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Research article

Using Bench Press Load to Predict Upper Body Exercise Loads in Physically Active Individuals

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Abstract

This study investigated whether loads for assistance exercises of the upper body can be predicted from the loads of the bench press exercise. Twenty-nine physically active collegiate students (age: 22.6 ± 2.5; weight training experience: 2.9 ± 2.1 years; estimated 1RM bench press: 54.31 ± 14.60 kg; 1RM: body weight ratio: 0.80 ± 0.22; BMI: 22.7 ± 2.1 kg·m^{-2}) were recruited. The 6RM loads for bench press, barbell bicep curl, overhead dumbbell triceps extension, hammer curl and dumbbell shoulder press were measured. Test-retest reliability for the 5 exercises as determined by Pearson product moment correlation coefficient was very high to nearly perfect (0.82-0.98, $p < 0.01$). The bench press load was significantly correlated with the loads of the 4 assistance exercises (*r* ranged from 0.80 to 0.93, $p < 0.01$). Linear regression revealed that the bench press load was a significant (R^2 range from 0.64 to 0.86, $p < 0.01$) predictor for the loads of the 4 assistance exercises. The following 6RM prediction equations were determined: (a) Hammer curl = Bench press load (0.28) + 6.30 kg, (b) Barbell biceps curl = Bench press load (0.33) + 6.20 kg, (c) Overhead triceps extension = Bench press load (0.33) - 0.60 kg, and (d) Dumbbell shoulder press = Bench press load (0.42) + 5.84 kg. The difference between the actual load and the predicted load using the four equations ranged between 6.52% and 8.54%, such difference was not significant. Fitness professionals can use the 6RM bench press load as a time effective and accurate method to predict training loads for upper body assistance exercises.

Key words: Strength training, resistance training, training load, weight, repetition maximum.

Introduction

Among upper body, multi-joint training exercises, the bench press is one of the most frequently used exercises (Koshida et al., 2008; Schick et al., 2010). Prime movers for the bench press exercise include pectoralis major, anterior deltoid, and triceps brachii muscles (Ojasto and Hakkinen, 2009). Owing to the multi-joint nature of this exercise, where movement occurs simultaneously at the shoulder and elbow joints, the aforementioned muscle groups can be strengthened simultaneously (Schick et al., 2010). In contrast, single-joint exercises such as the flat dumbbell fly or triceps extension, where movement occurs only at the shoulder or elbow joint, respectively, strengthen only one or two muscle groups acting around these individual joints (Baechle and Earle, 2008).

Bench press has been a staple exercise for both testing and training the upper body strength of athletes in many professional sports including American football and basketball (Ebben and Blackard, 2001; Ebben et al., 2004). Aside from the athlete population, numerous studies in the non-athletic population have also employed bench press as a strength measurement and training exercise (Andrade et al., 2011; Elliott et al., 2002). For example, Andrade et al. (2011) employed bench press load to measure upper body strength of healthy, sedentary male participants, whereas Elliott et al. (2002) used bench press as a major upper body training exercise in their interventional studies of postmenopausal women.

Exercise load is one of the most critical factors that determines training adaptations and should be considered during any resistance training program planning (Earle and Baechle, 2004). Exercise load can be (1) self-determined through subjective trials; (2) more randomly assigned by an instructor through trial and error; or (3) by calculating percentages of a pre-assessed maximum strength load (Ebben et al., 2008; Wong et al., 2010b). The first two methods are not sufficiently accurate and vary between participants (Ebben et al., 2008; Wong et al., 2010b), whereas the third one requires initial determination of a one repetition maximum (1RM) load, which is not only time-consuming, but also limited to a few multi-joint, large muscle group major exercises such as squat and bench press (Earle and Baechle, 2004). In addition, performing 1RM tests on individuals who are not highly trained or highly motivated may be somewhat difficult, as inexperienced lifters lack proper technique and a proper strength base to lift maximal loads. In consideration of this, a previous study found that 6RM load is reliable (Intra-class correlation coefficient > 0.95) and can be an alternative to 1RM load determination (Wong et al., 2010b). Moreover, previous studies used major exercises to predict the loads of assistance exercises, which are exercises that involve movement at one primary joint and recruit smaller muscle groups or only one larger muscle group (Earle and Baechle, 2004; Ebben et al., 2008; Wong et al., 2010b). For example, Ebben et al. (2008) found that squat load is highly correlated with other quadriceps-dominant lower body assistance exercises, such as dead lift, lunge, step-up, and leg extension) in college students (correlation values ranged from 0.79 to 0.90). In addition, Wong et al. (2010b) also used squat load to predict loads for dead lift, inclined leg press, lunge and step-up exercises in professional Karate athletes. These studies suggested that the major exercise of squat and the above-mentioned assistance exercises use the same prime mover: the quadriceps muscles.

The co-activation of agonist and antagonist muscle

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groups acting across the same joint affects force production and joint angular velocity, for instance, leg extension exercise load prediction requires co-activation of quadriceps and hamstrings (Maynard and Ebben, 2003). It might be concluded that co-activation of agonist and antagonist is one of the requirements for predicting exercise loads. Moreover, previous studies showed that it is possible to predict exercise load of antagonist muscle groups from the agonist muscle groups. For example, Ebben et al. (2010) used squat load (i.e., quadriceps as agonist) in an athletic population to predict loads in exercises for the antagonist hamstring muscle group: leg curl, stiff leg dead lift, single leg dead lift and good morning exercises.

As the previously mentioned studies demonstrated that major exercise loads can be used to predict loads for assistance exercises of the lower body, it is logical to hypothesize that such a method could be applicable to upper body exercises. Therefore, the aim of this study was to investigate whether assistance exercises of the upper body can be predicted from the loads of an upper body major exercise: the bench press.

Methods

Experimental approach to the problem

To predict upper body assistance exercise loads from the bench press exercise load, we measured the 6RM loads for bench press, barbell bicep curl, overhead dumbbell triceps extension, hammer curl and dumbbell shoulder press. It has been found that 6RM load is reliable (Intraclass correlation coefficient > 0.95) and can be an alternative to 1RM load determination (Wong et al., 2010b). The 1RM load can be estimated by 6RM load using the conversion equation, i.e., 1RM load = 6RM load / 85% (Baechle and Earle, 2008). Each participant visited the Human Performance Laboratory three times, the first visit of which was for exercise familiarization and determination of perceived maximum load. The subsequent visits took place one week following the initial familiarization visit. The 5 exercises were randomly separated into 3 exercises during the second visit and 2 exercises during the third visit, 48-hours apart. All sessions were supervised by an NSCA-certified personal trainer to ensure proper movement and procedure. The choice of the selected free weight assistance exercises was made because they are common exercises and dumbbells are available in most health clubs or fitness centers (Spennewyn, 2008).

Participants

Twenty-nine healthy male participants (age: 22.6 ± 2.5; weight training experience: 2.9 ± 2.1 years; estimated 1RM bench press: 54.31 ± 14.60 kg; 1RM: body weight ratio: 0.80 ± 0.22; height: 1.73 ± 0.06 m; weight: 68.1 ± 7.3 kg; BMI: 22.7 ± 2.1 kg·m^{-2}; percentage of body fat: 15.1 ± 5.3 %; biacromial breadth: 41.3 ± 1.7 cm) were recruited from a population of physically active collegiate students. All participants were properly informed of the experimental risks and benefits of this study and signed an informed consent document before the investigation. The study was conducted according to the Declaration of Helsinki, and the study was approved by the Human Research Ethics Committee. Participants were instructed not to perform any vigorous physical activities 48 hours before and between sessions.

Procedures

One week period prior to the first testing session, participants completed a familiarization session with the exercise techniques and to determine a perceived maximum load for each exercise (Robbins et al., 2009). Age, body mass, height, body mass index (BMI), and percentage of body fat were first measured. Percentage of body fat was measured by a direct segmental multi-frequency bioelectrical impedance machine (Inbody 230, BIOSPACE, Korea) (Cha et al., 2006). Biacromial breadth width was also measured during this session by using the standard caliper (Wagner et al., 1992). Each exercise was demonstrated to the participants by an NSCA-certified personal trainer and each participant was required to execute these exercises (20 kg for bench press, 13 kg for barbell exercises, and 5 kg for dumbbell exercises) for 5-10 repetitions with proper technique. Subsequently, participants performed 3-5 repetitions at load increments until they could only perform 1 repetition to determine their perceived maximum load (Earle and Baechle, 2004). Five minutes rest was provided between trials and the perceived maximum load of each exercise was determined in no more than 4 sets.

On arrival for testing, participants were given a verbal description of the test and a demonstration prior to commencement of each exercise test. Participants were required to perform a set of standardized stretching exercises (including straight arms behind back, behind-neck stretch and cross arm in front of chest, each for 15-30 s at a point of little discomfort for each position (Torres et al., 2008) as well as 2 warm-up sets of 8 repetitions at 65%-75% of their perceived maximum loads (Wong et al., 2010a). In the 6RM test, the initial weight was arbitrarily selected by the participant (Koshida et al., 2008). Two-kilogram increments were added until participants failed to complete 6 repetitions with the proper technique (Wong et al., 2010a). Five-minute rest was provided between each trial to avoid fatigue which might influence subsequent performance (LeSuer et al., 1997; Willardson and Burkett, 2006). The 6RM load of each exercise was determined in no more than 4 sets (Wong et al., 2010a). In carrying out the bench press exercise, a spotter was present for safety and to assist participants with moving the bar from rack to the starting position above the chest (Earle and Baechle, 2004), as well as to change exercise loads between trials.

Exercise guideline

The exercise instructions were in accordance with the guidelines of National Strength and Conditioning Association (Earle and Baechle, 2004; Baechle and Earle, 2008). All exercises were performed such that it took 2 s each to complete the upward and the downward phases. Participants were instructed to keep the body stable throughout the movement and all movements should be controlled. Any jerking, bouncing or changing body posture was regarded as an incorrect exercise action and that trial was not counted (Earle and Baechle, 2004). Also, the set was rejected if a participant received any assistance from the spotter.

The bench press grip was set at a width equal to 165% of measured biacromial breadth (Simpson et al., 1997). The movement started with the arms fully extended over the chest; the barbell was then lowered until the bar touched the chest at nipple level. One full repetition was completed when the participant returned the barbell to the fully extended arm position.

A closed neutral grip was used for the hammer curl. Participants stood erect and maintained a stationary posture, positioning the dumbbells alongside the thighs. The movement started with arms fully extended, forearms pronated 90°, and dumbbells resting at the sides of the upper thighs. The elbow of one arm was flexed until the dumbbell reached the height of the anterior deltoid at the end of the upward phase, and was then returned to the original position during downward phase. This sequence repeated with the other arm until both arms completed 6 repetitions.

For the barbell bicep curl, participants grasped the bar evenly at shoulder width with a closed supinated grip. The movement started with arms fully extended and barbell resting on the front of the thighs. The elbows were required to remain alongside the trunk throughout the motion. The forearm was then flexed at the elbow during the upward phase until the barbell was at the level of the anterior deltoid. A single repetition was completed when the barbell was lowered under control to the start position. Participants held a dumbbell overhead while gripping the inside of one plate with both hands during overhead triceps extension. The movement started with the arms at a fully extended position above the head. The arms were then flexed at the elbows until the dumbbell was lowered in the downward phase under control to a point where it almost touched the base of the head or neck position in the downward phase (Baechle and Earle, 2008). Participants flexed the wrists at the bottom to avoid having the dumbbell come into contact with the head. The dumbbell was then raised back to the overhead position by extending the forearm at the elbows of a fixed and stable upper arm.

Participants assumed a seated position on vertical back seated bench and the five-point body contact position during the dumbbell shoulder press. With a closed, pronated grip, the movement was started at a fully extended arm position overhead, and dumbbells were lowered in the downward phase until they just brushed contact with the anterior deltoid. The dumbbells were then pressed overhead during the upward phase until the elbows were once again fully extended to complete one full repetition.

Statistical analyses

Values are presented as mean ± SD. Pearson's product moment correlation coefficient was used to examine the relationship between bench press and the other four exercises. Linear regression analysis was used to develop the prediction equations for each of the four exercises with bench press load being a predictor. The accuracy of these predictive equations for each of the exercises was examined by mean absolute percentage error (MAPE) method, and pair-sample t-test to examine the difference between the actual 6RM load and the predicted 6RM load. Fourteen participants were instructed to perform the reliability test within 2 weeks of the initial tests. Pearson product moment correlation coefficient was used to determine the within-participant test-retest reliability. The magnitude of the correlations was determined using the modified scale by Hopkins (2000): trivial: $r < 0.1$; low: 0.1-0.3; moderate: 0.3-0.5; high: 0.5-0.7; very high: 0.7-0.9; nearly perfect > 0.9; and perfect: 1. Coefficient of variation was used to determine the between-participant variance. The significance level was defined as $p < 0.05$.

Results

The 6RM loads for the 5 exercises are presented in Table 1. Test-retest reliability for the 5 exercises was very high to nearly perfect (Table 1), and the coefficient of variation was 17.6–26.9%. Results showed that 6RM bench press load was significantly correlated with the other 4 upper-body exercises' 6RM loads: hammer curl ($r = 0.80$, very high, $p < 0.01$), barbell biceps curl ($r = 0.90$, very high, $p < 0.01$), overhead triceps extension ($r = 0.93$, nearly perfect, $p < 0.01$), and dumbbell shoulder press ($r = 0.87$, very high, $p < 0.01$).

Linear regression showed that the 6RM bench press load was a significant ($p < 0.01$) predictor for the 6RM loads of hammer curl, barbell biceps curl, overhead triceps extension, and dumbbell shoulder press. The respective prediction equation was presented in Table 2. The MAPE showed that the difference between the actual load and the predicted load ranged between 6.52% and 8.54% (Table 3). There were no significant differences between the actual 6RM loads and the predicted 6RM loads in the four equations ($p > 0.05$, Table 3).

Discussion

The aim of this study was to investigate whether upper body assistance exercises can be predicted from the major bench press exercise 6RM load in a similar way that previous studies were able to predict lower body assistance exercise loads from the lower body major squat exercise load (Ebben et al., 2008; Ebben et al., 2010; Wong et al.

Table 1. Reliability and variation of the 6RM measurements. Data are means (SD).

	6RM Load (kg)	Test-retest reliability	Coefficient of variation (%)
Bench press	50.10 (12.18)	.96 *	26.9
Hammer curl	20.53 (4.32)	.92 *	19.3
Barbell biceps curl	22.62 (4.43)	.97 *	17.6
Overhead triceps extension	16.14 (4.40)	.98 *	25.5
Dumbbell shoulder press	26.65 (5.79)	.82 *	21.9

* $p < 0.01$.

Table 2. **The 6RM prediction equations, regression values and the statistical power for each exercise (n = 29).**

Equation	R^2	SEE (kg)	Statistical power
Hammer curl = Bench press (0.28) + 6.30kg *	.64	2.63	.99
Barbell biceps curl = Bench press (0.33) + 6.20kg *	.81	1.95	.99
Overhead triceps extension = Bench press (0.33) - 0.60kg *	.86	1.69	1.00
Dumbbell shoulder press = Bench press (0.42) + 5.84kg *	.76	2.87	.99

* $p < 0.01$. SEE = Standard error of the estimate.

2010b). The results confirmed our hypothesis that the lower body predictive method could be applied to upper body exercises. Previous findings support the present results in that there is a high correlation between the weight lifted in a major multi-joint exercises and that which can be lifted in assistance exercises, suggesting the former may be a good predictor for exercises that demonstrate similar agonist and antagonist muscle movements (Ebben et al., 2008; Ebben et al., 2010; Wong et al., 2010b). This study shown that test-retest reliability of the 6RM load measurement on upper body exercise ranged from very high to nearly perfect, indicating a reliable within-participant measurement of all exercises used in the present study. Through the formulation of linear regression equations, the time required to determine upper body exercises loads could be substantially reduced by avoiding the trial and error method. Nonetheless, the large coefficient of variation (17.6–26.9%) may imply large between-participant variance in this group of physically active individuals, and thus coaches should pay special attention when using the equations developed by this study.

The result of this study suggested that the 6RM bench press load was a significant predictor ($p < 0.01$) for hammer curl, barbell bicep curl, overhead triceps extension and dumbbell shoulder press (Table 2). Nonetheless, higher shared variances were found in barbell bicep curl and overhead triceps extension, whereas the hammer curl and shoulder press exercises both showed relatively lower shared variances to the bench press. The reason may be due to the nature of the exercises in that both the hammer curl and shoulder press exercises involve holding a separate weight in each arm, whereas bench press, bicep barbell curl and overhead triceps extension use two hands to simultaneously lift the same weighted object. Hence the latter three exercises are more bilateral in nature. It has been shown that the strength generating capacity may be compromised when homologous limbs contract bilaterally, a phenomenon referred to as bilateral strength deficit. This occurs when maximal voluntary strength of a bilateral contraction is less than the sum of strength shown in either right or left limbs when contracting alone (Jakobi and Chilibeck, 2001). Monteiro and Simao (2006) did not find bilateral strength deficits in 10RM load, as opposed to maximal strength. Nonetheless, it appears that there may be higher correlations when exercises of the same nature, i.e., bilateral exercises, are predicted from other bilateral exercises. This may lend some support to the lower correlations between bilateral bench press and the two dumbbell assistance exercises.

Additionally, weight training exercises can be divided into open or closed kinetic chain with the former referring to exercises where the distal segment is not fixed with any external resistance while the distal segment of the latter is fixed (Earle and Baechle, 2004; Prokopy et al., 2008). In this sense, all of the exercises used in this study share similar biomechanical characteristic, in that they are all open chain exercises, which may help explain the high correlation in these exercises.

When making use of predictive equations, users should be aware of variables that might affect these equations. For instance, this study incorporated a slow tempo (2 s for concentric phase and 2 s for eccentric phase) for all the exercises. It has been reported that stretch-shortening cycle in a faster tempo bench press would increase the number of repetitions at a given intensity, considering the pre-stretched muscles can generate more power and work outputs than those do not (Sakamoto and Sinclair, 2012). Additionally, all barbell exercises utilized a grip width that was assessed according to participants' biacromial breadth and it has been shown that grip width affects the muscle recruitment pattern of the same strength exercise (Lehman, 2005). The training experience of participants and degree of familiarization with the exercises should also be considered. Since improvements in training loads are mostly due to initial improvement in neural factors for recreationally-trained and untrained individuals (Earle and Baechle, 2004), there may be a greater learning effect during the data collection session if familiarization sessions are not previously carried out. Therefore, the purpose of placing the familiarization session before data collection sessions was to minimize the learning effect as it is likely that they have different training backgrounds.

The present study was carried out in collegiate athletes and recreationally active individuals with weight training experience (2.9 ± 2.1 years), so there remains a question of whether these equations may be applicable to elite level athlete populations. Extra measures and possibly adjustments to upper body exercise equations are needed if they are to be applied to different participant groups with different athletic backgrounds and genders.

Table 3. **The accuracy of the 6RM prediction equations (n = 29).**

Equation	Mean difference (actual load - predicted load)	MAPE (%)
Hammer curl = Bench press (0.28) + 6.30kg	.42kg *	8.54
Barbell biceps curl = Bench press (0.33) + 6.20kg	.37kg *	6.52
Overhead triceps extension = Bench press (0.33) - 0.60kg	.54kg *	7.78
Dumbbell shoulder press = Bench press (0.42) + 5.84kg	.29kg *	7.05

* Not significant in t-test comparison. MAPE = Mean absolute percentage error.

Conclusion

The bench press is a major upper body strengthening exercise commonly performed with other upper body exercises using similar prime movers. Using the results of this study, coaches can predict loads for other upper body assistance exercises effectively based on bench press data, or use the technique to tweak the accuracy of loads. It also provides a relatively simple way to calculate loads for assistance exercises, which may be deemed unsafe for carrying out a 1RM. For the ordinary fitness room users, these equations provide scientific information about the determination of free weight upper-body exercise loads, which could help users save time and gain a better understanding of how to estimate loads for exercises of the upper body.

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References

Andrade, R., Araujo, R.C., Tucci, H.T., Martins, J. and Oliveira, A.S. (2011) Coactivation of the shoulder and arm muscles during closed kinetic chain exercises on an unstable surface. *Singapore Medical Journal* **52**, 35-41.
Baechle, T.R. and Earle, R.W. (2008) *Essentials of strength training and conditioning* (3th ed.). Human Kinetics, Champaign.
Cha, M.H., Shin, H.D., Kim, K.S., Lee, B.H. and Yoon, Y. (2006) The effects of uncoupling protein 3 haplotypes on obesity phenotypes and very low-energy diet-induced changes among overweight Korean female subjects. *Metabolism: Clinical and Experimental* **55**, 578-586.
Earle, R.W. and Baechle, T.R. (2004) *NSCA's Essentials of Personal Training*. Human Kinetics, Champaign.
Ebben, W.P. and Blackard, D.O. (2001) Strength and conditioning practices of National Football League strength and conditioning coaches. *Journal of Strength and Conditioning Research* **15**, 48-58.
Ebben, W.P., Carroll, R.M. and Simenz, C.J. (2004) Strength and conditioning practices of National Hockey League strength and conditioning coaches. *Journal of Strength and Conditioning Research* **18**, 889-897.
Ebben, W.P., Feldmann, C.R., Dayne, A., Mitsche, D., Chmielewski, L.M., Alexander, P. and Knetgzer, K.J. (2008) Using squat testing to predict training loads for the deadlift, lunge, step-up, and leg extension exercises. *Journal of Strength and Conditioning Research* **22**, 1947-1949.
Ebben, W.P., Long, N.J., Pawlowski, Z.D., Chmielewski, L.M., Clewien, R.W. and Jensen, R.L. (2010) Using squat repetition maximum testing to determine hamstring resistance training exercise loads. *Journal of Strength and Conditioning Research* **24**, 293-299.
Elliott, K.J., Sale, C. and Cable, N.T. (2002) Effects of resistance training and detraining on muscle strength and blood lipid profiles in postmenopausal women. *British Journal of Sports Medicine* **36**, 340-344.
Hopkins, W.G. (2000) Measures of reliability in sports medicine and science. *Sports Medicine* **30**, 1-15.
Jakobi, J.M. and Chilibeck, P.D. (2001) Bilateral and unilateral contractions: possible differences in maximal voluntary force. *Canadian Journal of Applied Physiology* **26**, 12-33.
Koshida, S., Urabe, Y., Miyashita, K., Iwai, K. and Kagimori, A. (2008) Muscular outputs during dynamic bench press under stable versus unstable conditions. *Journal of Strength and Conditioning Research* **22**, 1584-1588.
Lehman, G.J. (2005) The influence of grip width and forearm pronation/supination on upper-body myoelectric activity during the flat bench press. *Journal of Strength and Conditioning Research* **19**, 587-591.
LeSuer, D.A., McCormick, J.H., Mayhew, J.L., Wasserstein, R.L. and Arnold, M.D. (1997) The accuracy of prediction equations for estimating 1-RM performance in the bench press, squat, and deadlift. *Journal of Strength and Conditioning Research* **11**, 211-213.
Maynard, J. and Ebben, W.P. (2003) The effects of antagonist prefatigue on agonist torque and electromyography. *Journal of Strength and Conditioning Research* **17**, 469-474.
Monteiro, W.D. and Simao, R. (2006) Is there bilateral deficit in the practice of 10RM in arm and leg exercises? *Revista Brasileira de Medicina do Esporte* **12**, 104-107.
Ojasto, T. and Hakkinen, K. (2009) Effects of different accentuated eccentric load levels in eccentric-concentric actions on acute neuromuscular, maximal force, and power responses. *Journal of Strength and Conditioning Research* **23**, 996-1004.
Prokopy, M.P., Ingersoll, C.D., Nordenschild, E., Katch, F.I., Gaesser, G.A. and Weltman, A. (2008) Closed-kinetic chain upper-body training improves throwing performance of NCAA Division I softball players. *Journal of Strength and Conditioning Research* **22**, 1790-1798.
Robbins, D.W., Young, W.B., Behm, D.G. and Payne, W.R. (2009) Effects of agonist-antagonist complex resistance training on upper body strength and power development. *Journal of Sports Sciences* **27**, 1617-1625.
Sakamoto, A. and Sinclair, P.J. (2012) Muscle activations under varying lifting speeds and intensities during bench press. *European Journal of Applied Physiology* **112**, 1015-1025.
Schick, E.E., Coburn, J.W., Brown, L.E., Judelson, D.A., Khamoui, A.V., Tran, T.T. and Uribe, B.P. (2010) A comparison of muscle activation between a Smith machine and free weight bench press. *Journal of Strength and Conditioning Research* **24**, 779-784.
Simpson, S.R., Rozenck, R., Garhammer, J., Lacourse, M. and Storer, T. (1997) Comparison of one repetition maximum between free weight and universal machine exercises. *Journal of Strength and Conditioning Research* **11**, 103-106.
Spennewyn, K.C. (2008) Strength outcomes in fixed versus free-form resistance equipment. *Journal of Strength and Conditioning Research* **22**, 75-81.
Torres, E.M., Kraemer, W.J., Vingren, J.L., Volek, J.S., Hatfield, D.L., Spiering, B.A., Ho, J.Y., Fragala, M.S., Thomas, G.A., Anderson, J.M., Hakkinen, K. and Maresh, C.M. (2008) Effects of stretching on upper-body muscular performance. *Journal of Strength and Conditioning Research* **22**, 1279-1285.
Wagner, L.L., Evans, S.A., Weir, J.P., Housh, T.J. and Johnson, G.O. (1992) The effect of grip width on bench press performance. *International Journal of Sport Biomechanics* **8**, 1-10.
Willardson, J.M. and Burkett, L.N. (2006) The effect of rest interval length on bench press performance with heavy vs. light loads. *Journal of Strength and Conditioning Research* **20**, 396-399.
Wong, P.L., Chaouachi, A., Chamari, K., Dellal, A. and Wisloff, U. (2010a) Effect of preseason concurrent muscular strength and high-intensity interval training in professional soccer players. *Journal of Strength and Conditioning Research* **24**, 653-660.
Wong, D.P., Tan, E.C., Chaouachi, A., Carling, C., Castagna, C., Bloomfield, J. and Behm, D.G. (2010b) Using squat testing to predict training loads for lower-body exercises in elite karate athletes. *Journal of Strength and Conditioning Research* **24**, 3075-3080.

Key points

- The bench press load was significantly correlated with the loads of the 4 assistance exercises.
- No significant differences were found between the actual load and the predicted load in the four equations.
- 6RM bench press load can be a time effective and accurate method to predict training loads for upper body assistance exercises.

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