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The Effects of Periodization Versus Progressive Resistance Exercise on Upper and Lower Body Strength in Women

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ABSTRACT

This study compared periodization (PER) with active rest periods to progressive resistance exercise (PRE) to determine which led to more strength gains and whether a performance plateau occurred during 15 weeks of training. Twenty women were randomly assigned to the PER group ($n = 10$) or the PRE group ($n = 10$). One repetition maximum (1-RM) was recorded for both groups on the bench press and parallel squat as a pretest, every 3 weeks, and again as a posttreatment test. Both groups trained on the same equipment 2 days a week. PER underwent 8 weeks of hypertrophy training (3 × 10-RM), 2 weeks of strength and power training (3 × 4-RM), and 2 weeks of peak training (3 × 2-RM), with a 1-week aerobic active rest period between phases. PRE maintained the same 3 × 6-RM program throughout the study. ANOVA with repeated measures revealed no statistical difference between groups for the bench press or parallel squat. PER had consistent increases in strength while PRE appeared to be plateauing near the end of the 15-week study. Volume of work performed was more powerful in determining strength than was the manipulation of repetitions, sets, or periods of active rest.

Key Words: cycled training, plateau effect, ceiling effect, variation, active rest, tapering

Introduction

Strength and power are the main ingredients needed for most athletic participation (3). The goal of any strength training program is to help the athlete reach top physical condition and potential. Over the last several decades, in order to improve their performance, athletes have trained harder and longer without the benefit of the traditional off-season rest period. This can lead to overtraining, with symptoms such as burnout, stagnation, illness, possible injury, muscular soreness and stiffness, and decreased performance (4).

Traditional progressive resistance exercise (PRE) incorporates the "overload principle" and was long thought to be the most effective way to train for strength gains. PRE depends on the muscle's ability to adapt both physiologically and neuromuscularly to the new stress placed on it by an increase in weight. However, PRE may not be the best way to maximize strength and power gains because it may not allow enough time for adaptation during year-round training. With the increase of athletic competition and year-round training has come the need for alternative training programs.

An alternative may be periodization (PER), which allows for periods of active rest and adaptation of the muscle through variations in intensity, volume, and rest. Fleck and Kraemer (4) state that prevention is the best guard against overtraining, which could result from using a PRE program year-round. A program of periodization allows for muscle adaptation according to the principles of the general adaptation syndrome (6, 11).

Few studies have investigated the effects of periodization on sports, and even fewer have focused on the development of health related fitness components such as strength. We know of no published study that has compared progressive resistance exercise and periodization in women. Stone et al. (10), Stowers et al. (12), and Willoughby (13) studied periodization in men. Progressive resistance exercise studies in women have suggested no qualitative difference between men and women (14). The only training difference appears to be a quantitative one due to smaller body size and lower lean body mass in women.

Those few investigations that have compared periodization training with various other strength programs have reported statistically significant differences favoring periodization (10, 12, 13). The results of those studies suggest that the variations in volume of work, intensity, and sets/repetitions found in periodization produced significant differences favoring periodization over other forms of strength training.

Previous literature suggests that the use of PRE without variation can lead to a plateau effect and

perhaps a less than optimal level of strength gain (5). The literature implies that a periodization weight training program, with its variations in intensity and active rest periods, could avoid the plateau effect, lessen the likelihood of overtraining, and lead to increased strength and power because it allows the body to recover and adapt to each new training cycle (11, 13).

Studies have reported periodization as being superior to other forms of weight training such as 3 × 6-RM, pyramids, sets to exhaustion, high reps, low reps, etc. (9–13). When comparing weight training protocols, investigators often fail to equate and report the training workloads. Lombardi (8) notes that calculating the workload can be cumbersome, hence the weight training workload can be estimated by repetitions and sets.

With the exception of Willoughby (13), previous periodization studies have disregarded the additional repetitions, and therefore the increased volume of work performed by the periodization group. Thus there may be some question as to whether the results attributed to periodization were due to variations in the program or the additional work performed.

When differences in body size (lean body mass) were considered, Wilmore (14) found women to have more lower body strength but less upper body strength than men. After a 10-week strength program, the women had an absolute increase in upper and lower body strength of 28.6% and 29.5%, respectively (14). The men increased absolute upper and lower body strength by 16.5% and 26.0%, respectively. Based on this, it appears that the quality of muscle fiber between men and women is the same (15). The strength difference between them can be attributed to a greater muscle mass in men. If the muscle fiber quality is similar, then women's responses to periodization should be similar to those reported in untrained men (10, 12).

The purpose of this study was to compare periodization to progressive resistance exercise in women, using equal workloads, to determine (a) whether periodization produced greater strength gains and (b) whether a progressive resistance program without variation would result in a plateau effect during 15 weeks of training.

Methods

Subjects

The subjects, 22 untrained college-age women, were randomly assigned from three beginning weight training classes offered at a major university. At the first meeting the investigators explained the general purpose and procedures of the study and each subject signed informed consent. Two women dropped out of the study, resulting in complete data on 20 subjects. The subject characteristics were as follows:

- PER Group: *M* age 20.7 yrs, *SD* 2.2; *M* height 164.1 cm, *SD* 6.6; *M* weight 55.6 kg, *SD* 6.5.
- PRE Group: *M* age 24.1 yrs, *SD* 5.6; *M* height 166.4 cm, *SD* 7.1; *M* weight 62.8 kg, *SD* 9.3.

The subjects filled out questionnaires evaluating their prior resistance training experience and medical history. Those with extensive strength training experience or any who had a medical condition that might be aggravated by the study were eliminated from the study. After screening, the subjects were instructed on proper techniques, nutrition, and the importance of regular attendance. They agreed not to participate in any other strength development activities during the 15-week period.

Equipment and Instrumentation

This study employed 6 specifically designed weight training exercises for strength development in the upper and lower body: upper body (bench press, lat pulls, behind-the-neck seated press) and lower body (parallel squat, leg curl, leg extension). Two exercises were used for each testing session: bench press for upper body strength and parallel squat for lower body strength. Subjects were introduced to each exercise and were shown the proper technique for lifting. They were also familiarized with the relative perceived exertion (RPE) scale (2). The week before the study began, the subjects used the equipment to familiarize themselves with each exercise, acquire adequate technique, and establish their 1-RM for each exercise.

Procedures

Both groups trained 2 days a week for 15 weeks. They had their loads prescribed and adjusted to ensure that the principles of progressive resistance exercise and periodization were being followed. During the training sessions they used Borg's (2) RPE scale to record intensity. Intensity was adjusted by referring to previous training records and the RPE scale. Subjects who recorded below 16 (hard to very hard) on the RPE scale for any set had the weight increased for the next training session as long as they could complete the required number of repetitions and sets for their training group.

Training Regimens. The PRE group program was consistent with the concepts of progressive resistance (1). This group trained with 3 sets of 6 reps (3 × 6-RM) for the entire 15 weeks. The PER group emphasized the principles of periodization as set forth by Stone et al. (11). The training program consisted of 8 weeks of 3 × 10-RM, 2 weeks of 3 × 4-RM, and 2 weeks of 3 × 2-RM with 1 week of active rest between each cycle. Active rest consisted of aerobic training on a Lifecycle at low resistance (Level 1).

Testing Sessions. Two tests were used to evaluate the effects of training on upper body and lower body

strength: the bench press and parallel squat. These tests were carried out every 3 weeks beginning with a pretest and ending with a posttest at Week 15. The tests were conducted on both groups, using the same techniques, for one repetition maximum (1-RM). The investigators were present at all times during testing to ensure that proper technique and maximum effort was used.

Statistical Analysis

A 2 × 6 (Group × Test) ANOVA with repeated measures was conducted to compare the data. The two groups underwent repeated testing 6 times over the 15-week study. When an F ratio was found to be significant, a Tukey post hoc test was used to locate the statistical difference. To show that the volume of work was approximately equal between training groups, independent t tests were performed on the total amount of weight lifted for the 6 exercises. Statistical significance for all tests was set at $p \leq 0.05$. Absolute weights were used during the testing sessions because a statistical analysis using relative weight (kg/kg body weight) yielded a similar response.

Results

Figure 1 illustrates the training volumes for both groups for each exercise. The training volume was calculated by multiplying the amount of weight lifted by the number of repetitions per set and then adding all the sets together. Mean comparisons indicated that the training volumes did not differ significantly between groups for any of the 6 exercises.

Bench Press (upper body)

Table 1 shows the mean and standard deviation values of upper body strength as measured by the bench press. ANOVA results found no statistically significant group differences between PRE and PER. Both training protocols resulted in significant within-group increases in strength ($p < 0.0001$). The statistical power was low (0.06) for the between-group analysis but high (1.00) for the within-group analysis. Table 1 also shows the location and significance of within-group statistical differences using the Tukey post hoc test for the PER and PRE groups.

Parallel Squat (lower body)

Table 1 reports the means and standard deviations for lower body strength as measured by the parallel squat. A similar trend was present with the lower body measures, with comparisons indicating no significant difference between the two protocols at any testing period. Statistically significant improvements were found in both groups ($p < 0.0001$). Statistical power was high (1.00) within groups but low (0.15) between groups. The location and statistical significance of the Tukey post hoc test for both groups are shown in Table 1.

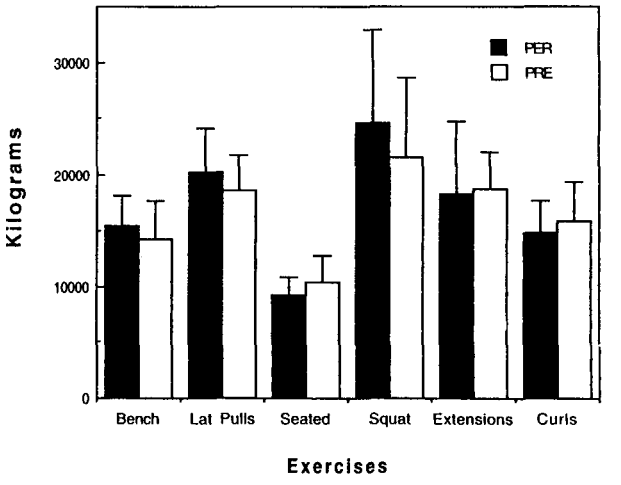

Figure 1. Mean (±*SD*) volumes of work among both groups for the 6 exercises. Mean volumes were calculated by multiplying the amount of weight lifted by the number of repetitions per set and then adding all the sets together.

Table 1
Absolute Strength at Each Testing Period for Periodization (PER) and Progressive Resistance Exercise (PRE)

	T1	T2	T3	T4	T5	T6
Bench Press						
PER (kg)						
Mean	29.5[a]	32.0[a,b]	32.7[b,c]	35.0[c,d]	37.0[d,e]	38.9[e]
SD	5.0	5.5	4.8	5.0	6.5	5.7
PRE (kg)						
Mean	31.4[a]	33.0[a,b]	35.0[a,b]	35.5[b,c]	39.3[c]	39.3[c]
SD	6.2	8.7	8.3	8.4	8.9	9.2
Parallel Squat						
PER (kg)						
Mean	44.1[a]	49.5[a,b]	53.4[b,c]	57.3[c,d]	62.0[d,e]	67.7[e]
SD	21.9	22.5	20.7	23.0	20.1	19.9
PRE (kg)						
Mean	48.0[a]	57.7[b]	65.5[c]	66.8[c]	69.1[c]	70.2[c]
SD	16.0	16.7	17.7	18.9	18.1	18.5

Note: Any two means within the same training program that do not share a common superscript are significantly different at $p < 0.05$ by Tukey HSD.

Performance Taper

The post hoc results indicated that between T3-T5, T3-T6, and T4-T6 for both upper and lower body tests, the PER group had 6 significant increases. The PRE group had only 2 significant increases during that same period at T3-T5 and T3-T6, hence the rate of improvement for the PRE group begins to taper after 6 weeks for the parallel squat and after 12 weeks for the bench press.

Discussion

Several studies have found significant differences in strength favoring periodization weight training com-

pared to other training methods (10, 12, 13). The results of this study did not reveal a statistical difference between groups. The limitations associated with this investigation may have contributed to that result: The subjects trained twice a week versus the more typical 3 times a week in most other studies. The investigators attempted to follow the theoretical basis of PER by including an aerobic active rest period between phases, which unfortunately resulted in two 11-day periods of non-strength training for that group. Despite those limitations, both training regimens produced significant pre to post strength increases.

The investigators attempted to equate the volume of work done both by the total volume of weight lifted and the total number of repetitions. Statistical analysis confirmed that the volume of weight lifted was not significantly different. Previous studies have not considered the additional volume of work performed in PER training (10, 12).

A few studies have used net changes or relative weight comparisons (10, 13). This method of comparing programs might create a statistical advantage when analyzing the data. Small changes in absolute weight lifted can be magnified into larger differences when net change or relative weight is used, thus statistical difference might be found comparing net change or relative weight, which might not be present when comparing absolute weight. This study used absolute weight and did not find a significant difference between the training protocols.

The results suggest that total repetitions and volume of weight lifted may be more important in developing strength than the periodic manipulation of sets, repetitions, and/or periods of active rest during a 15-week period. While the PRE group was showing less strength improvement or tapering toward the final stages of this study, the PER group was continuing to improve in a more linear fashion.

Effects of Periodization on Women's Strength

Most comparative studies and reviews on women's strength gains suggest that women are weaker then men in total body strength and in upper body strength, but compare more favorably in lower body strength (7, 14). The results from this study appear to support these findings. When comparing men from prior periodization studies and women in this study, the 6-week (T3) values showed little change from pretest (T1) values. The women on the PER program were 38.3% (at Week 0) and 39.2% (at Week 6) of the strength of men in previous periodization studies (12).

A review of the literature on muscular strength found that women were on average 55.8% as strong as men in the upper body, a greater difference than was found in this study (7, 14). For the lower body strength measure, the PER group proved to be 45.9 nd 43.8% of the strength of men in prior studies when tested at Week 0 (T1) and Week 6 (T3), respectively (12). These values were slightly less then those reported by Laubach's (7) review, which found women to range from 57 to 86% of the strength of men in lower body measures.

The overall increase on the bench press was 31.9 and 25.2% for the PER and PRE groups, respectively. This change was greater than that reported in previous studies on men in a periodization program (12, 13). The difference in strength increase might have been the result of different genders and/or duration of training. This study lasted 15 weeks compared with one of the previous studies which lasted only 7 weeks (12).

At Week 6 (T3) the increases in this study were 10.8 and 11.5% for the PER and PRE groups, respectively. The PER change was similar to those found by Stowers et al. (12) during a 7-week periodization study on men. Willoughby's (13) study with men found that periodization produced an increased of 23.1% over 16 weeks, whereas the present study with women yielded a 31.9% increase for the PER group over 15 weeks.

The changes in the parallel squat were similar to those for the bench press. Stowers et al. (12) reported an increase of 27.1% for a periodization group of men. Those results are similar to the results of the present study, which found a 21.1% increase after 6 weeks for the PER group. At the end of this study the PER group reported an increase of 53.5%. This is much greater than Willoughby's (13) increase of 36.7% in the parallel squat. The disparity could be due to gender differences and/or the effects of active rest periods, which allows the muscle to adapt to each periodization phase.

Performance Taper

The slope of improvement for the PRE group suggests that periodization might be superior to progressive resistance exercise for year-round training. This speculation is based on an extrapolation of test data points beyond 15 weeks.

Although both groups had significant strength increases from pre- to postmeasurement at 15 weeks, the PER group maintained a relatively linear increase throughout the study. The PRE group produced sharper increases early in the study, but the increase tapered toward the end of the training period. The slope of improvement for the PER group was still increasing at the end of the program.

After the introduction of the strength cycle in PER at 9 weeks of training (T3 to T6), 4 significant improvements occurred in addition to 2 significant improvements from Weeks 12 to 15 (T5-T6). The PER program produced 6 significant improvements over the second half of the study regardless of body region tested. The PRE group produced only 2 significant improvements after 9 weeks of training (T3 to T6), and none during the final 3 weeks (T5-T6) (Table 1).

Perhaps the PRE group exhibited a tapering or plateau effect toward the end of the training program be-

cause of overtraining (6, 11). Theoretically, this may have been prevented in the PER group in that the body was allowed to adapt to each new cycle with periods of active rest and variations in the program. Stone et al. (11) stated that overtraining could be avoided or reduced with changes in volume, intensity, or technique. The PRE group did not incorporate these changes and, as a result, might have been exhibiting early signs of the plateau effect or overtraining. Only a longer study could provide accurate information on the benefits of periodization for long-term training.

During the last 9 weeks of the 15-week study, the PER group continued to increase in a linear fashion and reported significant increases in all 6 post hoc comparisons. The PRE group increased significantly in only 2 of the 6 comparisons. The results can be seen in Table 1. Results of this study suggest the need for further research on periodization and untrained individuals over an extended period of time to determine the benefits of periodization for prolonged strength training.

Practical Applications

Given the increased demands of athletic performance and year-round training at all levels of competition, optimal strength programs need to be developed. The results of this study did not support the benefits of periodization over a progressive resistance exercise program during a relatively short (15 weeks) period of time. Prior research with men has reported periodization to be superior over a similar time period. This study found periodization to be as effective as a progressive resistance training program. Therefore, both periodization and progressive resistance exercise training can be recommended for the woman athlete who wants to maximize strength.

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