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Comparison of Division II College Offensive and Defensive Football Players' Upper Body Strength Across One Repetition Maximum Test and The NFL-225 Test

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The purpose of this study was to evaluate the effectiveness of predicting actual one repetition maximum (1RM) bench press strength from the National Football League (NFL) 225-test in college football players. Forty-one Division II college football players participated in this study. Participants' upper body strength scores were expressed relative to body weight and results were compared across both tests. Mayhew et al. equation was used to predict 1RM. A repeated measures ANOVA and one-way ANOVA was used to compare the groups. The present study found that the Mayhew equation overestimated relative upper body strength of college football players, while high degree of reliability was found between the actual 1RM and the NFL-225 tests [Wilks λ =0.43, F (1,40) = 53.07, p =0.000, Eta-squared =0.57] and the correlation between these two tests was very high (r =0.94, p<0.001). The present study also found that defensive players were stronger than offensive players when scores were expressed relative to body weight. The finding of this study indicates that the NFL-225 test's applicability may not be identical for all college players. This study elucidates some of the difficulties associated with predicting 1RM. However, while it is difficult to predict 1RM, testing using sub-maximal loads are far less time consuming especially when they involve a large number of athletes. The results of this study should facilitate coaches in choosing the most appropriate strength testing procedure for their programs.

Key words: bench press, college football, one repetition maximum test, NFL test

Introduction

Strength is an important part of athletes' training schedule and focuses on developing an athlete's strength, speed, power and endurance in relation to the particular demands of every individual and sport. Over the past few decades, athletes' strength performance has been extremely improved. For example, the average lineman, today, run 40-yard dash faster than the average football lineman two decades ago. Strength training is most likely responsible this type of improvement. In other words, the basic elements of speed, mobility and endurance are all functions of muscular strength. A football player needs to have great relative body strength to meet the performance demands of the sport. On the other hand, the football player who can move his own

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body weight with the greatest ease will generally be able to perform at a higher level.

Resistance training is an essential part of athletic preparation today and an organized program can lead to the development of muscular strength of athletes (Fleck and Kramer, 1997). Many sports require athletes to have high levels of muscular strength (Atha, 1981; Wilson, 1994). The assessment of strength, therefore, is recognized by coaches as necessary for evaluation of a football players' athletic potential. The assessment of strength must be accurate. Accurate assessment of strength is especially fundamental for both occupational functional capacity evaluation and appropriate athletic and rehabilitation exercise prescription (Brown and Weir, 2001).

To compare the strength of athletes, relative strength is usually calculated (Zatsiorsky, 1995). Although absolute strength is important for the tall and heavy athletes, for sports in which the athletes' body rather than an implement is moved, relative strength is of greater importance (Zatsiorsky 1995). Football requires a solid strength foundation. Not only does the athlete have to be strong enough to move his own body weight, but he has to do it quickly. Therefore, relative strength is an important quality to develop for increased power and speed. Notably, evidence from a number of different types of research as well as observational data indicates that relative strength is strongly related to sports performances that rely on speed and motor skills (Fry et al., 1991, Stone et al., 1980). Barker et al. (1993), for example, studied a Division IAA university team and divided the players into starters and non-starters. Based on the 1 RM squat, normalized for body mass, Barker et al. (1993) statistically divided the team into 3 relative strength group levels: high, moderate and low. A continuum is evident as stronger players also had higher vertical jumps compared to moderate- and low-level relative strength groups.

One of the most popular measurements of upper body strength is the 1RM bench press (Arthur, 1982; Brzycki, 1993; Mayhew et al., 1992). Strength is normally measured by the maximal amount of weight an individual can lift in a single repetition of a movement or in one isometric contraction (Baechla, 1994). Measuring 1RM provides a trial-and-error method of manipulating weight loads until a maximal effort is achieved (Kuramoto and Payne, 1995). However, this can be time consuming and cause increased possibility of injury including fractures, torn ligaments, and deformation of growth plates in young participants (Matheson et al., 1989; Mayhew et al., 1993; Niewiadomski et al., 2008). As a result, many coaches and strength specialists have applied submaximal testing to estimate the 1RM strength in the bench press.

Previous studies applying submaximal tests for estimating 1RM strength used either a generalized prediction equation or prediction equations for specific exercises including bench press, squat, and deadlift (Bryzcki, 1993; Dohoney et al., 2002; Kuramoto and Payne, 1995; Lander, 1985; Matthew et al., 2003). Regression equations typically include the number of repetitions completed (Mayhew et al., 1999), the resistance used (Kim et al., 2002) or body weight (Rose and Ball, 1992). One of the most common submaximal tests used by the National Football League (NFL) and the National Collegiate Athletic Association (NCAA) is the 225-lbs bench press with repetitions to fatigue (Mayhew et al., 1999; Mayhew et al., 2002; Sierer et al., 2008). Because this test is generally performed in the NFL, it has been called the NFL-225 test (Matthew et al., 2003; Mayhew et al., 2002; Slovak et al., 1997).

Previous studies have produced high correlations between NFL-225 repetitions and 1 RM bench press (Chapman et al., 1996; Everett et al., 1995). Chapman et al. (1996), for example, found a high correlation between NFL-225 repetitions and 1 RM bench press in Division II players. The authors recommend that the NFL-225 test may be a valid predictor of 1 RM bench press for most college players. However, these authors are concerned about the application of the NFL-225 for college players. If more data can be obtained by examining different levels of football players and this shows a strong relationship between 1 RM and the NFL-225 tests regardless of the level, the NFL-225 test will save training time and avoid exposure of the player to any potential danger from handling excessively heavy loads during maximal attempts (Chapman et al., 1996, Mayhew et al., 1999). For example, Chapman et al. (1996) noted that when testing 98 football players for the 1-RM bench press, three testers were required for the completion of the testing procedure, which took six hours with five testing stations. Such information would be of value to coaches, athletic trainers, and fitness professionals in evaluating strength and planning resistance training programs (Mayhew et al., 1999). It will also be important to assess if any differences exist between the ability to predict 1RM by position. Furthermore, examining strength differences among

player positions will be useful for coaches, athletic trainers, and fitness professionals. Therefore, the purposes of this study were (a) to determine reliability of the actual 1RM and predicted 1RM tests, (b) to examine the relationship between the actual 1RM and the NFL-225 test tests (c) to compare the actual 1RM test and the predicted one repetition maximum by the NFL-225 test, (d) to compare upper body strength of college offensive and defensive players.

Methods

This study sought to examine the effectiveness of predicting actual one repetition maximum (1RM) bench press strength from the National Football League (NFL) 225-test in college football players and to compare the upper body strength of college football offensive and defensive players across these two tests. As part of their routine off-season training, all participants performed a 1RM and as many repetitions as possible using a weight of 225 lbs.

Participants

Forty-one Division II National Collegiate Athletic Association (NCAA) college football players (24 defensive players and 17 offensive players) participated in the present study. Participants were informed of the experimental risks and signed an informed consent prior to the investigation. The investigation was approved by an Institutional Review Board for use of Human subjects. Each player had undergone a minimum of 8 weeks of heavy resistance training during the winter off-season conditioning program prior to measurement. The off-season program focused on low repetitions and heavy loads and emphasized a periodized methodology for core exercises such as the bench press, squats, deadlifts, and push presses. Players were evaluated a week after the last workout of the cycle to allow sufficient recovery for peak performance. None of the participants had a serious pre-existing injury that could hinder their performance throughout the study. All athletes participating in the study were familiar with bench press tests. Participants were experienced with weight lifting programs prior to the date of tests. Participants' ages ranged from 18 to 30 years with a mean of 20.58 (*SD* = 2.07).

Procedures

Anthropometry. All of the subjects' body weight and height were measured. Body weight ranged from 154.80 to 336.80 lbs with a mean of 224.31 (*SD* = 49.90) while body height ranged from 64.50 to 81.75 inch with a mean of 71.98 (*SD* = 3.59) (Table 1). After all data had been collected, the participants were tested in the 1RM bench press test and then the NFL-225 test. Data collection was completed within two weeks from the end of the training cycle, with a minimum of 48 hours between tests.

Instruments. Each participant was measured on the 1RM bench press test, and the NFL-225 test, using free weight standard Olympic plates, a seven-foot Olympic bar and a standard Olympic flat bench. For height, Novel Products INC., Pat # DES 290237 stadiometer and for weight, TANITA BWB-G27A Class III scale was used. These instruments are certified by their manufacturers.

Administrative procedure. The tested subjects were in the supine position with their feet on the floor and buttocks on the bench during lifting. The participant then lowered the bar in a controlled manner and returned the bar to the starting position. The arms were required to extend fully on each repetition. The bar could not rest on the chest or with arms fully extended for more than two seconds (McGee and Burkett, 2003). Spotters and coaches assisted the participants during the performance of the lift. These spotters were trained to ensure the proper lifting techniques were applied. The spotters assisted the athletes in lifting the bar from the support rack, and the participant lowered the bar to the chest and returned it to full arm extension. The test terminated when the participant could not complete a repetition with fully extended arms or until the weight was racked voluntarily by the participant.

Testing procedure for 1RM bench press test. The 1 RM bench press procedure followed the standard ''touch-and-go'' protocol in which the bar was required to touch the chest before being pressed to full arms' extension (Ware et al., 1995). Each subject was required to follow a general warm-up prior to testing by jogging a quarter mile and stretching upper and lower extremities. They were also allowed a specific warm-up that consisted of performing the bench press using light weights of approximately 50 to 75% of estimated 1RM. A 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 (Wagner et al., 1992). After each successful 1RM attempt, the participants were

encouraged to add between 5 and 10 pounds, depending on the degree of difficulty of the previous lift. Each participant was required to find his 1RM between 2 and 7 attempts, with 3 to 10 minutes rest between attempts (Weir et al., 1994). The greatest weight lifted for each participant was recorded as the 1RM.

Testing procedure for the NFL-225 test. Each athlete was required to perform as many repetitions as possible using an Olympic barbell with a weight of 225 pounds. The same warm-up procedure as used for the 1RM test was used prior to the NFL-225 test. They were also allowed a warm-up that consisted of performing the bench press using light weights of approximately 50 to 75% of estimated 1RM. Following warm-up, each participant grasped the bar and kept his feet on the floor at the same position as during the 1RM procedure. No more than a 2-second rest was allowed during an individual attempt of the repetition test. The participant completed as many successful repetitions as possible until muscular fatigue. The test was terminated when the participant could not complete a repetition with proper form. The number of successful repetitions completed was recorded.

Statistical Analyses

Relative strength of participants was calculated in this study, because of its influence on speed and power. Relative strength was determined by taking the weight lifted and dividing it by body weight for each individual. Descriptive statistics were generated to provide an overall outlook of football players' upper body strength scores across 1RM and the NFL-225 tests. Intraclass correlation coefficient (ICC) was used to determine reliability of the actual 1RM and predicted 1RM tests. Pearson's correlation coefficient were calculated to examine the relationship between the actual 1RM and predicted 1RM (i.e. the NFL-225) tests. The data was analyzed through repeated measures analysis of variance and one-way analysis of variance (one-way ANOVA). The statistical mean of the data was compared through the predicted 1RM and actual 1RM tests between offensive and defensive college football players using one-way ANOVA. Each player was given two different body strength tests (i.e., 1RM and the NFL-225 test) and the hypothesis - mean body strength score will be the same in the two types of measurement was tested. Another hypothesis stated that there would not be a significant difference between offensive and defensive players' upper body strength. Because the equations derived from Mayhew et al. (1999; 2002) were reported to be most accurate for the bench press, their equation [1RM (lbs) = 226.7 + 7.1* reps] was used to predict the actual 1RM from the NFL-225 test.

Results

Participants' 1RM scores ranged from 185 to 405 lbs with a mean of 272.80 $\pm$ 53.74 lbs and the NFL-225 scores ranged from 233.80 to 418.40 lbs with a mean of 300.77 $\pm$ 44.07 lbs (Table 1). A high degree of reliability was found between the actual 1RM and the NFL-225 tests (ICC = 0.95 with a 95% confidence interval from 0.89 - 0.97.) Correlation coefficients between these two tests are shown in Table 1. The results showed that the actual 1RM test scores were highly correlated with the NFL-225 test scores (r =0.94, p<0.001).

The result of repeated measures analysis of variance indicated that the actual 1RM (M = 1.25, SD = .24) and the predicted 1RM (M = 1.34, SD = 0.23) scores by using Mayhew et al. equation as measured

Table 1

General Characteristics of College Football Players and Correlation between the Actual 1RM and the Predicted 1RM (the NFL-225 Test)

Characteristics	Number	Minimum	Maximum	*M*	*SD*	The actual 1RM test	The NFL-225 test
The actual 1RM test	41	0.66	1.74	1.25	0.24	-	0.94*
The NFL-225 test	41	0.81	1.73	1.34	0.23	0.94*	-
Weight (lbs)	41	154.80	336.80	224.31	49.90		
Height (in.)	41	64.50	81.75	71.98	3.59		
Age	41	18.00	30.00	20.58	2.07		
1RM (lbs)	41	185	405	272.80	53.74		
Mayhew (lbs)	41	233.80	418.40	300.77	44.07		
NFL-test	41	1.00	27.00	10.43	6.21		

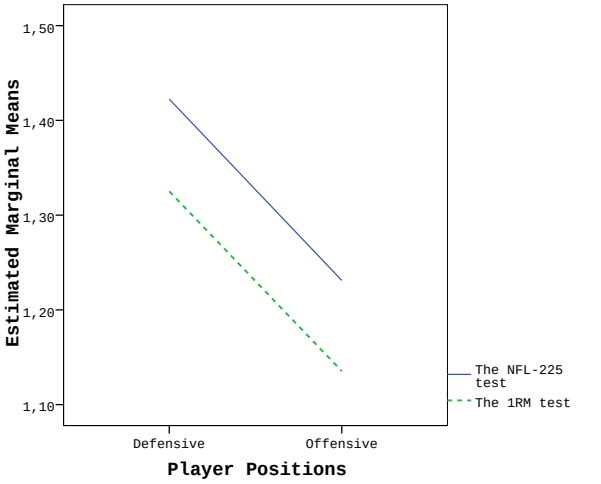

Fig. 1

Comparison of offensive and defensive football players' upper body strength across the actual 1RM and the NFL 225-tests

relative to body weight differed significantly [Wilks $\lambda = 0.43$, F (1,40) = 53.07, p=0.000, Eta-squared = 0.57]. The Mayhew et al. (2003) equation overestimated the upper body strength of college football players although equation showed the same trends with the actual 1RM when scores were expressed to relative body weight (Figure 1). However, statistics indicated that the relationship between these two was very high (p<0.001). The results of one-way ANOVA analysis showed that there was a significant difference between defensive players (M = 1.32, SD = .20) and offensive players (M = 1.13, SD = 0.25) when scores were expressed relative to body weight for the actual 1RM, F (1, 39) = 6.93, p = 0.012, Eta-squared = 0.15. Results of one-way ANOVA also showed that a significant difference occurred between defensive (M = 1.42, SD = 0.20) and offensive players (M = 1.23, SD = 0.22) for the predicted 1RM, F (1, 39) = 8.61, p = 0.007, Eta-squared = 0.17.

Discussion

Four conclusions were drawn from the findings of the present study: (a) A high degree of reliability was found between the actual 1RM and the NFL-225 tests (b) the correlation between these two tests was also very high, (c) Mayhew et al. (2003) equation overestimated the relative upper body strength of college football players, (d) defensive college players were stronger than offensive football players when scores were expressed to relative body weight.

The results of the present study indicate a considerable degree of consistency with previous studies that found a high correlation between the actual and predicted 1RM values. However, the finding that Mayhew et al. (2002) overestimated the relative upper body strength of college football players is contrary to most of the previous studies (Matthew et al., 2003; Rose and Ball, 1992). Slovak et al. (1997), for example, compared the actual and predicted 1RM utilizing the NFL-225 test from three different equations (i.e., Brzycki, Epley and Mayhew et al. 2003, equations). Their study indicated that the prediction of 1RM bench press in NCAA Division II football players was possible using 1RM prediction equations by Epley or Mayhew (Mayhew et al. 1999, Mayhew et al. 2002) also assessed the efficacy of the NFL-225 test to evaluate upper body strength in football players. Sixty-eight percent of the cross-validation sample had predicted 1RM values within +/- 10 lbs of their actual 1RM performance. Their study determined that muscular endurance repetitions with an absolute load of 225 pounds could be used to predict actual 1RM bench press strength in college football players, although the error in prediction increases when endurance performance exceeds 10 repetitions. Slovak et al. (1997) and Mayhew et al. (1999; 2002) findings appear to differ with the results of the present study regarding the efficacy of the Mayhew et al. (2003) equation. Therefore, the present study concludes that the Mayhew et al. (2003) equation cannot predict relative 1RM and overestimates the relative upper body strength of college football players. One possible explanation for the inconsistency could be that the Mayhew et al (2003) equation is only effective in participants whose 1 RM bench press is at least 225 pounds, and therefore may have limited utility in testing weaker subjects (Brown et al., 2001). Another possible explanation could be that the accuracy of the equation decreases as the number of repetitions increase beyond 10 repetitions (Chapman et al., 1998; Mayhew et al., 1999), which limits its efficiency in very strong participants. The last explanation could be that the NFL-225 test's predictive ability may not be the same for all college football players (Bryzcki, 1993). The validity of the NFL- 225 test, for example, can vary as a prediction of the actual 1-RM test in college football players who are familiar with the work out and sufficiently conditioned to perform reps with 225 lbs (Chapman et al., 1998). Anatomical and physiological variation could also confound

efforts when predicting 1RM. These could include muscle fiber types, length of arms, and the depth of the chest.

Although the present study seems to cover a widely studied area for understanding college football players' upper body strength, it specifically examined the upper body strength of college football offensive and defensive players across the 1RM and the NFL-225 tests. The results are consistent with the study of Berg et al. (1990) that showed the strength differences between offensive and defensive college football players. Upper body strength scores were expressed relative to body weight. The conclusion of the authors was that the defense was stronger when their scores were expressed relative to body weight. The current study findings appear to agree with the findings of Berg et al. (1990).

Significantly, the only group represented in this study is 41 Division II football players. Therefore, findings of this study may not be applicable to players in the different divisions of college football. Studies that compare the 1RM and predicted 1RM between divisions are recommended. A similar study should be also performed with a larger number of participants. The results of a study of this type could possibly be more accurate in determining the prediction of 1RM from the Mayhew et al. (2003) equation. A third recommendation is to test the differences among football player positions by repetitions into two categories: (1) fewer than 11 repetitions, and (2) more than 11 repetitions. By this way, strength differences can be measured more accurately.

In order to prescribe weight-training programs for football players, their maximum lifting capacity should be assessed accurately. Although the NFL-225 test may be a valid predictor of 1 RM bench press for most college players, the current study agrees with Chapman et al. (1996) that this test's applicability may not be identical for all college players. Therefore, college football coaches, athletic trainers, and fitness professionals in evaluating strength and planning resistance training programs should be careful about the accuracy of predicted 1RM's.

If a methodology was developed that could accurately assess the 1RM from submaximal loads it could ease the process of strength testing. The standard methods for testing 1RM strength are cumbersome from a time standpoint as each athlete needs multiple attempts to achieve the 1RM. Most coaches have seen athletes attempt a weight and fail. After the failed attempt their subsequent successful maximum lift is much less than the athlete and coach expected. This could be a result of premature fatigue caused by the missed attempt and the athlete fails to recover for subsequent attempts. Estimating the 1RM accurately could obviate the instances of premature fatigue due to failed attempts at the 1RM. The NFL-225 test has the practical benefit of being less time consuming for evaluating upper body strength. The risk is that the NFL-test may not be as accurate at estimating maximal upper body strength compared to the 1RM. The final decision to use the NFL-225 test instead of a 1RM is one that is left to coaches. The practitioners must weigh the benefits and risks associated with each type of testing and decide which is the most appropriate for their program.

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