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Periodization: Effects of Manipulating Volume and Intensity. Part 2

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THE PREVIOUS DISCUSSION OF periodization (Part 1 of this article) dealt with a short history of periodization as well as with a brief description of the goals and underlying concepts. The purpose of the following discussion is to examine the efficacy of short-term (mesocycle-length) periodization models and variation parameters in the context of volume and intensity manipulation. Although some discussion is necessary, the primary purpose of this paper is not to elucidate underlying mechanisms, which have been previously discussed (5, 23, 25), but to concentrate on maximum-strength performance adaptations using the 1 RM (1-repetition maximum) squat as an example. Although portions of this paper are technical in nature, it is important for practitioners, particularly strength and conditioning coaches, to understand the intricacies and nuances of appropriate volume and intensity manipulation. A more complete understanding of these factors will allow the coach to plan training programs with more efficiency and with superior results.

Discussion

Although the majority of comparative studies suggest that periodized training is superior (see Part 1 of this article), Baker et al. (1), using moderately trained subjects, concluded that when training volume and intensity are equated by total and average repetitions, short-term strength-training effects on the 1-RM squat should be equal. Their subjects trained 3 days per week and squatted 2 days per week (1). Three groups were used: GP1 (n = 9) was a linear model (5 (6 RM), GP2 (n = 8) was a stepwise (volume decreasing in steps) periodized model, and GP3 (n = 5) was a variation model in which the number of repetitions per set varied through the week (Table 1).

More recently, Schoitz et al. (18) concluded that equal total repetitions across a short-term training protocol produced equal results regardless of variation fac-

Table 1
Training Volume and Intensity of the Study of Baker et al. (1): Equal Work Equals Equal Results

	Week			
Group	**1–4**	**5–8**	**9–11**	**12**
1	5 × 6	5 × 6	5 × 6	5 × 6
2	5 × 10	5 × 5	3 × 3 (1 × 10)	3 × 3
3	Varied	Varied	Varied	Varied

Group	**Sample size**	**1 RM before training (kg)**	**1 RM after training (kg)**	**Difference (%)**
1	9	115.0	143.6	24
2	8	113.8	142.5	25
3	5	107.0	134.0	25

Note: Values are expressed as number of sets by repetition maximum. Planned repetitions had no statistical differences. No statistical differences were found between groups. The groups trained 3 days a week; subjects were moderately trained.

tors. However, a closer examination of the results presented in this study (18), 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 (5, 12, 25, 27). 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 probabilities of overtraining and reduction in 1-RM variables (3, 24). The degree of variation used is unclear; apparently, there was no programmed day to day variation. The running program was not integrated in a periodized fashion with the weight-training program; there is no record of volume and intensity for the running training. Furthermore, combining distance-running training with strength training may introduce a confounding factor in interpreting strength data, particularly in terms of the 1-RM squat. Kraemer et al. (11) have shown that distance-running training may attenuate gains in leg and hip maximum strength, although upper-body maximum strength is largely unaffected. Schoitz et al. (18) point out that in their study, the bench press performance improved to a greater extent in the periodized group, with no difference in the squat, a result which may have been influenced by the running program. Although not statistically significant, there was a 9.6% difference in squat volume load favoring the linear group, which may have influenced the results. However, even with these apparent design problems, the periodized group showed more improvement (within group analyses) in body composition (percentage fat), 1-RM bench press, timed sit-ups, and (according to the abstract) the ruck run (weighted 10-K run) than did the constant-repetition group. The constant-repetition (linear) group was not statistically superior to the periodized group on any of the 3 physical or 6 performance variables measured. Thus, the periodized group actually produced superior overall results. The results of Schoitz et al. (18) are particularly impressive considering the short training period (10 weeks) and the use of relatively untrained subjects.

Baker et al. (1) also suggest that higher volumes of work should produce greater gains in strength measures. Baker et al. (1) also assume that volume can be accurately indicated by total repetitions. While differences in training volume can be related to alterations in both physiology and performance, it is our contention that it is the appropriate manipulation and sequencing of volume (and intensity) that guide the final outcome of a training program (5, 25). For example, a reexamination of the 1-RM squat data for the 1983 study by Stowers et al. (28) suggests an important role for volume and intensity variation (20). In this study (Table 2), the subjects received 2 weeks of preliminary training/familiarization before the study began, so they were basically untrained, in contrast to subjects in the studies by Baker et al. (1) and Stone et al. (27). There were 3 training groups: G1 = periodization, G2 = 1 set to failure, and G3 = 3 sets to failure. Subjects trained 3 days per week and squatted on Mondays and Fridays. All training sessions were monitored by investigators. The subjects in G1 used RM values for their squats, while the other 2 groups trained to failure; no day to day variation was used in any group. It can be seen that G1 and G3 used somewhat different programmed volumes (repetitions) across the 7-week protocol (Table 2); there was an 8.4% difference favoring G3. If volume (repetitions) were the primary determinant of performance adaptation, then the

gains in squat performance should have favored G3 or, at best, should have been equal. However, the 1-RM gain for G3 was between the values for the other 2 groups, with an 11.6% difference between gains for G1 and G3. Although this study lasted only 7 weeks and used untrained subjects, it indicates the following: (a) very low volumes (i.e., 1 set to failure, such as in G2) are not sufficient to cause optimum increases in the 1-RM squat and (b) when using higher volumes and multiple sets (such as in G1 and G3), intensity and variation are more important factors than volume for 1-RM squat adaptation.

Stone et al. (27) presented evidence supporting the work of O'Bryant (15) and Willoughby (29). 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 1-RM squat. Two groups were equalized on repetitions, and a third group used significantly fewer repetitions. The control (Gp1: n = 5) was a nonperiodized linear model (5 × 6 RM) with 720 total repetitions programmed. Two periodized models were chosen for comparison. A stepwise (volume decreases in steps) periodized model (Gp2: n = 9) was a direct-comparison group that used an approximately equal number (732) of programmed total repetitions. An overreaching periodized model (Gp3: n = 7) used 590 programmed repetitions. Gp 1 and Gp2 were direct comparisons of 2 models used by Baker et al. (1). The models are shown in Table 3. The subjects trained 3 days per week and squatted on Mondays and Fridays. Groups 1 and 2 used RM values for each training session. Group 3 used day to day variation in order to avoid training to failure and overtraining (12). For example, in the squat, Monday was a RM day, and on Friday, the weight was reduced by 15%. Thus, Gp1 did not use any variation, Gp2 used variation on 1 level (across the mesocycle), and Gp3 used variation across 2 levels (across the mesocycle and the microcycle).

Table 2
Training Volume and Intensity of the Study of Stowers et al. (28): Higher Volumes of Work Produce Greater Strength

Group	Sample size	Week 1–2	Week 3–5	Week 6–7
1	23	5 × 10	3 × 5 (1 × 10)	3 × 3 (1 × 5)
2	35	1 × 10–12	1 × 10–12	1 × 10–12
3	26	3 × 10–12	3 × 10–12	3 × 10–12

Group	1 RM before training (kg)	1 RM at 2 weeks (kg)	1 RM at 5 weeks (kg)	1 RM at 7 weeks (kg)	Change (%)
1	95.6	107.6	116.8	125.4*	31
2	95.4	102.3	108.3	111.8	17
3	94.8	106.0	115.1	116.9	23

Group	Programmed repetitions: Total	Programmed repetitions: Average
1	426	7.1
2	154	11
3	462	11

Note: Subjects trained 3 days a week and performed squats on Mondays and Fridays. Programmed repetitions did not include subjects' warm-up exercises. Group 1 used periodization; group 2 used 1 set to failure; and group 3 used 3 sets to failure.
*$P < 0.05$; group 1 < group 2.

Stone et al. (27) made comparisons using the absolute 1 RM, the absolute value of the squat divided by body mass, and by applying the Sinclair Formula, a method of obviating the influence of differences in body mass (6, 7, 19). All training sessions were supervised by 1 or more investigators. The results of this study showed that training using equality of volume and intensity by repetitions does not produce equal results (Table 3), in contrast to the findings of Baker et al. (1). Their results (27) indicate that periodized models increased the squat 1-RM capacity to a greater extent than a constant-repetition (linear) scheme, even when the repetitions were equalized (Gp 1 vs. Gp 2) or when the repetitions were substantially fewer (Gp 1 vs. Gp 3).

Previous study of short-term strength training using untrained and moderately trained subjects and using both constant (linear) repetition and periodized programs suggests that percent fat is unchanged or slightly decreased and that body mass and lean body mass (LBM) tend to be increased (1, 12). Several researchers have suggested that training volume is strongly related to increases in LBM (1, 15, 21, 25). Additionally, Baker et al. (1) suggest that increases in LBM are the primary contributing factor to increases in strength in trained subjects. The data of Stone et al. (27) and Kramer et al. (12) do not complete-

Table 3
Training Volume and Intensity of the Study of Stone et al. (26): Variation Contributes More to Outcome Than Volume

			Week[a]							
Group	**Variation**	**Type**	**1–2**	**3–4**	**5**	**6–8**	**9**	**10**	**11**	**12**
1	Linear	Major	5 × 6	5 × 6	5 × 6	5 × 6	5 × 6	5 × 6	5 × 6	5 × 6
		Assistance	3 × 8	3 × 8	3 × 8	3 × 8	3 × 8	3 × 8	3 × 8	3 × 8
2	Stepwise	Major	5 × 10	5 × 10	5 × 5	5 × 5	3 × 3 (1 × 10)[b]	3 × 3 (1 × 10)	3 × 3 (1 × 10)	3 × 3
		Assistance	3 × 10	3 × 10	3 × 8	3 × 8	3 × 6	3 × 6	3 × 6	3 × 6
3	Overreach	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[c]
		Assistance	3 × 10	3 × 10	3 × 10	3 × 5	3 × 5	3 × 5	3 × 5	3 × 5

	Body mass (kg) (mean ± SD)		1 RM squat (kg) (mean ± SD)	
Group	**Before**	**After**	**Before**	**After**
1	76.2 ± 10.7	77.4 ± 10.5	141.4 ± 28.1	155.4 ± 23.7
2	76.4 ± 11.1	77.6 ± 10.8	124.8 ± 12.0	143.4 ± 12.1*
3	81.7 ± 6.3	81.8 ± 7.3	132.8 ± 17.0	153.3 ± 19.3*

	Gain scores		
Group	**Squat (kg)**	**Squat per body mass**	**Sinclair formula**
1	14.0	0.15	14.6
2	18.6	0.23	19.4
3	20.5	0.25	30.5

Note: subjects trained 3 days a week and performed squats on Mondays and Fridays. [a] Units are measured as number of sets by number of repetitions maximum (RM). [b] Units in parentheses are 25% less than target sets, performed as rapidly as possible. [c] Subjects performed a cluster with 30 seconds' rest between sets. The overreach group used a heavy- and light-day protocol. The other groups used repetition maximum protocol. The average relative intensity for group 1 was 67; for group 2, 61; and for group 3, 72.

ly support this contention. In the 14-week study by Kramer et al. (12) using trained subjects, gains in the 1-RM squat occurred despite little change in body mass or body composition. Although LBM was not measured, Stone et al. (27) argue, on the basis of previous studies, that the small increases in body mass noted in Gp1 and Gp2 (Table 3) were primarily results of increases in LBM that, in turn, were partially responsible for the increased 1-RM squat in these 2 groups. However, Gp3, which used a substantially lower total number of repetitions but a somewhat higher average intensity (Table 3) than the other 2 groups, did not show changes in body mass but did show the greatest gains in 1-RM variables. These studies (12, 27) suggest that substantial strength gain can occur without marked changes in body mass or body composition in moderately trained subjects. Hakkinen et al. (4) suggest that training at higher relative intensities is related to more complete neural activation, which is a possible explanation for the observations of Kramer et al. (12) and Stone et al. (27). It is likely that different stimuli (hypertrophic vs. neural factors) interacted in different manners to produce the gains in maximum strength observed among the various groups (linear vs. periodized/variation) investigated in comparative studies (1, 8–10, 12–18, 26–29). Hakkinen et al. (4) suggest that prolonged training periods (months) with relatively high intensities and little variation can result in "neural fatigue," which is indicative of overtraining. It is possible that neural fatigue influenced the results of Gp1 in the study by Stone et al. (27).

Variation is also an important training variable that can have a strong influence on adaptations to a training protocol (2, 12, 25). In

the study by Stone et al. (27), the degree and level of variation and the 1-RM changes resulted in similar group continuums: Gp1 < Gp2 < G3 (Table 3). If average relative intensity had been the most important factor, then the RM continuum should not have been the same as the variation continuum. 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 periodic 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 that results in a delayed performance increase approximately 2–5 weeks after a return to normal training. The physiological and performance aspects of overreaching among strength/power athletes have been discussed by Stone and Fry (22). In keeping with the concept of overreaching, Gp3 used increases in volume at weeks 1–2 and at week 9 as the overreaching stimulus (Table 3). It should also be noted that in this study (27), the overreaching group (Gp 3) used the greatest volume and intensity manipulation, including day to day variation, and realized the greatest gains in 1 RM despite a lower training volume.

Absolute compliance during longitudinal studies is rarely attained. For example, in the study by Stone et al. (27), of the 7 subjects who were removed for noncompliance, 4 were in Gp1; 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 program. Over the 12-week training period, Gp1 accomplished 619 repetitions (86% of the total programmed sets) and used an average relative intensity of 67%; Gp2 accomplished 629 repetitions (86% of total programmed sets) at an average relative intensity of 61%, and Gp3 accomplished 529 repetitions (88% of total programmed sets) at an average relative intensity of 72% of the initial 1 RM. Average accomplished repetitions per set were 6.0 (Gp1), 6.6 (Gp2), and 5.2 (Gp3). Lack of compliance was due to missed days or an occasional missed repetition. While 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, 26, 28). The disparity between programmed repetitions and actual training volume can be observed in the study by Schoitz et al. (18). Although total programmed repetitions were somewhat similar for the 2 groups (linear = 480 vs. periodized = 458) and represented a 4.6% difference between groups, there was a 9.6% greater volume load used by the linear group (periodized = 36,924 kg vs. linear = 40,468 kg).

The studies by Stone et al. (27), Schoitz et al. (18), and Willoughby (29) indicate that variation can be a major factor in the outcome of strength-training programs, and they lend support to the concept of volume and intensity manipulation as proposed by O'Bryant in 1982 (15). Although it is apparent that the manipulation of volume and intensity can influence the outcome of a training program, the authors wish to point out that no one study is definitive and that interested readers should carefully survey the literature. It is equally apparent that considerable additional study is necessary. It should be noted that there are few studies lasting longer than 15 weeks, that only Kraemer's groups (10, 13) have attempted longer comparative studies, and that there are no true long-term (years) studies investigating multiple mesocycles. This leaves a large gap in our current knowledge.

Summary

Periodization/variation appears to be a superior method of strength/power training (5, 10, 12, 13, 15–18, 27–29). Interestingly, these studies used comparison groups with variation at several different levels. 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.

Practical Aspects

Conceptually, periodized programs are nonlinear. Variables including sets, repetitions, loading, and exercise speed can be manipulated such that specific training goals are emphasized during different portions of a micro-, meso-, or macrocycle (2, 5, 20, 25). In addition to phasic variation of volume and intensity across the mesocycle, there is also day to day variation, which appears to be particularly important for advanced trainers. Part of the reason for variation is the avoidance of overtraining (22, 23, 24).

These 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. Furthermore, this effect can occur even when the volume and intensity are equal across the training period. In this

context, it should be noted that differences between protocols sometimes appear relatively small. It should be noted that the difference in performance between the first- and fourth-place finishers at the Olympics or World Championships for a variety of sports is typically less than 1.5% (J.T. Kearney, USOC, personal communication, June, 1996); thus, seemingly small differences may in fact be quite significant. Although understanding and designing appropriate periodized programs requires some time and effort, the results in the performance arena . ▲

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