

Periodized Strength Training: A Critical Review

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ABSTRACT

Variation or periodization of training is an important concept in designing weight-training programs. To date, the majority of studies examining periodization of weight training have used a traditional strength/power training model of decreasing training volume and increasing training intensity as the program progresses. The majority of these studies have used males as subjects and do support the contention that periodized programs can result in greater changes in strength, motor performance, total body weight, lean body mass, and percent body fat than nonperiodized programs. However, studies are needed examining why periodized training is more beneficial than nonperiodized training. Studies are also needed examining the response of females, children, and seniors to periodized weight-training programs and the response to periodized models other than the traditional strength/power training model.

Key Words: weight training, periodization, program design

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Introduction

Periodized strength training refers to varying the training program at regular time intervals in an attempt to bring about optimal gains in strength, power, motor performance, and/or muscle hypertrophy. A goal of periodized strength training is to optimize training during short (e.g., weeks, months) as well as long periods of time (e.g., years, a life time, or an athletic career). In the case of a competitive athlete, another goal is to peak physical performance at a particular point in time, such as for a major competition.

The training variables that can be manipulated in an attempt to optimize the training program include number of sets performed of each exercise, number of repetitions per set, exercises performed, number of exercises performed per training session, rest periods between sets and exercises, resistance used for a set, type of muscle action performed (e.g., eccentric, concentric, isometric), and number of training sessions per day and per week. The term intensity is frequently used

when describing weight-training programs and will be used in this review to refer to the weight lifted or repetition maximum weight used to perform a certain number of repetitions (repetition maximum, RM). The highest intensity that can be used is a one repetition maximum weight. A weight allowing the performance of more than one repetition of an exercise is thus a lower training intensity. The term training volume will be used in reference to the total number of repetitions performed. It is a product of the total number of sets, number of repetitions per set, and number of exercises performed. A greater total number of repetitions implies a higher training volume.

Unfortunately, despite the virtually limitless combination of these training variables, the majority of studies examining the effectiveness of periodized training have focused on strength/power gains and manipulated only training intensity and training volume. Thus, the results of these studies are applicable predominantly to strength/power-type sports or activities and not directly to other sports or activities, such as weight training for endurance-type sports or achieving optimal gains in muscle hypertrophy. When showing periodized training to be superior to nonperiodized training, these studies only indirectly support its use for nonstrength/power-type sports.

A consideration related to training variables concerns comparisons of single-set programs to traditional multiset periodized programs. It is obvious in such a comparison that the periodized program will have a greater training volume. Thus, any difference between the programs could be due to the difference in training volume. This is a result of the design of the programs and is an inherent difference between the programs. From a scientific perspective, this is an important consideration. However, from a practical perspective, if a difference in results is shown between the programs, it means one program is superior to the other.

A factor that needs to be considered when examining the efficacy of periodized training is the use of untrained individuals as subjects in many studies. During the first several weeks of any training program, the majority of strength/power gains occur due to neural factors (6). Thus, in short-term studies, a significant difference in strength/power between any

weight-training programs may be difficult to achieve because any and all programs may result in similar neural factor gains in untrained people. If superiority in strength/power is shown in short-term studies, it may merely imply that the superior program brings about quicker neural factor gains. This may be especially true if changes in lean body mass are not significantly different between two training programs.

The applicability of the results of studies using untrained subjects has some limitations in application to the training of athletes or trained subjects. It has been shown that strength gains occur at a slower rate in highly trained vs. moderately trained subjects (2). This may in part be due to neural factors as discussed above. However, whatever the reason for larger gains in untrained subjects vs. trained subjects, automatically assuming the results of studies using untrained subjects are directly applicable to trained subjects in terms of magnitude of change and rate of change is tenuous.

The concept of periodized strength training has been utilized by the athletic community at least since the late 1950s. Despite the use of periodized strength training by the athletic community for at least 40 years, few published sport science projects have investigated the efficacy of periodized strength training. The goal of this paper is to critically review and draw conclusions from the projects that have been published in English and provide direction for future research concerning periodized strength training.

Studies Examining Periodization

Considering the popularity of periodized training, there are surprisingly few studies examining the effectiveness of periodized resistance training. The studies available in the English sport science literature are summarized in Table 1.

The earliest of these (7) trained college age males for 6 weeks. This project compared a nonperiodized program of 3×6 (sets \times repetitions per set) vs. a strength/power periodized program that progressed from high volume and low intensity to lower volume and higher intensity training. Both groups increased the resistance used during training at their own rate. The periodized group increased significantly more than the nonperiodized group in one repetition maximum (1 RM) parallel back squat and vertical jump power using the Lewis formula ($4.9 \times \text{body mass [kg]} \times \text{vertical jump [m]}$) but not in vertical jump ability (centimeters improvement). In addition, the periodized group demonstrated a significantly greater increase in lean body mass and decrease in percent body fat than the nonperiodized group as determined by hydrostatic weighing. Total body mass did not change significantly in either group. Unfortunately, absolute or

percent changes in any variable examined were not published.

This previous study (7) has been cited as supporting the conclusion that periodized weight training results in greater gains in vertical jump ability or motor performance than nonperiodized training. However, a caveat of this conclusion is that the periodized training resulted in a greater increase in vertical jump power and not a significantly greater increase in vertical jump height than the nonperiodized training. Thus, the results support periodized training in some strength/power-type activities, like American football or the shot put, where leg strength power may enhance performance. However, the results do not support the conclusion that the periodized training model used in this study is superior to the nonperiodized training in increasing performance in an event like the high jump, where total jump height and not jump power is a major deciding factor in determining success.

A second study published in the early 1980s (8) utilized untrained college age males as subjects. Training consisted of performing either 1×10 , 3×10 , or a strength/power periodized program for 7 weeks. Total body mass did not change significantly in any group. One RM bench press and back squat ability significantly increased in all training groups, with the periodized group demonstrating a significantly greater increase in 1 RM squat ability than the other two training groups. The 3×10 training group demonstrated no significant change in vertical jump ability or power (Lewis formula) at any point in the 7-week training period. The 1×10 group showed an increase in vertical jump ability after 5 weeks of training; however, this group's vertical jump ability decreased after this time point and showed no significant difference from pretraining after the 7-week training period. Only the periodized group showed a consistent significant increase in vertical jump ability and vertical jump power throughout the training period and a significant increase after all 7 weeks of training. The results of this study do support the conclusion that short-term periodized training does increase 1 RM strength and vertical jump ability in untrained males to a greater extent than single and multiple set, nonperiodized training.

Another study published in the 1980s also used college-aged males as subjects (5). It is unclear as to the exact training status (untrained, moderately trained, or highly trained) of the subjects. Training lasted 11 weeks and consisted of either 3×6 or a strength/power periodized program. Both training groups performed the same exercises. One RM back squat ability increased with both types of training, but a significantly greater increase was shown by the periodized group. Total power output (watts) during cycling was also examined. This test consisted of cycling

Table 1. Periodized studies.

Reference	Training length (wk)	Frequency per week	Sets × reps	Intensity	Exercises trained	Test(s)	Percent increase
Stone et al. (7)	6	3	3 × 6	Progressed at own rate	Squats and 5 others	Squat	?
						Vertical jump	?
						Squat	?+
						Vertical jump	?,+
Stowers et al. (8)	7	3	1 × 10	10 RM	Combination of 8	Bench press	7*
						Squat	14*
						Vertical jump	0
						Bench press	9*
						Squat	20*
O'Bryant et al. (5)	11	3	3 × 6	81–97% of pretrain 1 RM	Squat and 8 others	Vertical jump	1*
						Bench press	9*
						Squat	27*+†
						Vertical jump	10*
						Squat	32*
						Cycle power	6*
						Squat	38*+†
McGee et al. (4)	7	3	1 × 8–12	70–117% of pretrain 1 RM	Squat and 8 others	Squat	17*+†
						Cycle power	6*
						Cycling to exhaustion	12
						Squat reps to exhaustion	46
						Cycling to exhaustion	15*
Willoughby (9)	12	2	3 × 10	Pretrain 10 RM	Bench press Squat Bench press Squat Bench press Squat	Squat reps to exhaustion	71*
						Cycling to exhaustion	29*
						Squat reps to exhaustion	74*
						Bench press	8*
						Squat	13*
						Bench press	17*§
						Squat	26*§
Willoughby (10)	16	3	5 × 10	79% 1 RM	Bench press Squat Bench press Squat Bench press Squat	Bench press	8*
						Squat	14*
						Bench press	10*
						Squat	22*
						Bench press	23*#
						Squat	34*#
						Squat	48*
Willoughby (9)	12	2	3 × 10	8–12 RM	Combination of 7	Cycling to exhaustion	12
						Squat reps to exhaustion	46
						Cycling to exhaustion	15*
						Squat reps to exhaustion	71*
						Cycling to exhaustion	29*
						Squat reps to exhaustion	74*
						Bench press	8*
						Squat	13*
						Bench press	17*§
						Squat	26*§
Willoughby (10)	16	3	5 × 10	83% 1 RM	Bench press Squat Bench press Squat Bench press Squat	Bench press	8*
						Squat	14*
						Bench press	10*
						Squat	22*
						Bench press	23*#
						Squat	34*#
						Bench press	8*
						Squat	13*
						Bench press	17*§
						Squat	26*§
Willoughby (10)	16	3	6 × 8	83% 1 RM	Bench press Squat Bench press Squat Bench press Squat	Bench press	8*
						Squat	14*
						Bench press	10*
						Squat	22*
						Bench press	23*#
						Squat	34*#
						Bench press	8*
						Squat	13*
						Bench press	17*§
						Squat	26*§
Willoughby (10)	16	3	4 × 5 × 10	79% 1 RM	Bench press Squat Bench press Squat Bench press Squat	Bench press	8*
						Squat	14*
						Bench press	10*
						Squat	22*
						Bench press	23*#
						Squat	34*#
						Bench press	8*
						Squat	13*
						Bench press	17*§
						Squat	26*§
Willoughby (10)	16	3	4 × 4 × 5–7	83% 1 RM	Bench press Squat Bench press Squat Bench press Squat	Bench press	8*
						Squat	14*
						Bench press	10*
						Squat	22*
						Bench press	23*#
						Squat	34*#
						Bench press	8*
						Squat	13*
						Bench press	17*§
						Squat	26*§
Willoughby (10)	16	3	4 × 3 × 3–5	88% 1 RM	Bench press Squat Bench press Squat Bench press Squat	Bench press	8*
						Squat	14*
						Bench press	10*
						Squat	22*
						Bench press	23*#
						Squat	34*#
						Bench press	8*
						Squat	13*
						Bench press	17*§
						Squat	26*§
Willoughby (10)	16	3	4 × 3 × 4	92% 1 RM	Bench press Squat Bench press Squat Bench press Squat	Bench press	8*
						Squat	14*
						Bench press	10*
						Squat	22*
						Bench press	23*#
						Squat	34*#
						Bench press	8*
						Squat	13*
						Bench press	17*§
						Squat	26*§

Table 1. Continued.

Reference	Training length (wk)	Frequency per week	Sets × reps	Intensity	Exercises trained	Test(s)	Percent increase		
Baker et al. (1)	12	3	5 × 6 core exercise, 5 × 8 all others	6 RM	Combination of 17	Bench press Squat	12*		
				8 RM			Vertical jump	26*	
			4 wk 5 × 10 core exercise, 3 × 10 all others	10 RM	combination of 17	Bench press Squat	11*		
				10 RM			Vertical jump	18*	
			4 wk 5 × 5 core exercise, 3 × 8 all others	5 RM					
				8 RM					
			3 wk 3 × 3, 1 × 10 core exercise, 3 × all others	3, 10 RM					
				6 RM					
			1 wk 3 × core exercise, 3 × 6 all others	3 RM					
				6 RM					
Kraemer (3)	14	3	2 wk 5 × 10 core exercise, 3 × 10 all others	10 RM	Combination of 17	Bench press Squat	16*		
				10 RM			Vertical jump	28*	
			2 wk 5 × 6 core exercise, 3 × 8 all others	6 RM					
				10 RM					
			2 wk 5 × 4 core exercise, 3 × 6 all others	4 RM					
				6 RM					
			2 wk 5 × 6 core exercise, 3 × 8 all others	6 RM					
				8 RM					
			2 wk 4 × 3 core exercise, 3 × 6 all others	3 RM					
				6 RM					
1 × 8–10, forced reps	8–10 RM								
3	3	3 wk 2–3 × 8–10 2 wk 3–4 × 6 Repeat all weeks	50% of 1 RM	12 exercises	Bench press Hang clean Vertical jump Wingate power Bench press Hang clean Vertical jump	3*			
			70–85% of 1 RM			4*			
			85–95% of 1 RM			3*			
						0			
							11** 19** 17**		

Table 1. Continued.

Reference	Training length (wk)	Frequency per week	Sets × reps	Intensity	Exercises trained	Test(s)	Percent increase
Kraemer (3)	24	3	1 × 8-10, forced reps	8-10 RM	20 exercises	Bench reps at 80% of 1 RM Leg press reps at 85% of 1 RM	37* 22*
						Bench press Leg press Wingate power Bench reps at 80% of 1 RM	13* 6* 5* 56**,**
	4		Strength session	2-4 × 12-15, 8-10, 3-5 RM	21 exercises	Leg press reps at 85% of 1 RM	41**,**
			Hypertrophy	2-4 × 8-10 RM		Bench press Leg press Wingate power	29**,** 20**,** 55**,**

* Significant increase pre-to posttraining.
 * Significant increase pre-to posttraining.
 † Significant difference from 3 × 6 group.
 ‡ Significant difference from 1 × 10 and 3 × 10 groups.
 § Significant difference from 3 × 10 group.
 || Significant difference from 3 × 10 and 3 × 6-8 groups.
 ¶ Significant difference from 5 × 10 group.
 # Significant difference from 5 × 10 and 6 × 8 groups.
 ** Significant difference from 1 × 8-10 group.

at 0 watts for 1 minute, 60 watts for 3 minutes, whereafter the workload was increased 30 watts every minute until exhaustion. After the 11-week training period, both groups increased significantly in maximal cycling power, with the periodized group demonstrating a significantly greater increase than the 3×6 group. Both groups showed a nonsignificant increase (1.0 kg) in total body mass. The results support the concept that periodized weight training does result in greater gains in 1 RM strength and short-term high intensity work ability.

A study published in 1992 (4) examined the effects of three different programs 7 weeks in length on leg and hip endurance. The training status of the subjects previous to the programs is not defined. Adaptations of young men to two nonperiodized programs, $1 \times 8-12$ and 3×10 , and a strength/power periodized program were examined. Leg and hip endurance were measured during a cycling test and back squat repetitions to exhaustion. Cycling endurance time was defined as time to exhaustion at 265 watts after 2 minutes at 30 watts and 2 minutes at 120 watts. Back squat endurance was determined by squatting with 60 kg at a cadence of one squat per 6 seconds. Mass squatted was increased 2.5 kg each minute until exhaustion. The $1 \times 8-12$ group showed increases in both tests; however, the increases were not significant. Both the 3×10 and periodized groups showed significant increases in both tests. Although the increases of the 3×6 and periodized groups were substantially greater than for the $1 \times 8-12$ group, no significant differences between groups were shown. In addition, although not significant, the periodized group showed almost a twofold (15 vs. 29%) greater increase in cycling endurance time than did the 3×10 group. Total body mass was not significantly changed in any of the groups. The results indicate the type of training program does not significantly affect high-intensity endurance during short-term training (7 weeks) periods.

A second study published in 1992 (9) examined the effects in trained young men of two nonperiodized programs and a periodized program on 1 RM strength in the bench press and back squat. In this study, subjects were considered trained if their 1 RM bench press and back squat were equal to or greater than 120 and 150% of total body weight, respectively. One nonperiodized group trained using their pretraining 10 RM (no increase in resistance) for 3×10 for the bench press and back squat during the entire training period. A second nonperiodized group trained using $3 \times 6-8$ with the weight used increased 4.54 kg after each set during a training session and increases in the starting resistance for a training session as strength gains were made. The periodized group followed a traditional periodized program of initial high volume, low intensity progressing to low volume, high intensity. All groups significantly increased in 1 RM bench press

and back squat ability, with the $3 \times 6-8$ and the periodized groups showing significantly greater increases than the 3×10 group. The periodized group also demonstrated significantly greater increases than the $3 \times 6-8$ group in both the bench press and back squat.

The results show that, in order for continued gains in 1 RM strength to occur, the weight used in training must be increased as strength gains occur. The results support that, in trained subjects, a periodized program results in greater 1 RM strength gains than nonperiodized multiple set programs.

In 1993, Willoughby (10) published a second paper on the effectiveness of periodized training. Young men with previous weight-training experience and capable of a minimum bench press and back squat of 120 and 150% of total body weight, respectively, trained for 16 weeks. Two nonperiodized groups trained with 5×10 or 6×8 for the entire training period. The periodized group followed a classic strength program starting with high volume, low intensity training progressing to low volume, high intensity training. All groups significantly increased 1 RM bench press and squat ability. However, by week 16, the 6×8 group's improvement in 1 RM squat was significantly greater than the 5×10 group's and the periodized group's increases in both the bench press and squat were significantly greater than both nonperiodized groups.

A unique aspect of this study was that, for the first 8 weeks of training, there was no significant difference in training volume between any of the groups. After week 8, the periodized group's training volume, due to the decrease in repetitions performed, was significantly lower than the nonperiodized group's. Interestingly, at week 8 of training, all groups had significantly increased their 1 RM for both exercises, but there was no significant difference between any of the groups. Only after week 8, when the periodized group's training volume was decreased significantly compared to the other two groups, did significant differences between groups in 1 RM ability start to become apparent. This indicates that the decrease in training volume may in part be responsible for the greater improvement in 1 RM strength and that it may take up to 8 weeks of training in trained subjects for periodized programs to show superior results compared to nonperiodized programs.

The effects of traditional and "undulating" periodized training in trained young men with previous weight-training experience who could bench press and back squat a minimum of 100% of body weight was reported in 1994 (1). A nonperiodized group trained using 5×6 for core exercises and 5×8 for all other exercises. The squat, bench press, and clean pull constituted core exercises. One periodized group trained using what has been termed undulating periodization. This means that the training volume and intensity was increased and decreased on a regular basis but did not

follow a general pattern of always increasing intensity and decreasing volume as the training period progressed. A second periodized group trained using a traditional strength/power periodized program of increasing intensity and decreasing volume as the training period progressed.

A unique aspect of this study was that, for the entire 12-week training period, training volume (total mass lifted) and relative intensity (percent of 1 RM resistance) were equated between the groups. This allowed any differences in strength to be attributed to the manipulation of training volume and intensity and not the total training volume performed or intensity used throughout the entire training program. All groups significantly improved in 1 RM bench press, 1 RM squat, vertical jump ability, and lean body mass determined by skinfold measurements, with no significant difference noted between groups in any criterion measure. None of the groups demonstrated a significant change in percent body fat. The results of this project, coupled with the Willoughby results (10), indicate the decrease in training volume present in many periodized programs is in part responsible for increases in strength that are greater than nonperiodized programs.

A one-set program has been compared to a strength/power periodized program over 14 weeks of training in Division III college football players (3). The one-set program consisted of nine exercises all performed using weight machines. All exercises were formed for 8–10 repetitions at an 8–10 RM weight with forced repetitions at the conclusion of each set. The periodized program consisted of 12 predominantly free-weight exercises and followed a traditional strength/power periodized format. The one-set program resulted in significant increases in 1 RM bench press and vertical jump ability. However, no significant change in 1 RM hang clean or power during a Wingate test was shown due to the one-set training. The periodized training resulted in significantly greater increases in 1 RM bench press and hang clean ability, vertical jump ability, and power during the Wingate test than did the one-set program. The one-set program resulted in a significant decrease in percent fat determined by skinfold measurements but no significant change in total body mass. The periodized group showed a significant decrease in percent body fat and gain in total body mass, with both of these changes being significantly different from the one-set program. It can also be speculated that, due to the significantly greater decrease in percent fat and increase in total body mass of the periodized group, a significantly greater increase in lean body mass occurred in the periodized group compared to the one-set group.

The results of this study do show that a periodized free-weight program does result in greater changes in

1 RM strength, vertical jump ability, percent body fat, lean body mass, and total body weight than a one-set, machine-oriented program. The use of machines for the one-set program does limit the interpretation of the results to the comparison of a one-set, machine program to a periodized free-weight program.

Comparison of a single-set program performed three times per week with a periodized program performed four times per week over 24 weeks of training has also been reported (3). Division III college football players comprised both training groups. The single-set training consisted of performing one set of 8 to 10 repetitions at an 8–10 RM weight with each set followed by forced repetitions. Two different total body workouts of 10 exercises each were performed on alternating days of training during the single-set training. The periodized training was a type of nonlinear periodization consisting of two different training sessions, each performed two times per week. One session stressed strength/power and was composed of eight exercises, most of which were multijoint exercises. The second was composed of 13 exercises, 6 of which were single joint exercises, and was termed a hypertrophy workout. The strength/power session's set repetition scheme was varied and consisted of sessions using 3–5, 8–10, and 12–15 repetitions per set, with all sets using a RM weight. During the strength/power session, the weight used for hang cleans and power cleans was varied, with sets of five repetitions being performed using either 85–90, 65–70, or 40–60% of the 1 RM weight. All exercises in the strength/power sessions were performed for two to four sets. The hypertrophy session always consisted of sets of 8–10 repetitions at an 8–10 RM weight and used super sets, with 1–2 minutes rest between sets and exercises. Both training groups also participated in the same run and agility training sessions.

The nonlinear periodized training resulted in significantly greater changes in percent body fat (skinfolds), total body weight, and all variables examined for strength, power, and high intensity endurance (Table 1). The results support the concept that periodized training does result in greater fitness gains than a varied one-set program. However, the generalizability of the study's conclusions are limited by several factors, including differences in training frequency and use of different exercises by the two training groups.

Summary and Practical Applications

Although relatively few studies have examined the effects of periodized training, the following conclusions seem warranted. Periodized programs can result in greater strength (1 RM) gains than nonperiodized multiset and single-set programs. The greater strength gains may be related to the changes in training volume found in periodized programs. Very few studies have

examined motor performance, body composition, and short-term endurance changes. These few studies do indicate that periodized programs may result in greater gains in lean body mass, total body weight, and motor performance (vertical jump ability) and in greater decreases in percent body fat than nonperiodized programs. Due to the lack of significant differences in criterion measures between periodized and nonperiodized programs in some studies using untrained subjects, a tentative conclusion may be that periodized training is not necessary until some level of base strength fitness has been achieved.

All of these studies are relatively short term in nature especially if the results are placed in the context of an athletic career or a life time of recreational fitness training. Therefore, a future direction of research concerning periodized strength training should be longer term studies. Future studies are also needed concerning all outcomes of periodized training compared to nonperiodized training, but especially concerning body composition and motor performance changes. In addition, all studies reviewed utilized young males as subjects, and therefore projects in which the response of females, children, and older individuals to periodized strength training are needed. Studies are also needed examining periodized models other than the traditional strength/power periodized model. A long-term goal of research concerning periodized training should be to understand why periodized training may result in greater fitness gains. If this is understood, it will be substantially easier to design optimal strength-training programs to meet the goals and needs of elite athletes and the fitness enthusiast.

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