Validation of the NFL-225 test for predicting 1-RM bench press performance in college football players

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Background. The purpose of this study was to evaluate the accuracy of repetitions-to-fatigue (RTF) using an absolute load of 102.3 kg (225 lbs) to estimate one-repetition maximum (1-RM) bench press performance in college football players using various prediction equations.

Methods. Experimental design: a prospective study on the association between muscular endurance and muscular strength. Participants: 266 players from NCAA Division IA (n=45), IAA (n=63), II (n=129), and red-shirts (n=25) were evaluated at the conclusion of a minimum of eight weeks of heavy-resistance training during the off-season. Measures: all subjects performed a 1-RM bench press and RTF using an absolute load of 102.3 kg.

Results. The Mayhew et al. NFL-225 equation nonsignificantly overestimated 1-RM from RTF by 0.5 kg, while the Chapman et al. NFL-225 equation significantly underpredicted by 3.2 kg, although both equations were comparable in the number of players predicted within ±4.5 kg of actual 1-RM (52% vs 51%, respectively). Only two of nine RTF equations currently in use produced predicted 1-RM values that were not significantly different from actual 1-RM performance.

Conclusions. Specific NFL-225 equations are more accurate in estimating 1-RM bench press from absolute muscle endurance in college football players than previous published RTF equations. The accuracy of prediction decreases at higher repetitions.

KEY WORDS: Muscle, skeletal physiology - Exercise - Physical endurance - Football.

Although the one-repetition maximum (1-RM) technique is often accepted as the most valid measurement of strength, many athletic programs have begun to adopt the technique of absolute muscular endurance as a measure of upper body muscular performance. Absolute muscular endurance is typically defined by the number of repetitions that can be completed with a standard load for each individual. Absolute muscular endurance performance, regardless of the load used, is usually highly correlated with 1-RM strength. Therefore, individuals with greater strength are able to accomplish more repetitions before fatigue terminates movement.

Because of its prevalence in the National Football League (NFL), one of these tests has become known as the NFL-225 test since as many repetitions as possible are completed with a load of 102.3 kg (225 lbs). Like so many athletic evaluation tests, this one has gained favor without rigorous statistical evaluation of its validity. Speculation has it that the famous coach for the Miami Dolphins professional football team,
Don Shula, instituted the test feeling that most players at the professional level should be able to complete at least one repetition with that load and that better players would perform more repetitions before fatigue. Owing to the great success of this team, the NFL-225 test appears to have been widely adopted as criteria for outstanding performance.

More recently an increasing number of colleges and universities have adopted the NFL-225 test as a measure of upper body strength and player potential. Chapman et al.\(^5\) were the first to evaluate the test on a college football team, producing a correlation of 0.96 between the number of repetitions completed and 1-RM performance. Later, Mayhew et al.\(^4\) evaluated several teams at different levels of performance and found the same correlation, although their standard error of estimate (SEE) was slightly greater than that of Chapman et al. (6.4 kg vs 4.5 kg, respectively).

Prior to the emergence of the NFL-225 test, the number of repetitions completed with a given weight was widely used to predict 1-RM strength levels. Several prediction equations have been widely used but again without substantial statistical support for their validity. One factor common to most of these prediction equations is the requirement of fewer than 10 repetitions to fatigue (RTF) for best prediction of the 1-RM. In the two previous NFL-225 studies, the range of RTF completed by the players reached as high as 30, thus bringing into question the use of previously developed equations for the prediction of 1-RM.

If the NFL-225 test is to be accepted as a viable means of predicting strength levels in college football players, a rigorous evaluation of its validity should be established. Furthermore, the degree to which previously developed RTF prediction equations can be used for predicting strength when high RTF levels are achieved deserves consideration. Therefore, the purposes of this study were to evaluate the accuracy of RTF using an absolute load of 102.3 kg (225 lbs) to predict 1-RM bench press in college football players and to assess the accuracy of previously developed prediction equations for estimating 1-RM strength when high RTF are noted.

**Materials and methods**

**Participants**

Two hundred and sixty players from NCAA Division I A (n=43), Division I AA (n=63), Division II (n=129), and Division II red-shirt (n=25) teams were evaluated after giving their informed consent to participate. Each player had undergone a minimum of eight weeks of heavy-resistance training during the winter off-season conditioning program prior to measurement. The programs differed slightly in their content and approach to resistance training, but all emphasized a periodized methodology for core exercises such as bench press, squats, deadlifts, and push presses. In addition, all programs used four to seven supplemental exercises such as incline presses, French presses, lat pulls, barbell or dumbbell curls, upright or bent-over rowing, hamstring curls, and calf raises. Players were measured the week following the last workout of the cycle to allow sufficient recovery to achieve peak performance. The highly competitive atmosphere of the team testing environment provided sufficient motivation to achieve superior performance from each player.

**Testing procedure**

The 1-RM bench press procedure followed a standard “touch-and-go” protocol in which the bar was required to be lowered slowly to touch the chest before being pressed immediately to full arms’ extension.\(^5\) During testing, each player was allowed to warm up according to personal preferences using light weights of approximately 50 to 75% of estimated 1-RM. When testing began, a weight was selected by the player, and one repetitions was performed.

Following this repetitions (and all others), a minimum of 5 min rest was given\(^6\) before attempting subsequent repetitions with additional weight. Most players reach their 1-RM withing three to five attempts. Standard Olympic bar and plates were used for all lifts, and the player used a grip that was slightly wider (approximately 15-35 cm) than shoulder width.\(^7\)

During the week preceding the 1-RM testing, each player performed as many repetitions as possible using a load of 102.3 kg (225 lbs). Following individual warmups, the player grasped the bar at the same position used during the 1-RM procedure. Although no cadence was set for the repetition tests,\(^8\) each player was encouraged to maintain a constant pace but was allowed no more than a 2-sec pause between each repetition. The bar was required to touch the chest on each repetition, but the subject was admonished not to bounce the bar off the chest and to return it to full- arm extension on each repetition. The head, upper back, and buttocks were required to remain in contact
with the bench throughout the test. The test was terminated when the subject could not complete a repetition with proper form.

**Strength predictions**

Because of their application to the current sample or due to their wide use throughout the resistance training community, seven prediction equations were evaluated for their efficiency in estimating 1-RM bench press (Table I). Three of these equations have statistical suppose for their development and use while four offer not information on their origins and application. Five of the equations were linear derivations suggesting a decrease of 1.25 to 3.3% in the %1-RM for each additional repetition accomplished. Two of the equations were curvilinear suggesting a faster decrease in %1-RM at the higher end of the repetition continuum.

**Statistical analysis**

Mean and standard deviations were calculated for each variable. A one-way ANOVA with Tukey post hoc comparisons was used to determine differences among physical and performance characteristics across the levels of play. Pearson correlation and linear regression were used to determine the relationship and predictive potential of RTF for estimating 1-RM bench press. Previously reported repetition prediction equations were evaluated using Pearson correlations and paired "t"-tests. In addition, the constant error (CE) was calculated as the difference between the predicted 1-RM value and the actual 1-RM value to assess the magnitude of the absolute error. The total error (TE) was estimated from \( \sqrt{\sum (\text{predicted} - \text{actual})^2/N} \) and expressed not only the difference between the predicted and actual 1-RM values, but also the degree of their association with each other. The coefficient of variation (CV) was calculated by dividing the standard error of estimate for each equation by the actual 1-RM mean to indicate the relative variability of each prediction equation.

**Results**

Physical and performance characteristics of the players are shown in Table II. The red-shirt players were significantly younger than the other groups, which did not differ in age. Players at the higher Division IA and IAA levels were taller, had greater absolute and relative strength, and performed more RTF than players at the Division II level. Body weight was significantly greater for the Division IA players, did not differ between the Division IIA and II players, and was significantly less for the red-shirt group. The 102.3-kg load represented a significantly increasing percentage of the 1-RM across all divisions of players.

Table III illustrates the effectiveness of the pre-
TABLE III.—Comparison of equations to predict 1-RM from repetitions @ 225 Lbs.

<table>
<thead>
<tr>
<th>Equations</th>
<th>Predictedc (Means±SD)</th>
<th>Constant errorb (Means±SD)</th>
<th>Total Errorc</th>
<th>tc</th>
<th>CVd</th>
<th>% within±4.5 kgf</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chapman et al. NFL-2253</td>
<td>133.6±20.7</td>
<td>-3.2±8.4</td>
<td>9.0</td>
<td>0.94*</td>
<td>6.08*</td>
<td>6.1</td>
</tr>
<tr>
<td>Mayhew et al. NFL-2254</td>
<td>137.3±22.0</td>
<td>0.5±8.3</td>
<td>8.3</td>
<td>0.94*</td>
<td>1.02</td>
<td>6.1</td>
</tr>
<tr>
<td>Brzycki8</td>
<td>149.3±61.0</td>
<td>12.5±44.8</td>
<td>47.3</td>
<td>0.49*</td>
<td>3.06*</td>
<td>39.6</td>
</tr>
<tr>
<td>Lander10</td>
<td>148.2±55.7</td>
<td>11.4±39.3</td>
<td>41.9</td>
<td>0.43*</td>
<td>2.74*</td>
<td>54.1</td>
</tr>
<tr>
<td>Mayhew et al.11</td>
<td>134.2±14.6</td>
<td>-2.6±11.3</td>
<td>11.2</td>
<td>0.93*</td>
<td>3.65*</td>
<td>8.3</td>
</tr>
<tr>
<td>Wathen12</td>
<td>137.9±21.6</td>
<td>1.1±8.9</td>
<td>8.7</td>
<td>0.93*</td>
<td>2.08*</td>
<td>6.5</td>
</tr>
<tr>
<td>Welday13</td>
<td>138.1±23.1</td>
<td>1.3±8.4</td>
<td>8.5</td>
<td>0.94*</td>
<td>2.56*</td>
<td>6.1</td>
</tr>
</tbody>
</table>

* Actual 1-RM = 136.7±23.6 kg; b Constant error = predicted 1-RM - actual 1-RM; c Total error = √(predicted - actual)^2/N; d CV = (SEE/1 - RM mean) x 100; e % of actual 1-RM within±4.5 kg of actual 1-RM; r=0.24; * p<0.01.

Discussion and conclusions

The current findings support the use of RTF with an absolute load of 102.3 kg (225 lbs) to predict 1-RM bench press strength in college football players at different levels of competition. Specific NFL-225 equations3, 4 appear to be better suited for prediction using an absolute endurance task than were other equations identified in the literature.9-13 The tendency for the disparity between predicted and actual 1-RM values to increase at higher strength levels and with greater RTF has been noted previously.3, 4 This phenomenon may be one of the major limitations to the use of absolute muscular endurance tests to estimate muscular strength.

Several sources have indicated that better strength predictions exist when the RTF remain at 10 or less.14-16 This could explain part of the poor performance by several of the equations evaluated in this study, since 46% of the sample performed more than 10 RTF. The standard error of estimate increased by 35-48% when the RTF moved from less than 10 to greater than 10 in the current players. These findings were comparable to those noted previously by Ware et al.17 in Division II college football players.

The standard deviation of the constant error (Table III) is an approximation of the standard error of estimate of a prediction equation in a given sample. When this value is approximately equal to the total error, it provides strong support for the cross-validation of a prediction equation. Both NFL-225 equations, as well as the linear equation of Welday and the curvilinear equation of Wathen, appeared to achieve this requirement (Table III). In addition, the smaller values for the constant error and total error for these equation would support their use over the linear equations of Brzycki and Lander. Furthermore, both linear equa-
tions of Brzycki and Lander produced very large predicted standard deviations and total errors, indicating potentially huge variations between the predicted and actual 1-RM performance. Indeed, 23 subjects had predicted values 50 kg or more greater than their actual 1-RM using these equations.

A major problem in any prediction is the degree of accuracy associated with the equation as given by the standard error of estimate. Beyond the conclusions typically noted in a statistical analysis, users of any given prediction equation tend to evaluate the size of the error based on anecdotal perceptions from past experience. That is to say, if strength coaches and athletes are to accept an equation as useful, it must predict within a very small window of error for most players.

The statistical results of the current study agreed with previous perceptions that the standard error of estimate for most strength prediction equations are not likely to be below 6.8 kg.4 The fact that the Mayhew et al. NFL-225 equation4 predicted 67% of the current diverse sample within ±6.8 kg (15 lbs) of their actual 1-RM should be encouraging for the practitioner wishing an accurate prediction of strength.

The significant differences noted among the levels of competition of the current sample for 1-RM and RTF (Table II) might suggest that this could be a factor in the prediction of strength from absolute muscular endurance.18 However, the addition of a level of competition factor to a multiple regression analysis accounted for less than 5% of the common variance in predicting 1-RM and thus would appear to be of no consequence. Therefore, prediction of 1-RM strength performance among college football players can be achieved using RTF with an absolute load of 102.3 kg regardless of the level of competition.

References