indicated the validity of this test as a predictor of strength nor included a prediction equation to es-
timate maximal strength from the number of repetitions completed. In addition, there is no evidence that this cadence is a better predictor of strength than any other cadence. The purpose of this study was to test the hypothesis that the YMCA bench press test is a valid predictor of 1RM in young adults over a wide range of strength levels. Additionally, the effect of cadence on the validity of the test for predicting 1RM bench press strength was assessed.

### Methods

#### Subjects

Data were obtained from 59 first- and second-year medical student volunteers (22 women and 37 men) whose physical characteristics are shown in Table 1. One woman was subsequently omitted from the study because of problems in compliance with the cadence protocol. Before testing, all subjects had been cleared for physical activity after undergoing a physical examination. The subjects were not selected from any organized strength or conditioning program but were all volunteers from among those participating in a campus-wide fitness evaluation. Each participant had signed an informed consent to be included in the campus wellness study, which was approved by the Institutional Review Board. During the fitness evaluation, height and weight were obtained, and percent body fat was estimated by the 3-skinfold thickness method described by Jackson and Pollock (13) using Lange calipers. These measurements were made by an individual who had over 10 years of experience testing several thousand subjects. Men were measured in the abdominal, thigh, and chest regions. Women were measured in the suprailiac, triceps, and thigh regions.

All the women and a majority of the men indicated limited weight training experience. A few of the men were currently or had previously been involved in aggressive resistance training programs. All participants had been tested 6 months before this study using the modified YMCA bench press test of 60 reps-min⁻¹ as part of a routine fitness assessment and were therefore familiar with the test environment and procedure.

### Procedure

All participants first performed a 60-reps-min⁻¹ bench press test during the college-sponsored fitness evaluation. Volunteers were asked to return twice during the subsequent 2 weeks to participate in follow-up bench press testing. A minimum of 5 days rest was given before beginning the second round of testing to avoid any negative effects of delayed onset muscle soreness. The subjects were randomly assigned to perform either the 30-reps-min⁻¹ cadence or the 1RM test. After an additional 5-day rest, the subjects returned to perform the final remaining test. Throughout the testing, the volunteers were encouraged not to change their daily habits. Mild verbal encouragement was given throughout the testing. The same individual administered all performance tests.

#### One-Repetition Maximum Bench Press

Individuals were instructed to grip the bar at a comfortable position, which was typically 10–20 cm beyond shoulder width (26). A warm-up set was then performed at a weight that allowed 6–10 repetitions to be completed comfortably. After resting for 2–5 minutes, the subject attempted to press a weight agreed upon by both the tester and the volunteer. The bar was lowered by the individual until it touched the chest and was then immediately pressed into a full arm extension. On the basis of the relative ease of performance, 5–20 lb was added for the next attempt. If the attempted weight was too heavy, the individual was allowed to decrease the weight to reach the 1RM. This procedure was repeated until a maximal weight was determined. A 2- to 5-minute rest was allowed between each attempt (27), and the 1RM was usually achieved within 4 attempts. Two trained spotters were always present to prevent injury.
Standard YMCA Test of Muscular Endurance
The standard YMCA test was administered according to the procedures given by Golding et al. (8). After a warm-up of individual preference, a barbell was placed on the chest (in the "down position") with hands grasping the bar at the same position as during the 1RM test. A 36.4-kg (80 lb) barbell was used for men, and a 15.9-kg (35 lb) barbell was used for women. After a cadence set at 1 b·s⁻¹ by a metronome, the bar was either raised or lowered with each beat to achieve an overall lifting cadence of 30 reps·min⁻¹. The subject was instructed to maintain a controlled pace throughout the test. The test was terminated when the subject could no longer lift the bar or could not maintain the cadence.

Modified YMCA Test of Muscular Endurance
The modified test was identical to the standard YMCA test (30 reps·min⁻¹) except that the cadence was set at 2 b·s⁻¹. The bar was either raised or lowered with each beat to achieve an overall lifting rate cadence of 60 reps·min⁻¹. The test was terminated once the individual could no longer lift the bar or could not maintain the cadence, and the number of repetitions performed constituted their score.

Statistical Analyses
All data were expressed as mean ± SD. Summary statistics were calculated on all variables for each gender. Wilcoxon rank sum tests were used to assess differences between genders on measured variables. Pearson correlation coefficients were used in testing for relationships between numbers of repetitions performed at each cadence. Differences between the 2 cadences were identified using the Wilcoxon signed rank test. Linear regression was used to examine how well each dynamic exercise test predicted performance on the 1RM test, and the slopes of the regression lines were compared using the procedure suggested by Morehouse and Stull (22; pp. 258–259). Comparison of values between this and other studies used an unpaired t-test as previously described (22). All statistical tests were evaluated at p ≤ 0.05.

Results
Physical and performance characteristics of the subjects are indicated in Table 1. Men were significantly stronger than women according to the 1RM test. The YMCA weight represented 41% of 1RM and 44% of body weight in men and 50% of 1RM and 26% of body weight in women.

In men, the numbers of repetitions performed at the 2 cadences were significantly correlated (r = 0.87) and were not significantly different (Figure 1). Although women had a significant correlation between the repetitions performed at the 2 cadences (r = 0.92) (Figure 1), they performed more repetitions during the 30-reps·min⁻¹ cadence than during the 60-reps·min⁻¹ cadence (Figure 2). Performances on all 3 tests correlated positively with body weight and fat-free weight for both men and women (Table 1).

The repetitions completed at the 30 and 60-reps·min⁻¹ cadences correlated well with 1RM bench press performance in both men (r = 0.87 and 0.94, respectively) and women (r = 0.87 and 0.90, respectively). Linear regression equations for each gender and at each cadence are shown in Table 2. In men, the
Table 2. Prediction equations to estimate 1RM bench press from muscular endurance repetitions.*

<table>
<thead>
<tr>
<th>Equations</th>
<th>$r^2 \times$ SEE</th>
<th>$r$</th>
<th>100 (kg)</th>
<th>CV(^{+})</th>
</tr>
</thead>
<tbody>
<tr>
<td>Men‡ ($n = 37$)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$1RM (kg) = 1.55(reps @ 30 min(^{-1})) + 37.9$</td>
<td>0.87</td>
<td>75.7</td>
<td>8.0</td>
<td>9.0</td>
</tr>
<tr>
<td>$1RM (kg) = 1.34(reps @ 60 min(^{-1})) + 40.8$</td>
<td>0.94</td>
<td>88.4</td>
<td>8.2</td>
<td>9.2</td>
</tr>
<tr>
<td>Women§ ($n = 21$)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$1RM (kg) = 0.31(reps @ 30 min(^{-1})) + 19.2$</td>
<td>0.87</td>
<td>75.4</td>
<td>3.1</td>
<td>9.9</td>
</tr>
<tr>
<td>$1RM (kg) = 0.30(reps @ 60 min(^{-1})) + 22.3$</td>
<td>0.90</td>
<td>81.6</td>
<td>2.7</td>
<td>8.5</td>
</tr>
</tbody>
</table>

* 1RM = 1 repetition maximum; reps = repetitions; SEE = standard error of estimate.
† Coefficient of variation (CV) = (SEE/Mean) × 100.
‡ Repetition load = 36.4 kg (80 lb).
§ Repetition load = 15.9 kg (35 lb).

Figure 3. Correlation among men of scores on the 30 and 60 repetitions per minute (reps·min\(^{-1}\)) cadence tests with 1 repetition maximum. Solid line represents linear regression for the 60 reps·min\(^{-1}\) cadence test, and dashed line represents linear regression for the 30 reps·min\(^{-1}\) cadence test.

Figure 4. Residuals are plotted for men (A) and women (B). Each residual value represents the actual 1 repetition maximum (1RM) weight lifted minus the predicted 1RM. Closed circles are for the 60 repetitions per minute (reps·min\(^{-1}\)) cadence, and open circles are for the 30 reps·min\(^{-1}\) cadence.

Discussion

The major finding of this study was that both cadences at which repetitions were performed using an absolute load had reliable prediction accuracy for estimating 1RM bench press performance in either men or women as demonstrated by similar, significant correlations. The men were able to accomplish a similar number of repetitions at both the fast and slow cadences, whereas the women performed significantly fewer repetitions at the faster cadence. Pincivero et al. (23) have suggested that male muscle may be more conducive to high-intensity exercise than is female muscle. This might be because of the lower neuromuscular drive (3, 6) or a lower glycolytic capacity (9) (or both) in women. Our findings would appear to support the suggestion of Pincivero et al. (23). Another possible factor was lifting experience. Anecdotally, many men in our study mentioned familiarity with weightlifting equipment, whereas few women indicated that they had prior weightlifting experience. 

LaChance and Hortobagyi
(16) previously reported that strength-trained men performed 137% more push-up repetitions using a self-paced, faster cadence than they did using a 2-second concentric/4-second eccentric cadence. Furthermore, LaChance and Hortobagyi speculated that novice exercisers might perform better if they were allowed to adopt a slower cadence. Untrained subjects were used in this study. The results should not be interpreted to mean that this test would be valid for resistance-trained individuals. Because this test uses a standard low weight, the estimate of 1RM may be much less precise in stronger individuals who can perform many more repetitions.

An advantage of having a prediction equation for 1RM from repetitions performed on the standard or modified YMCA bench press test is that it allows novice individuals being tested to have an estimate of their personal strength without the risks associated with 1RM testing. In addition, it makes testing very inexpensive because it limits the equipment necessary to a single bar and 2 light sets of weights. Also, because performing a 1RM test to quantify strength can be time prohibitive when testing a large group of individuals, having the ability to provide an accurate prediction of 1RM in less total time would be preferable.

Typically, institutional fitness or industrial screening programs test large groups of individuals with highly varying strength levels. When working with limited testing facilities, equipment, or personnel, a cadence test substantially cuts the testing time and is advantageous to prevent undesirable delays in the testing process. The results of our study indicated that increasing the cadence twofold provided equally predictive results for the 1RM while providing a means for greatly reducing overall testing time.

The results of the current study agree with the findings of Invergo et al. (11) in men and of Rose and Ball (24) in women for the standard YMCA test. The correlations between repetitions completed and 1RM were very similar between the studies, as were the standard errors of the estimate. In addition, the regression equations developed in the current study for the men and women were similar in slope and intercept to those reported by Invergo et al. (11) and Rose and Ball (24). It should be noted, however, that the men in the current study produced significantly higher values for both bench press (p < 0.05) and repetitions at the 30-reps-min⁻¹ cadence (p < 0.05) than did the men in the Invergo et al. study (11). The women in the current study produced significantly more repetitions (25%) at the 30-reps-min⁻¹ cadence (p < 0.05) but a significantly lower 1RM bench press than did the women in the study by Rose and Ball (24).

**Practical Applications**

When testing physical fitness in large populations of people, as is done in institutional settings, economy of time and resources is often a prohibitive factor. The advantage of using a prediction equation for 1RM from repetitions performed on the standard or modified YMCA bench press test is the relatively small amount of equipment and time needed to run the tests. Although the 1RM is widely regarded as the reference standard for the evaluation of muscular strength, administering it requires an entire set of weights rather than 2 dedicated bars. It also requires multiple spotters. Additionally, to allow for the multiple attempts and resting period in between attempts, an individual can take up to 15 minutes to complete the test. When using the standard or modified YMCA bench press test, however, not only is the amount of equipment simplified by the use of only 2 barbells, a flat bench, and a single spotter, but also the time required to test the average individual drops to no more than 2 minutes. Because both prediction equations have been demonstrated to be valid for untrained adults, administering a test of physical strength on a large group of people may be much easier. It is likely that in strength-trained individuals, the accuracy of this test for estimation of 1RM will be diminished. Yet, using this methodology, many organizations may find that they can economically add this popular test to predict the upper-body strength of their untrained subjects.

**References**

11. Invergo, J.J., T.E. Ball, and M. Looney. Relationship of push-

Acknowledgments
The authors wish to thank Dan Martin and the staff at the Thompson Campus Center for their support in conducting the experiments. The authors also thank Jane Johnson for valuable advice and for performing the statistical analysis. We also thank Bonnie King for technical support, Jan Dabney for secretarial support, and Dr. W.L. Sexton for valuable suggestions. This work was supported, in part, by the American Osteopathic Association grant 98-04-461.

Address correspondence to D. Fred Peterson, fpetersen@kcom.edu.