

The Short-Term Effects of Periodized and Constant-Intensity Training on Body Composition, Strength, and Performance

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Reference Data

Schiotz, 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 and Cond. Res.* 12(3):173-178. 1998.

ABSTRACT

This study examined the effects of manipulating training intensity on strength, body composition, and performance in trained ROTC cadets. Fourteen male ROTC cadets were pre- and posttested for % body fat and 1-RM strength on the bench press and parallel squat. Performance was measured via the physical fitness components of the Army Ranger Challenge and consisted of push-ups, sit-ups, 2-mile run, and 10-km ruck-run. Subjects were matched according to military experience and randomly assigned to a periodized model or a constant-intensity model for 10 weeks of resistance training. Total training volume was equal between groups. The periodized group significantly increased in 1-RM bench press, 1-RM parallel squat, and push-ups, and significantly decreased % fat and ruck-run time. The constant-intensity group significantly increased 1-RM parallel squat and push-ups, and significantly decreased their 2-mile run and ruck-run time. The periodized group completed the ruck-run significantly faster than the constant-intensity group. The results indicate that following a 10-week training cycle with trained subjects, significant improvements in body composition, strength, and performance can be obtained using two different training programs that have equal total relative training volume.

Key Words: periodization, volume, variation, hypertrophy

Introduction

Muscular strength is an essential component for optimal athletic and military performance. Increases in strength can be achieved with a multitude of program designs. One training method often implemented is periodization, which was developed based on Selye's general adaptation syndrome (GAS) (7, 21, 25). Periodization utilizes the theories of GAS, organizing training into cycles of undulating volume and intensity to achieve training objectives, prevent overtraining, and optimize performance (7, 28).

Periodized training is characterized by high initial volume and moderate intensity. Over the course of an 8- to 12-week mesocycle, intensity progressively increases while volume inversely decreases until a peak is reached at the end of the training period (27). This is done to maximize strength gains and minimize overtraining and staleness. Many periodization models have been developed using these general principles (8, 26, 27). Past research has compared these periodized models to various other training methods of unequal training volume and found periodization to be superior for developing muscular strength (8, 9, 26, 27, 29, 30, 32).

Periodization models have been compared to the traditional, nonperiodized method of training that maintains a constant volume and intensity with no variation (3, 26, 29, 30, 32, 33). Nonperiodized models are typically characterized by 3 sets at a constant intensity or load. A maximal effort intensity ≤ 6 reps has been reported to represent the optimal training range for strength development (2, 5, 8). This nonvaried design of constant intensity and volume elicits strength gains but does not guard against possible overtraining (10, 29).

Prior to Willoughby (33), research on periodization was often conducted with groups of unequal training volumes. This may have created a problem, skewing the comparison between the different training programs. Willoughby compared periodization and two different constant-intensity training systems using partially equated training volumes. Periodization was found to be superior for developing upper and lower body strength when compared to programs with a partially equated training volumes.

However, Willoughby controlled for volume in terms of workload, not number of repetitions or level of intensity. This led Baker et al. (3) to conduct a similar study, while controlling for training volume and relative training intensity. No differences in maximal strength were reported when training volume and relative intensity were equated for a 12-week mesocycle. It was concluded that the reported success of the periodized model over the more traditional methods of strength training might have been due to the higher training volume or intensity rather than the training structure used.

Periodization (8, 9, 26, 27, 29, 30, 32, 33) and constant-intensity training (2, 5, 20, 26, 29, 30, 32) have been reported to increase strength levels. The results of the research that addressed the potential problem of unequal training volume between groups have been split, both for and against periodization as being superior for developing muscular strength. The purpose of this study was to compare the effect of a periodized training program to a constant-intensity resistance training regimen, of equal relative training volume, over a 10-week mesocycle, on body composition and upper and lower body strength in male Reserve Officers Training Corps (ROTC) cadets. A secondary purpose was to determine if increases in strength would enhance performance on an Army Ranger Challenge course.

Methods

Subjects

Initially 22 trained college-age men volunteered for the study. All were enrolled in the university's Army ROTC program. As part of their ROTC commitment, the subjects participated in the Army's physical training program. This program consisted primarily of training for cardiovascular endurance, anaerobic capacity, and muscular strength and endurance with modifications relating to conditions of military service. The subjects were matched for level of training and then randomly assigned to one of two exercise treatment models, either a periodized group (Per) or a constant-intensity group (CI), prior to participating in a 10-week resistance training program.

Level of training was determined from the following ranking: (a) years of prior active military service; (b) years affiliated with an active reserve or National Guard unit; and (c) semesters in the ROTC program. All 22 subjects provided written informed consent in accordance with university guidelines for human experimentation. Of the 40 total exercise sessions, the subjects had to attend 90% to be included in the study. Upon completing the 10-week training program, 6 subjects in the Per group and 8 in the CI group had fulfilled the participation requirement for use in data analyses. Mean (\pm SE) physical characteristics for Per and CI were: age 24.1 ± 1.3 and 21.1 ± 1.8 yrs; Ht 176.0 ± 3.6 and 177.4 ± 4.7 cm; body mass 74.0 ± 2.5 and 77.4 ± 3.4 kg, respectively.

Procedures

Testing. Pre- and posttesting for body composition, muscular strength, and physical performance were conducted over 3 consecutive days. The sequence of tests, protocols, and rest periods for the posttest were consistent with those of the pretest. All subjects were instructed to abstain from additional physical activity during the testing period.

Body mass was measured on a digital scale to the nearest 0.1 kg. Body composition was determined via skinfold measurements taken with a Harpenden cali-

per. All measures were made on the right side of the body by the same experienced tester, using identical anatomical points for pre- and posttesting (1). Three skinfold measures were collected—chest, abdomen, and thigh—then averaged to calculate body density (18) with % body fat determined using the Siri equation (23).

Maximum strength on the bench press and parallel squat were determined using Olympic standard free weights. Two days before testing, proper techniques and procedures were explained and demonstrated for both exercises. Subjects then practiced each exercise and were critiqued by the primary investigator. The one-repetition maximum (1-RM) for bench press and parallel squat was measured according to published guidelines (34). The progression of incremental load increases used for both tests had already been established for 1-RM testing (4). The subject and primary investigator determined the initial starting weight. The load was increased by 5 kg after each successful lift until the bar became difficult to raise. At this point the load was increased in 2.5-kg increments per lift until a maximum was achieved. The 1-RM was determined to be the maximal weight lifted after 2 consecutive unsuccessful trials.

Physical Performance Testing. Physical performance was determined according to scores achieved on the Army Ranger Challenge, a battery of tests used by the Army for competition and physical fitness assessment of ROTC cadets. The physical performance component of the Ranger Challenge consists of the Army Physical Fitness Test which includes push-ups, sit-ups, 2-mile run, and a 10-km run carrying a 15-kg ruck sack. All subjects were familiar with the test.

Performance scores on push-ups and sit-ups were determined by the number of successful repetitions completed in a 2-min trial. The push-up test began with the arms at full extension, body in a straight line, and hands shoulder-width apart. The chest was then lowered until the humerus was at least parallel with the floor, at which point the arms were extended to a locked position. Each repetition during the sit-up began with the subject supine, knees flexed at 90°, ankles held by a partner, and the fingers interlocked behind the head with the back of the hands touching the floor. One repetition was deemed successful when the subject sat up raising his upper body forward to or beyond the vertical position. The vertical position is defined as the base of the neck rising above the base of the spine (13).

The 2-mile run was performed on an indoor 230-m track. The ruck-run was completed outdoors on a measured 10-km road course. Scores for both tests were determined by the amount of time required to complete the specified distance of the test. The ruck-run is a field test the Army uses as a measure of muscular endurance and cardiovascular fitness. It involves running a distance of 10 km while carrying a 15-kg pack, a rubber M16A1 rifle weighing 3.3 kg, and attired in the Army's battle uniform. It was developed to train military per-

sonal under conditions approximating those experienced during combat or field exercises.

Training Procedures. The subjects trained on both Olympic free weights and Universal power circuit exercise machines. The training program was selected to develop strength in all major muscle groups including chest, back, trunk, and legs. Training of the minor muscle groups included shoulders, triceps, and biceps. Sets and reps for Per training were established to match the total training volume of the CI group. Based on past research, it is generally accepted that 3 sets of 6 reps is close to the optimal range for strength development (11, 12). The selection of exercises, sequence, and rest periods was identical for both training models. In addition, total relative training volume for core lifts (bench press and parallel squat) was equated between groups for the 10-week mesocycle. Relative training volume was calculated by multiplying the number of reps \times percent intensity for each set. Relative training volumes for each set were then summed over the course of the 10-week training cycle to reach total relative training volume. Total relative training volume was equal for both groups during the training program:

Week	Per Group	CI Group
1	120.0	76.8
2	121.0	76.8
3	104.0	76.8
4	84.5	76.8
5	82.5	76.8
6	82.2	76.8
7	54.6	76.8
8	49.7	76.8
9	35.9	76.8
10	33.8	76.8
<i>Total</i>	768.2	768.0

Supervised training was conducted 4 days a week for each training protocol. On Days 1 and 3 the core exercise was the bench press. Assistance exercises included shoulder press, triceps extension, and abdominal crunch machine. On Days 2 and 4 the core exercise was the parallel squat. Assistance exercises included leg curl, seated row, biceps curl, and body weight abdominal exercises. Table 1 illustrates the set and rep progression for each training model. Table 2 outlines the schedule of exercises. A rest day was scheduled between Days 2 and 3.

In addition to the resistance training exercise sessions, both groups participated in identical aerobic running workouts 4 days a week immediately after the weight training sessions. The workouts consisted of the following training methods: Day 1, aerobic interval training; Day 2, long slow distance training (LSD) carrying a progressively weighted ruck-sack; Day 3, anaerobic interval training; Day 4, LSD training with no load.

To control for possible outside influences, all subjects were instructed to consume their normal diet and

Table 1
Exercise Treatment Models

Model									
<i>Constant</i> Wks 1-10 (Begins at 4 \times 6 ^a 80% 1-RM, progressing 3 \times 8 ^b at Ss' pace as they 4 \times 15 ^c increase strength) 8 \times 20 ^d									
<i>Periodized</i> Wk 1,2 Wk 3 Wk 4 Wk 5 Wk 6 Wk 7 Wk 8 Wk 9,10 (Begins at 5 \times 10 ^a 3 \times 10 2 \times 8 1 \times 8 1 \times 8 1 \times 8 2 \times 5 2 \times 5 2 \times 3 50% and 1 \times 8 3 \times 5 1 \times 6 4 \times 5 2 \times 5 1 \times 3 4 \times 1 progresses 1 \times 6 3 \times 5 1 \times 3 1 \times 2 to 105% 1 \times 1 1 \times 1 1-RM 3 \times 10 ^b 3 \times 10 3 \times 8 3 \times 8 3 \times 8 3 \times 6 3 \times 6 3 \times 4 on core 4 \times 20 ^e 4 \times 20 4 \times 15 4 \times 15 4 \times 15 4 \times 15 4 \times 10 4 \times 10 exerc. 8 \times 30 ^d 8 \times 30 8 \times 30 8 \times 30 8 \times 25 8 \times 25 8 \times 25 8 \times 20 Wks 3 & 7 = unloading weeks)									

^aCore exercises (bench press, parallel squat); ^bAssistance exercises (shoulder press, triceps exten., leg curl, seated row, biceps curl); ^cAbdominal crunch machine; ^dBody weight abdominal exercises.

Table 2
Schedule of Exercises

Exercise	Day:	1	2	3	4
Bench press ^a		x		x	
Shoulder press ^b		x		x	
Triceps extension ^b		x		x	
Abdominal machine ^b		x		x	
Parallel squat ^a			x		x
Leg curl ^b			x		x
Seated row ^b			x		x
Biceps curl ^b			x		x
Body weight abdominal ^b			x		x

^aCore exercise; ^bAssistance exercise

refrain from using any ergogenic aids throughout the 10-week training period. They were also instructed to avoid all supplemental exercise not associated with this research.

Data Analysis

An analysis of covariance, with pretest scores as the covariant, was used to determine if the two groups were significantly different following training. Within-group differences were determined using paired *t*-tests. An alpha probability level ≤ 0.05 was used to test for statistical significance. All values were reported as mean \pm standard error (*SE*). Due to the small subject number in each group, the statistical power for each dependent variable is reported as $1-\beta$.

Results

Relative training volume was not significantly different between groups for either the bench press or parallel squat. Training volume for the bench press was $30,612 \pm 2,236$ kg for the Per group and $32,743 \pm 2,591$ kg for the CI group. Training volume for the parallel squat was $36,924 \pm 3,463$ kg for the Per group and $40,468 \pm 3,430$ kg for the CI group.

The data for *anthropometric measures* are found in Table 3. After training, there were no significant differences between groups for body mass ($1-\beta = 0.072$), LBM ($1-\beta = 0.400$), and % Fat ($1-\beta = 0.105$). The periodized training group had a nonsignificant 1.2% increase in LBM and a significant decrease in % Fat, from 11.6 to 9.9%. The CI group also showed changes in LBM and % Fat. There was a 0.6% increase in LBM and a decrease in % Fat from 10.4 to 9.7%; however, neither change was significant. Body mass showed a nonsignificant change for both groups.

Dynamic 1-RM *strength* data for the bench press and parallel squat are shown in Table 4. Both groups improved 1-RM bench press strength pre- to posttesting by 8.3 and 5.0%, respectively. No significant differences were found between groups in bench press 1-RM strength ($1-\beta = 0.079$). Only the Per group had in a significant improvement in bench press performance. Parallel squat 1-RM strength significantly improved by 9.7 and 11.2% for Per and CI, respectively. No significant differences were found between groups for the 1-RM parallel squat ($1-\beta = 0.142$).

The data from the four *physical performance* components of the Army Ranger Challenge (push-ups, sit-ups, 2-mile run, ruck-run) are shown in Table 5. The Per group significantly improved in the number of push-ups by 15.5% and significantly decreased their ruck-run time by 9.5%. The 2-mile run time improved by 2.3% and sit-ups increased by 6.5%; however, these values did not represent a statistically significant improvement. The push-ups and ruck-run scores for the CI group significantly improved by 17.9 and 4.7%, respectively, and the 2-mile run time by 5.5%. Sit-up performance increased by 13.2%, but this value was not significantly different from pretest. No significant differences were found between groups for push-ups, sit-ups, 2-mile run, or ruck-run ($1-\beta = 0.140, 0.090, 0.053$, and 0.568, respectively).

Discussion

Concerning anthropometric measures, the body mass and LBM of both groups remained relatively unchanged, but % Fat did decrease in the Per group. Previous research has reported similar changes in body composition from resistance training (3, 16, 25, 26). Increases in LBM have been found to be directly related to the volume of training (6, 22, 24, 26, 27), and increases in muscular strength have been found to be directly related to increases in LBM (3, 6, 26, 27).

Table 3
Anthropometric Measures Following Training

Group	Body mass (kg)		Lean body mass (kg)		% Fat	
	Pretest	Posttest	Pretest	Posttest	Pretest	Posttest
Periodized	74.0	73.5	64.8	65.5	12.6	11.1*
	± 4.2	± 4.1	± 4.2	± 4.2	± 2.1	± 2.0
Constant	77.5	77.3	67.2	67.5	12.8	12.2
	± 3.7	± 3.4	± 3.0	± 2.9	± 2.7	± 2.8

No signif. diff. between groups. *Signif. diff. from pretest to posttest, $p \leq 0.05$.

Table 4
Muscular Strength Measures Following Training

Group	Bench press (kg)		Parallel squat (kg)	
	Pretest	Posttest	Pretest	Posttest
Periodized	72.9	80.4*	88.5	99.8*
	± 8.3	± 8.1	± 9.9	± 10.1
Constant	80.9	85.7	96.3	109.4*
	± 7.6	± 6.7	± 9.6	± 7.3

No signif. diff. between groups. *Signif. diff. from pretest to posttest, $p \leq 0.05$.

Table 5
Army Ranger Challenge Performance Measures Following Training

Group	Push-ups		Sit-ups		2-Mile run (sec)		Ruck-run (sec)	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Periodized	56.3	65.7*	69.4	75.1*	856.0	833.0	4416.3	3962.4*
	± 6.1	± 6.3	± 3.3	± 3.6	± 31.2	± 41.6	± 143.8	± 188.8
Constant	56.6	72.0*	61.2	69.1	930.2	908.6	4749.5	4526.8*
	± 6.7	± 9.6	± 7.2	± 7.2	± 42.8	± 59.0	± 123.3	± 72.4

No signif. diff. between groups. *Signif. diff. from pretest to posttest, $p \leq 0.05$.

If training volume is actually the essential component in gaining LBM, then it seems likely that two programs of equal training volume, as in this research, would not differ significantly in LBM gains over a short training cycle. The Per group gained 0.5 kg more LBM than the CI group. This slightly higher gain in LBM may be attributed to the hypertrophy phase in the periodized training model (25–27). Although total training volumes were equal, the periodized training was initiated with a high volume hypertrophy phase, which may have contributed to the larger percent increase in LBM for the Per group.

Both training models resulted in a decrease in % Fat, yet only in the Per group was it statistically significant. This decrease in % Fat may be attributed to a gain in LBM. The gaining of LBM increases basal metabolic rate (BMR), thus more calories are expended during a

resting state. An increase in BMR is a major factor contributing to a reduction in % Fat (6).

Concerning muscular strength, the improvements in bench press and parallel squat 1-RM were statistically similar between groups following the 10-week training cycle. This indicates that when the same relative training volume is undertaken over a short training cycle, subjects at this training level achieve similar results regardless of the training structure used. This confirms the findings of Baker et al. (3), who reported no differences in bench press and squat when training volume and relative intensity were equated between a periodized model and a constant-intensity model. Stowers et al. (29) also reported no differences in bench press strength between the linear increasing intensity method and the traditional method of strength training using constant volume and intensity. In earlier studies the superiority of periodized training over traditional constant-intensity strength training methods may have been due to the higher training volume (19, 26, 29) rather than the structure of training.

The increases reported in bench press and squat strength were in agreement with other researchers who have used similar training periods (3, 29, 33). The results also suggest that the degrees of improvement in bench press strength, 8.3 and 5.0% for Per and CI, respectively, were not as high as those in squat strength, at 9.7 and 11.5%, respectively. This finding has been reported in previous research (2, 29, 33). Stowers et al. (29) and Willoughby (33) suggested one reason may be that the smaller muscle mass used in the bench press produces smaller strength gains over a short training cycle.

Another possible issue could be recovery time. It has been reported that the upper body recovers faster than the lower body (29, 31). Therefore, it may be that the upper body tolerates greater workloads (higher intensities and training volumes), and it may take greater workloads to stimulate a greater training effect. The smaller strength gains (upper body) could make it harder to achieve significant differences between groups (29). In the present study the Per training model contained a high intensity phase which may have contributed to the significant increase in bench press strength. The CI training model maintained a moderate intensity throughout the mesocycle; this could have resulted in the reported nonsignificant increase, due to insufficient training stimulus to elicit upper body strength gains.

The training level of the subjects is also a factor to consider when interpreting the results of this research. Their prior training regimen consisted primarily of training for cardiovascular and muscular endurance, with limited structured resistance training. Novice resistance trainers typically gain strength during the first few weeks of training, with only minimal changes in cross-sectional area of muscle fibers. These initial increases in strength are attributable to neural adaptations that in-

clude increased rate of motor unit stimulation, enhanced recruitment of high-threshold motor units, improved coordination of antagonistic muscle groups, and enhanced motor unit synchronization (25). As the training program progresses, neural adaptations stagnate and hypertrophic actions begin to account for most of the increases in strength (25). Due to the subjects' initial training level, the training period may not have been long enough to elicit strength increases that would result in significant differences.

The structure of the training program may also have contributed to lack of significant differences. The training program consisted of strength training and aerobic training. Past research has reported that training for strength and endurance simultaneously will interfere with the rate of strength development (14, 15, 17). Hickson (14) found more than a 20% difference in strength gains between subjects who participated in programs training for strength and endurance simultaneously and those who only strength trained. It seems a longer training cycle would be needed in order to obtain significant differences in strength.

Concerning physical performance testing, both groups improved their scores on all measures. Increases in the muscular endurance tests (push-ups and sit-ups) may have resulted from an increase in muscular strength. A stronger muscle can contract at a lower percent of its maximal contractile force, thus experiencing greater blood perfusion through the active muscle tissue. This enhanced blood perfusion rate increases muscular endurance by enabling a greater contribution to adenosine triphosphate (ATP) production via oxidative metabolism, increasing lactate removal from the tissues, and decreasing creatine phosphate (CP) depletion. When performing a maximal muscular endurance test, the point of fatigue coincides with the depletion of CP (6). Increased blood flow brings more oxygen to the muscle fibers, thus allowing oxidative metabolism to contribute to the replenishment of ATP, decreasing lactate production, and delaying the utilization of CP in ATP restoration. This allows more muscular contractions to be performed before CP levels are depleted, lactate concentration increases, and fatigue occurs.

The 2-mile run time was significantly decreased for the CI group, and the ruck-run times of both groups also decreased significantly. The 2-mile run is a measure of cardiovascular endurance while the ruck-run measures both cardiovascular and muscular endurance. The significant decrease in 2-mile run and ruck-run times may have been attributable to an enhanced muscular endurance capacity resulting from an increase in strength.

During short-term, high intensity aerobic exercise such as the ruck-run, lactate accumulates due to increased energy demand. This lactate decreases pH, causing force production to decline and contributing to a decrease in running velocity (6). Increases in muscular

strength developed during resistance training enable the trained muscle fibers to contract at a lower percent of their maximal contractile force, thus producing less lactate and increasing blood perfusion through the active muscle tissue and enhancing the clearance of lactate.

Practical Applications

Given the varied nature of athletic and military performance, it is difficult to fully determine the relationship between an increase in muscular strength and a change in performance. When factors of competition, ability, and strategy are combined with stronger individuals, the result is usually enhanced performance. There are many theories and resistance training systems used in the area of strength development. Periodized training is effective for increasing upper and lower body strength in trained subjects. Periodization, however, was not found to be significantly superior to traditional constant-intensity training when relative training volume was equal over a 10-week mesocycle.

Within the limitations of the present research, the data indicate that an individual who resistance trains for 10 weeks can follow either the periodized model or constant-intensity model and develop similar improvements in body composition, muscular strength, and performance. This may be true if the athlete is only on a 10-week training program; however, most of today's successful athletes train year round. Further research should consider examining the effects of the periodized training model over multiple mesocycles.

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Acknowledgment

We thank the ROTC cadets who gave their time and effort to this research.

The body of this work does not reflect the position of the U.S. Department of Defense, the U.S. Department of the Army, or the Department of Military Science at the University of Kansas.