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Comparison of the Effects of Three Different Weight-Training Programs on the One Repetition Maximum Squat

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ABSTRACT

This study compares the effects of 3 weight-training programs on the 1 repetition maximum (1RM) squat (SQ). Subjects were 21 college-age men. The criteria for subject inclusion was initial 1RM >110 kg and >1.3 × body mass and the ability to complete >80% of the programmed repetitions. The groups were Group 1 ($n = 5$) 5 × 6RM, Group 2 ($n = 9$) stepwise periodized model, and Group 3 ($n = 7$) overreaching periodized model. Groups 1 and 2 were equalized on programmed repetitions (720 and 732), and Group 3 was programmed at 18 and 19.4% fewer repetitions (590). Actual repetitions achieved for Groups 1–3 were 619, 629, and 529, respectively. The 1RM squat was measured before and after 12 weeks. Within-group analysis showed that only Groups 2 and 3 increased significantly ($p < 0.05$) in the 1RM (kg ± *SD*): Group 1, 141.4 ± 28.1–155.4 ± 23.7; Group 2, 124.8 ± 12.0–143.4 ± 12.1; and Group 3, 132.8 ± 17.0–153.3 ± 19.3. Derived variables were squat (SQ) × body mass^{-1} and SQ gain score × Sinclair coefficient (the method of obviating differences in body mass). Percent differences between groups for Groups 1 and 2 were SQ = 33, SQ × body mass = 53, and Sinclair formula = 33. For Group 3, SQ = 46, SQ × body mass = 67, and Sinclair formula = 109. These data indicate that periodized models increased the 1RM squat to a greater extent than a constant repetition scheme, even when the repetitions were equalized (Group 1 vs. Group 2) or when the repetitions were substantially fewer (Group 1 vs. Group 3).

Key Words: strength, exercise, resistance training

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Introduction

Periodization may be defined as a ''logical phasic method of manipulation of training variables in order to increase the potential for achieving specific performance goals'' (27). Thus a basic tenet of periodization is training nonlinearity. The goals of periodization are (a) reduced overtraining potential, and (b) peaking at the appropriate time or providing a maintenance program for sports with a specific season. The goals are met by appropriately manipulating volume, intensity factors, and by appropriate exercise selection. Briefly, periodized training can be divided into 3 stages or levels: (a) the macrocycle (long-length cycle), (b) the mesocycle (middle-length cycle), and (c) the microcycle (short-length cycle, day to day variation). Each macro- and mesocycle generally begins with a high-volume, low-intensity of training and ends with a high-intensity, low-volume of training. The macro- and mesocycle can contain 4 phases: (a) general preparation, (b) competition, (c) peaking, and (d) transition or active rest. Each of these phases have different goals and require different levels of variation. Theoretically, well-planned periodized programs can allow for tighter control of training variables, superior performance adaptations, and generally superior performance at the appropriate time, such as peaking phases (6, 25).

The use of training factor variation or periodized strength training programs has gained considerable popularity in recent years. However, few studies have attempted to examine models of periodized/variation programs for strength training (1, 9–19, 26, 28, 29). All of these studies were of the mesocycle length and were 7–24 weeks in length. Two of the studies are actually a series of comparative studies (11, 16). Of these 14 studies, all but 2 (1, 9) indicated that periodized models produced statistically superior results in 1 or more performance measures relating to strength, power, and high-intensity exercise endurance compared with linear models. Of these papers, only 5 used subjects with a reasonably extensive previous strength-training experience (1, 10, 12, 16, 29).

A factor that may confound interpretation of the efficacy of various mesocycle length models deals with the total work accomplished as a result of the training program. O'Bryant (16) indicated that periodized models result in superior gains in strength that are at least partially independent of total work (volume) accomplished, and that variation of volume and intensity are the more important factors. By partially equating volume by an estimation of work (volume load), Willoughby (29) supported O'Bryant's interpretation. However, Baker et al. (1) found that mesocycle length models of strength training using equalized planned repetition schemes (which assumes work is essentially equal) produced essentially the same gains in maximum strength measures.

Baker et al. (1) suggest that total work (volume) accomplished during a training program is the more important factor, regardless of the variation (or lack of variation) scheme used. Thus it is possible that simply providing a greater volume of work (based on repetitions) would produce greater strength gains. They also indicate that if volume and intensity are equal over a training period, then the gains in strength will be equal (1). On the other hand, if O'Bryant (16) is correct, then superior strength gains are a function of both total work accomplished and manipulation of volume and intensity of training.

Recent evidence suggests that overreaching, if applied properly among advanced athletes, can stimulate a delayed increase in performance (22). Overreaching is a type of periodization/variation in which brief, short-term (1–2 weeks) increases in volume or intensity are followed by a return to normal training. The brief high-volume phase apparently stimulates physiology in a manner resulting in a delayed increase in performance approximately 2–5 weeks after a return to normal training. Stone and Fry (22) have discussed the physiological and performance aspect of overreaching among strength/power athletes.

The purpose of this study was to examine the efficacy of 3 different mesocycle-length (12 week) strength-training models in producing alterations in body mass and the 1RM squat. Two groups were equalized on repetitions, and a third group used significantly fewer repetitions. The purpose of this study was not to elucidate underlying mechanisms, which have been previously discussed (6, 22, 25), but to concentrate on performance change.

Methods

The subjects were 21 male volunteers meeting the following criteria: initial 1RM squat >110 kg and >1.3 × body mass, and the ability to complete at least 80% of the programmed repetitions. All subjects participated in a 2-week training program of 5 × 5RM immediately prior to the initiation of the study. Seven subjects were removed from the data analysis as a result of noncompliance. Initial values for the 21 subjects were body mass = 78.1 ± 9.4 kg and 1RM squat = 131.4 ± 17.5 kg.

The control (Group 1, n = 5) was a nonperiodized linear model (5 × 6RM) with 720 total repetitions programmed (1). Two periodized models were chosen for comparison. A stepwise (volume by repetitions decreases in steps) periodized model (Group 2, n = 9) was used as the comparison group, which used approximately equal (732) programmed total repetitions (1). An overreaching periodized model (Group 3, n = 7) used 590 programmed repetitions. There were 2 overreaching phases at weeks 1 and 9. The models are shown in Tables 1 and 2. The exercise schedule is shown in Table 1. Groups 1 and 2 used RM values for each training session. Group 3 used heavy and light days in order to avoid training to failure (9). For example, in the squat, Monday was an RM day, and on Friday the weight was reduced by 15%.

The 1 RM squat was assessed at 0 weeks and after 12 weeks of training using the methods described by Stone and O'Bryant (25). Additional comparisons were

Table 1. Training protocols.

	Group 1: control (n = 5)
	Weeks 1–12
Major	5 × 6RM
Assistance	3 × 8RM

	Group 2: Stepwise periodization (n = 9)			
	Weeks 1–4	Weeks 5–8	Weeks 9–11	Week 12
Major	5 × 10	5 × 5	3 × 3 (1 × 10)	3 × 3
Assistance	3 × 10	3 × 8	3 × 6	3 × 6

	Group 3: overreach periodization (n = 7)							
	Weeks 1–2	Weeks 3–4	Week 5	Weeks 6–8	Week 9	Week 10	Week 11	Week 12
Major	5 × 10	3 × 5 (1 × 10)	3 × 3 (1 × 5)	3 × 5 (1 × 5)	5 × 5 (1 × 5)	3 × 5 (1 × 5)	3 × 3 (1 × 5)	3 × 3/1
Assistance	3 × 10	3 × 10	3 × 10	3 × 5	3 × 5	3 × 5	3 × 5	3 × 5

* Parentheses indicate 25% less than target sets performed as rapidly as possible; 3 × 3/1 = cluster with 30-second rest between sets. Groups 1 and 2 trained using RM values. Group 3 trained using a heavy and light day protocol.

Table 2. Exercise schedule.

Exercise	Monday	Wednesday	Friday
Squat	x		x
Bench press	x		x
Assistant 1	x		x
Clean pull		x	
Power shrug		x	
Assistant 2		x	

Assistant 1 = incline press; Assistant 2 = lat pull downs.

made using the absolute value of the squat divided by body mass and by applying the Sinclair formula (6, 7). Body mass was measured using a medical scale. Subjects kept logbooks that were used for training data analysis. One or more investigators supervised all training sessions. Data (body mass and 1RM squat) were analyzed using within-group *t*-tests. A Bonferroni adjustment was used to control alpha-level inflation. Significance was determined using an alpha level of 0.05, Bonferroni alpha = 0.0125.

Results

The 1RM squat, squat $\times$ kg^{-1}, and Sinclair values increased significantly in Groups 2 and 3, but not in Group 1. Body mass did not change significantly in any group (Table 3).

Over the 12-week training period, Group 1 accomplished 619 repetitions (86% of the total programmed sets) and used an average relative intensity of 67%; Group 2 accomplished 629 repetitions (86% of total programmed sets) at an average relative intensity of 61%; and Group 3 accomplished 529 repetitions (88% of total programmed sets) at an average relative intensity of 72% of the initial 1RM. Average repetitions per set accomplished were Group 1 = 6.0, Group 2 = 6.6, and Group 3 = 5.2. Training variables over 12 weeks of training are summarized in Table 4.

Discussion

The primary finding of this study indicates that manipulation of training volume and intensity affects the 1RM squat independently from the total or average repetitions accomplished, agreeing with the observations of O'Bryant (16).

Baker et al. (1) suggest that when training volume and intensity are equated by total and average repetitions, short-term strength-training effects on the 1RM squat (and other variables) will be equal. More recently, Schoitz et al. (19) concluded that equal total repetitions across a short-term training protocol produced equal results regardless of variation factors. However, a closer examination of the results presented in this study (19), which used young men undergoing military training, suggests that this is not the case. First it should be noted that the periodization/variation protocol used may not be the most appropriate for improving the selected performance variables (6, 10, 25). For example, the use of very low volumes during the final 4 weeks may not provide an appropriate stimulus for endurance activities; additionally, a prolonged peaking phase (i.e., 4 weeks of increasingly heavy singles) may increase the probability of overtraining (3, 23). The degree of variation used is unclear; apparently there was no day-to-day variation. The running pro-

Table 3. Group body mass and 1RM squat values (M ± *SD*).

	Pre	Post	*p*-Value	Statistical power	Effect size
Group 1: Control					
Body mass (kg)	76.2 ± 10.7	77.4 ± 10.5	0.013	0.896	0.827
Absolute squat (kg)	141.4 ± 28.1	155.4 ± 23.7	0.770	0.437	0.582
Squats kg^{-1}	1.88 ± 0.46	2.02 ± 0.35	0.120	0.499	0.355
Sinclair	174.3 ± 38.2	188.8 ± 29.3	0.100	0.527	0.367
Group 2: Stepwise					
Body mass (kg)	76.5 ± 11.1	77.6 ± 11.6	0.019	0.726	0.516
Absolute squat (kg)	124.8 ± 12.0	143.4 ± 12.1*	0.002	0.725	0.979
Squat $\times$ kg^{-1}	1.66 ± 0.28	1.88 ± 0.31*	0.004	0.662	0.932
Sinclair	154.3 ± 22.0	175.2 ± 22.9*	0.003	0.688	0.955
Group 3: Overreach					
Body mass (kg)	81.7 ± 6.3	81.8 ± 7.3	0.920	0.051	0.002
Absolute squat (kg)	132.8 ± 17.0	153.3 ± 19.3*	0.006	0.747	0.936
Squat $\times$ kg^{-1}	1.63 ± 0.22	1.88 ± 0.27*	0.010	0.692	0.861
Sinclair	154.3 ± 19.5	178.4 ± 23.5*	0.008	0.720	0.902

* Significant within group difference ($p \leq 0.05$; Bonferroni adjustment, $p \leq 0.0125$).

Table 4. Training variables—mean values over 12 weeks of training.

Group	TI (kg)	VL (kg)	RI	TR	%PTR	ARS
1	95	58,805	67	619	86	6.0
2	76	47,804	61	629	86	6.6
3	96	50,581	72	529	88	5.2

TI = average bar mass.
VL = volume load (repetitions × mass lifted).
RI = relative intensity (% of initial 1RM).
TR = total accomplished repetitions.
%PTR = Percentage of total repetitions programmed actually accomplished.
ARS = average repetitions per set.

gram was not integrated in a periodized fashion with the weight-training program, and there is no indication of volume and intensity measures for the running training. Additionally, combining distance-running training with strength training can confound the interpretation of the strength data, particularly in terms of the 1RM squat. Kraemer et al. (13) indicate that distance running training may reduce gains in leg and hip maximum strength, although upper-body maximum strength is largely unaffected. Shoitz et al. (19) point out that in their study, the bench press results improved to a greater extent in the periodized group with no difference in the squat, a result that may have been influenced by the running program. Within-group analyses shows that, even with these apparent design problems, the periodized group showed greater improvement in body composition (% fat), 1RM bench press, timed sit-ups, and, according to the abstract, the ruck run (weighted 10K run) than the constant repetition (linear) group. The linear group was not statistically superior to the periodized group on any of the 3 physical or 6 performance variables measured. These observations indicate that the periodized group actually produced superior overall results.

Although not statistically different, a possible shortcoming of the present study is concerned with differences in initial 1RM squat and body mass. It should be noted that Groups 2 and 3 had initial 1RMs representing 88 and 94% of Group 1. Although these initial differences are similar to the initial percentage differences in the study by Baker et al. (1), one might expect larger gains from weaker groups. However, the same general trends in squat variable gain scores were observed when comparing the 5 strongest subjects from each group. Additionally, the body mass of Group 3 was nearly 5.5 kg higher than the other 2 groups. The relationship between body mass and maximum strength is not a linear function (7, 8, 20); thus mathematical models that allow strength comparisons of individuals with different body masses have been developed (7, 8). The application of the a mathematical model for obviating differences in body mass (20) supports the general trend, indicating the superiority of the periodized groups.

A previous study of short-term strength training using untrained and moderately trained subjects and using both constant repetition and periodized programs suggests that % fat is unchanged or slightly decreased and body mass and lean body mass (LBM) tends to be increased (1, 10). Several researchers have suggested that training volume is strongly related to increases in LBM (1, 16, 19, 21, 25). Although LBM was not measured in this study, based on previous studies (16) it may be argued that the small increases in body mass noted in Groups 1 and 2 were primarily a result of increases in LBM. Increases in LBM may have been partially responsible for the increased maximum 1RM strength in these 2 groups. Group 3, which used a substantially lower total volume of training but a higher average intensity than the other 2 groups, did not show marked changes in body mass. However, Group 3 did show the greatest gains in 1RM variables. Hakkinen (5) suggests that training at higher relative intensities is related to a more complete neural activation. Group 3 used the highest average relative intensity of training, which may have resulted in a greater neural activation compared with Groups 1 and 2. It is possible that different stimuli (hypertrophic vs. neural factors) interacted in different manners to produce the gains in maximum strength noted among the 3 groups in this study. Hakkinen (4) suggests that training for prolonged periods (months) with high intensities and little variation can result in ''neural fatigue'' and is indicative of overtraining. It is possible that neural fatigue influenced the results of Group 1.

Variation is also an important training variable that can have a strong influence on adaptations to a training protocol (2, 10, 25). In terms of the degree and level of variation, there was a continuum: Group 1 < Group 2 < Group 3. There was also a similar continuum for 1RM gains. If average relative intensity (RI) had been the most important factor, then Group 1 (RI = 67%) should have produced superior results compared with Group 2 (RI = 61%). This was not the case. Similar arguments can be made for volume load: Group 1 should have been superior to the other 2 groups. It should also be noted that in the present study, Group 3 used the greatest variation in manipulating training variables, including day-to-day variation, and realized the greatest gains in 1RM despite a lower training volume.

Absolute compliance was not obtained in the present study. This is typically a problem in any training study. Of the 7 subjects who were removed, 4 were in Group 1; all 4 of these subjects complained about the monotony and lack of variation in this program. It should also be noted that the remaining subjects performed only 86–88% of the total programmed repetitions because of missed days or an occasional missed repetition. Although Group 3 was programmed to accomplish 18 and 19.4% fewer repetitions than performed by Groups 1 and 2, the actual percentages were 14.5 and 15.9%. Although this type of noncompliance may affect the outcome, it is difficult to make comparisons to other studies that do not typically report this type of data, but rather report only the programmed sets and repetitions (1, 28).

The results of this study indicate that periodized models increased the 1RM squat to a greater extent than a constant repetition scheme, even when the repetitions were equalized (Group 1 vs. Group 2), or when the repetitions were substantially fewer (Group 1 vs. Group 3). These data, along with the studies of Willoughby (29) and Shoitz et al. (19), indicate that O'Bryant (16) was correct in his assessment of the effects of volume and intensity variation.

Although differences in training volume and intensity can be related to both alterations in physiology and performance, this study supports the periodization/variation concept. Thus it is the appropriate manipulation and sequencing of volume (and intensity) that "guide" the final outcome of a training program (6, 10, 25). Although it is apparent that the manipulation of volume and intensity can influence the outcome of a training program, no 1 study is definitive, and interested readers should carefully survey the literature. It is equally apparent that considerable further study is necessary and should include both sexes. It should be noted that no long-term studies (years) have been carried out, and this leaves a large gap in our current knowledge.

Practical Applications

Periodization/variation has previously been shown to be a superior method of strength/power training (6, 10, 12, 14, 16–19, 28, 29). These studies, along with the present data, suggest that it is the appropriate sequence and combination of training variable manipulation that produces superior results and not simply the amount of work or number of repetitions accomplished.

A basic tenet of periodized programs is nonlinearity. Variables including sets, repetitions, loading, and exercise speed are manipulated such that specific training goals are emphasized during different portions of a meso- or macrocycle (2, 6, 25). In addition to phasic variation of volume and intensity across the mesocycle, there is also day-to-day variation, which appears to be especially important for advanced trainers. Part of the reason for variation, particularly day-to-day variation, concerns the avoidance of overtraining (22, 24).

The present study and previous studies strongly suggest that a periodized approach to training, even over a short term, can produce superior results, especially in previously trained subjects, compared with constant-repetition programs. Additionally, this effect can occur even when the volume and intensity are similar across the training period. Although differences between protocols may appear relatively small, these small differences may confer large differences in performance results. For example, the difference between first and fourth place at the Olympics or World Championships for a variety of sports is typically less than 1.5% (J.T. Kearney, personal communication, June 1996); thus, seemingly small differences may in fact be quite large.

References

1. Baker, D., G. Wilson, and R. Carlyon. Periodization: the effect on strength of manipulating volume and intensity. *J. Strength Cond. Res.* 8(4):235–242. 1994.
2. Fleck, S.J., and W.J. Kraemer. *Designing Resistance Training Programs.* Champaign, IL: Human Kinetics, 1997.
3. Fry, A.C., W.J. Kraemer, B. Femke, J.M. Lynch, J.L. Marsit, E.P. Roy, N.T. Triplett, and H.G. Knuttgen. Performance decrements with high-intensity resistance exercise overtraining. *Med. Sci. Sports Exerc.* 26:1165–1173. 1994.
4. Hakkinen, K. Neuromuscular adaptation during strength training, aging, detraining, and immobilization. *Crit. Rev. Phys. Rehab. Med.* 6(3):161–198. 1994.
5. Hakkinen, K.A., M. Pakarinen, H. Alen, K. Kauhanen, and P. Komi. Neuromuscular and hormonal adaptations in athletes to strength training in two years. *J. Appl. Physiol.* 65:2406–2416. 1988.
6. Harris, G.R., M.H. Stone, H.S. O'Bryant, C.M. Proulx, and R.L. Johnson. Short-term performance effects of high speed, high force, or combined weight training. *J. Strength Cond. Res.* 14(1):14–20. 2000.
7. Hester, D., G. Hunter, K. Shuleva, and T. Kekes-Sabo. Review and evaluation of relative strength handicapping models. *Natl. Strength Cond. J.* 12(1):54–57. 1990.
8. Hunter, G., D. Hester, S. Synder, and G. Clayton. Rationale and methods for evaluating relative strength handicapping models. *Natl. Strength Cond. J.* 12(1):47–53. 1990.
9. Jesse, C., J. McGee, J. Gibson, and M.H. Stone. A comparison of Nautilus and free weight training. *J. Appl. Sports Sci. Res.* 2(3): 59. 1988.
10. Kramer, J.B., M.H. Stone, H.S. O'Bryant, M.S. Conley, R.L. Johnson, D.C. Nieman, D.R. Honeycutt, and T.P. Hoke. Effects of single versus multiple sets of weight training exercises on body composition and maximum leg and hip strength. *J. Strength Cond. Res.* 11(3):143–147. 1997.

11. Kraemer, W.J. A series of studies: the physiological basis for strength training in American football—fact over philosophy. *J. Strength Cond. Res.* 11(3):131–142. 1997.
12. Kraemer, W.J., R.U. Newton, J. Bush, J. Volek, N.T. Triplett, and L.P. Koziris. Varied multiple set resistance training program produces greater gain than single set program. *Med. Sci. Sports Exerc.* 27(5):S195. 1995.
13. Kraemer, W.J., J.F. Patton, S.E. Gordon, E.A. Harmon, M.R. Deschenes, K. Reynolds, R.U. Newton, N.T. Triplett, and J.E. Dziados. Compatibility of high strength and endurance training on hormonal and skeletal muscle adaptations. *J. Appl. Physiol.* 78: 976–989. 1995.
14. Marx, J.O., W.J. Kraemer, B.C. Nindl, L.A. Gotshalk, N.D. Duncan, J.S. Volck, K. Häkkinen, and R.V. Newton. The effects of periodization and volume of resistance training in women. *Med. Sci. Sports Exerc.* 30(5):935, S164. 1998.
15. McGee, D.S., C.T. Jesse, M.H. Stone, and D. Blessing. Leg and hip endurance adaptations to three different weight-training programs. *J. Appl. Sports Sci. Res.* 6(2):92–95. 1992.
16. O'Bryant, H.S. Periodization: a theoretical model for strength training. Doctoral dissertation, Louisiana State University, 1982.
17. O'Bryant, H.S., R. Byrd, and M.H. Stone. Cycle ergometer and maximum leg and hip strength adaptations to two different methods of weight training. *J. Appl. Sports Sci. Res.* 2(2):27–30. 1988.
18. Sanborn,. K.K., R. Boros, J. Hruby, B. Schilling, H. O'Bryant, R. Johnson, T. Hoke, and M.E. Stone. Performance effects of weight training with multiple sets not to failure versus a single set to failure in women. In: *Presentation at the International Symposium on Weightlifting and Strength Training.* K. Häkkinen (ed). Helsinki, Finland, 1998.
19. Schoitz, M.K., J.A. Potteiger, P.G. Huntsinger, and D.C. Denmark. The short-term effects of periodized and constant-intensity training on body composition, strength, and performance. *J. Strength Cond. Res.* 12(3):173–178. 1998.
20. Sinclair, R.G. Normalizing the performance of athletes in Olympic Weightlifting. *Can. J. Appl. Sports Sci.* 10: 94–98. 1985.
21. Stone, M.H., S.J. Fleck, W.J. Kraemer, and N.T. Triplett. Health and performance-related adaptations to resistive training. *Sports Med.* 11(4):210–231. 1991.
22. Stone, M.H., and A.C. Fry. Responses to increased resistance training volume. In: *Overtraining and Overreaching in Sport.* Champaign, IL: Human Kinetics, 1997. pp.
23. Stone, M.H., J. Josey, G. Hunter, J.T. Kearney, A.C. Fry, W.J. Kraemer, R.L. Johnson, D. Ciroslan, and G. Haff. Different taper lengths: effects on weightlifting performance. In: *The International Conference on Overtraining and Overreaching in Sport,* Memphis, TN, July 14–17. pp.
24. Stone, M.H., R. Keith, J.T. Kearney, G.D. Wilson, and S.J. Fleck. Overtraining: a review of the signs and symptoms of overtraining. *J. Appl. Sports Sci. Res.* 5(1):35–50. 1991.
25. Stone, M.H., and H. S. O'Bryant. *Weight Training: A Scientific Approach.* Minneapolis: Burgess International, 1987.
26. Stone, M.H., H.S. O'Bryant, and J. Garhammer. A hypothetical model for strength training. *J. Sports Med. Phys. Fitness* 21: 342–351. 1981.
27. Stone, M.H., H.S. O'Bryant, G.G. Haff, A.J. Koch, B.K. Schilling, R.L. Johnson, and M.E. Stone. Periodization: effects of manipulating volume and intensity (part 1). *Strength Cond. Res.* 21(2):56–62. 1999.
28. Stowers, T., J. McMillan, D. Scala, V. Davis, G.D. Wilson, and M.H. Stone. The short-term effects of three different strength-power training methods. *Natl. Strength Cond. Assoc. J.* 5(3):24–27. 1983.
29. Willoughby, D.S. The effects of mesocycle-length weight training programs involving periodization and partially equated volumes on upper- and lower-body strength. *J. Strength Cond. Res.* 7(1):2–8. 1993.