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A Meta-Analysis of Periodized Versus Nonperiodized Strength and Power Training Programs

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The purpose of this study was to quantitatively combine and examine the results of studies examining the effectiveness of periodized (PER) compared to nonperiodized (Non-PER) training programs for strength and/or power development. Two analyses were conducted to (a) examine the magnitude of treatment effect elicited by PER strength training programs compared to Non-PER programs and (b) compare these effects after controlling for training volume, frequency, and intensity. Studies meeting the inclusion criteria were coded based on characteristics that might moderate the overall effects (i.e., participant characteristics and characteristics related to the training program). Effect sizes (ESs) were calculated for each study, and an overall ES of 0.84 (± 1.41) favoring PER training was found. Further analyses identified the treatment effect specific to training variation to be ES = 0.25. Significant moderating variables included age, training status, and length of training program. As a result of this statistical review of the literature, it is concluded that PER training is more effective than Non-PER training for men and women, individuals of varying training backgrounds, and for all age groups. In line with the overload principle, additions to volume, intensity, and frequency result in additional training adaptations.

Key words: periodization, progressive resistance exercise, resistance training

Periodization, representing planned variations of training variables (i.e., volume, intensity, frequency, etc.), is one of the most written and talked about topics in strength and conditioning circles. The purported benefits of such training variation have included preparing athletes to peak at the right time, avoiding plateaus in training adaptations, decreasing risk of overtraining, and increasing adaptations as compared to nonperiodized training (Fleck & Kraemer, 1996a, 1996b; National Strength and Conditioning Association [NSCA], 2000).

Despite the prevalence of periodization (PER) in athletic communities for decades, few studies have actually compared the effectiveness of PER over nonperiodized (Non-PER) training. A critical review of such studies (Fleck, 1999) yielded only eight experimental studies published on the topic. While it was concluded that PER was more effective than Non-PER training at eliciting strength gains, a limitation of this review, and the few individual studies it examined, was the reliance on probability values ($p < .05$) and percent changes to make decisions regarding the superiority of PER.

Reliance on p values limits the evaluation of an intervention, because it offers no measure of the actual magnitude of the treatment effect. The reproducibility of a study's results may also be limited by statistical power, especially in studies using relatively small sample sizes. This practice may result in the inability to detect even a large treatment effect. Reliance on percent increases above baseline levels is also common among strength intervention studies. Calculating the increase in strength relative to the baseline measure (posttest-pretest/pretest) and reporting the mean increase is highly susceptible to erroneous decisions being made with respect to treatment effectiveness or ineffectiveness. Mean percent increases may be highly variable, which could lead to over- or underestimation of the actual

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magnitude of the treatment effect when variance within the sample is not considered.

The narrative review by Fleck (1999) failed to identify the actual magnitude of the strength increases between PER and Non-PER training and was unable to examine specifically the effect of variation in training as the driving factor in strength increases. There has recently been some controversy regarding whether greater volume and higher intensities in PER training elicit greater strength gains or if actual program variation, with equated volume and intensity, results in the observed strength gains (Stone, O'Bryant, et al., 1999).

The solution to these limitations and confounding influences is calculating and evaluating the effect size (ES), which represents a standardized (variance included in the calculation) measure of the magnitude of the treatment effect (Cohen, 1988). In addition, a more comprehensive review is needed that includes all available studies and provides a more objective and reproducible review process (i.e., meta-analysis; Glass, 1982). Quantitatively assessing the magnitude of strength and power increases across studies can accomplish a more accurate evaluation of PER effectiveness. Therefore, the purpose of this meta-analysis was to examine the magnitude of strength and power elicited by PER and Non-PER resistance training programs and evaluate the specific impact of program variation on such adaptations.

Two separate analyses were performed to (a) examine the magnitude of treatment effect elicited by PER strength training programs compared to Non-PER programs and (b) compare the effects of PER and Non-PER training programs after controlling for training volume and intensity. The first analysis involved calculating ESs in studies comparing a PER to a Non-PER training program. Due to the relative few comparison studies, especially those controlling for training volume and intensity, the second analysis involved calculating pre/post ESs, representing standardized mean differences, in strength and power training studies using either PER or Non-PER training programs. This analysis greatly increased the number of comparison interventions, thus providing the ability to compare numerous ESs in PER and Non-PER training programs with similar volumes and intensities.

Analysis 1

Method

Literature Search

Systematic searches were performed for all published and unpublished studies in English from 1962 through 2000 comparing PER and Non-PER training programs. Computer-aided searches of Science Citation Index, National Library of Medicine, Sport Discus, ERIC, Medline, and Dissertation Abstracts International were conducted. The key words used in these searches were periodization, strength training, anaerobic exercise, resistance training, and weightlifting. Hand searches of relevant journals and articles cited in the reference lists of articles found through the computerized searches were also conducted. Criteria for inclusion were: (a) the comparison of PER and Non-PER training interventions for strength or power development; (b) that the dependent variable measured strength and/or power and included a pretest baseline and postintervention value; and (c) that data necessary to calculate ESs were available. Calculating an ES requires one of the following: (a) means, standard deviations, and sample sizes for the treatment and comparison groups; (b) the value of the statistical test (r, t, or F) and the sample sizes of the treatment and comparison groups; or (c) the significance level and sample sizes of the treatment and comparison groups. It should be noted that due to the small number of experimental studies, studies were included in the analysis without regard to randomization. In addition, no minimum training intensity, frequency, or volume was required for inclusion. This resulted in 11 studies yielding 39 ESs that met the inclusion criteria (Baker, Wilson, & Carlyon, 1994; Herrick & Stone, 1996; Kraemer, 1997; Kraemer et al., 2000; Kramer et al., 1997; Marx et al., 2001; McCarthy, 1991; Mcgee, Jessee, Stone, & Blessing, 1992; Schoitz, Potteiger, Huntsinger, & Denmark, 1998; Stone et al., 2000; Willoughby, 1992).

Coding the Studies

Data necessary to calculate ESs were extracted from each study. Variables related to study participants (i.e., age, gender, and training status) and exercise program (i.e., length of training intervention, intensity of exercise, and training volume) characteristics were coded; however, due to the paucity of ESs in this analysis, examination of potential moderating variables was reserved for Analysis # 2. Training mode was not coded as a potential moderator variable. A variety of training modes, such as free weights, resistance training machines, and isometric, isotonic, and isokinetic training methods, were included in this analysis. However, no research to date has investigated whether training mode affects the difference between PER or Non-PER training programs. To assess potential coder drift, intrarater reliability was examined (Orwin, 1994). The primary investigator recoded all the studies randomly. Per case agreement was determined by dividing the variables coded the same by the total number of variables. A mean agreement of 0.90 was required for acceptance.

Statistical Analysis

Effect sizes were calculated, adjusted for sample size bias (Rosenthal, 1991), and weighted by the variance inverse (Hedges & Olkin, 1985) using the Non-PER training scores as the control group.

Results

The mean intrarater agreement rate was .99, indicating reliable and acceptable assessment of coder drift (Orwin, 1994). The overall mean ES after weighting by sample size was found to be 0.84 ($SD = 1.10$, $n = 39$, $p < .05$). The mean ESs for strength (.62 ± 1.22; $n = 33$) and power (2.06 ± 1.85; $n = 6$) measures were significantly different ($p < .05$); however, both were significantly greater than Non-PER training ($p < .05$). This suggests that PER training programs improve strength and power measures over Non-PER programs by 0.84 standard deviations, an improvement significantly different from zero ($p < .05$).

Analysis 2

Method

Literature Search

Computer and hand searches were performed for published and unpublished studies that included strength and/or power measurements before and after a training intervention program similar to Analysis #1. Relevant studies were selected and searched for data necessary to compute ESs and descriptive information regarding the training protocol. This literature search yielded 105 studies that met the inclusion criteria. An asterisk in the reference list designates studies included in Analysis #2.

Coding the Studies

Each study was read and coded for variables that might moderate the overall effect. Descriptive information including gender and age, frequency of training, mean training intensity, number of sets performed, and training status of the participants was coded. Frequency was determined by the number of days per week participants trained a particular muscle group. Intensity was coded as the average percent of an individual's one-repetition maximum (1 RM) used throughout the training program. When necessary, training percentages were predicted from repetition maximum values based on accepted methods for such predictions (NSCA, 2000). Volume was recorded as the number of sets performed per muscle group during each workout. Training status of the participants was divided into untrained, trained, and competitive athlete classifications. Participants must have been weight-training for at least 1 year prior to the study to be considered trained and for athlete classification, participants must have been involved in competitive athletics at the high school, collegiate, professional, or international level.

Statistical Analysis

Pre/post ESs were calculated ($n = 1{,}198$) with the following formula: [(Posttest mean – Pretest mean)/ Pretest SD]. Analyses of covariance were used to examine differences in ESs between PER and Non-PER training with volume, intensity, and frequency used as covariates. The next step in the analysis was to examine which moderating variables might significantly influence the magnitude of the effect. One-way analyses of variance were conducted with the unbiased ES as the dependent variable and various moderators as the independent variables. Significant omnibus F values ($p < .05$) were further examined using Scheffé post hoc tests.

Results

Overall ESs and moderating variables are presented in Table 1. The mean overall ES for PER training programs, based on 650 ESs, was 1.28 ($SD = 1.14$), which was significantly greater than zero ($p < .05$). The overall ES for PER training programs was also significantly different from the mean ES derived from Non-PER programs (ES = 1.03, $SD = 0.98$, $n = 549$, $p < .001$). Therefore, PER programs elicited approximately 0.25 standard deviations greater strength or power than Non-PER training. The mean ESs for strength (1.16 ± 1.09, $n = 1{,}039$) and power (1.16 ± 1.04, $n = 160$) measures were not significantly different ($p > .05$). Thus, PER training appears to have similar effects on strength and power. Significant moderator variables are examined next in greater detail.

Because a number of the studies secured for this review examined the effects of creatine supplementation on strength or power improvements, statistical analysis was performed to ensure that the influence of such supplementation did not confound the analysis of the PER effects. Statistical analysis revealed that ESs calculated from groups taking a creatine supplement were no different ($p > .05$) than those from groups reporting no creatine supplementation. Therefore, all ESs were included for analysis.

Moderating Variables. Gender was examined and found not to be a moderating variable, as both men and women experienced similar benefits of PER training (ES = 1.02 and 0.99, respectively). Age was found to be a significant moderator, with populations 55 years of age or younger experiencing significantly larger ESs (1.34) compared to those older than 55 years (ES = 0.85). Training status was also found to be a significant moderator. Specifically, untrained populations experienced the largest ES (1.59), while trained groups (ES = 0.78) and athletes (ES = 0.84) experienced smaller effects. Length of the training program also affected the magnitude of the treatment effect with shorter programs (i.e., those less than 8 weeks), resulting in a smaller ES (1.15) than programs of 9–20 weeks (ES = 1.39) but similar to programs over 20 weeks in duration (ES = 0.96).

Discussion

This meta-analysis is the first of its kind to analyze the magnitude of the strength and power gains elicited by PER and Non-PER training. The first analysis demonstrated that the concept of PER, as a whole (i.e., including the ability to train at higher volumes and intensities), elicits a greater increase in strength and power than Non-PER training (ES = 0.84). The second analysis allowed for strict evaluation of the program variables without the influences of different levels of volume and training intensity. This analysis demonstrated that, when volume and intensity are similar, PER training still elicits greater improvements than Non-PER training (ESs = 1.28 and 1.03, respectively). Thus, the difference in pre/post ESs for PER and Non-PER training is approximately one fourth of a standard deviation, when volume and intensity are held constant. When volume and intensity are not controlled, the ES was over three fourths of a standard deviation. Therefore, the increased strength and power gains with PER training are due to the ability to train at higher volumes and intensities without overtraining and the actual variation of the training variables.

O'Bryant (1982) suggested that superior strength gains with PER training are at least partially independent of volume and that variation of volume and intensity is more important. However, other researchers (Baker et al., 1994) concluded that PER does not elicit greater strength increases than Non-PER when volume and intensity are equated. Fleck (1999) contended that the additional strength gains elicited by PER training could be related to greater training volumes when following such training models. As previously mentioned, these conclusions have been based solely on probability values and percent increases observed in only a few studies. By calculating and analyzing treatment effects among a large number of studies, this meta-analysis supports the conclusion that the effectiveness of PER training is, in part, independent of greater volume and intensity. However, for maximal benefits additional volume and intensity must be incorporated along with variation of the training program.

The mechanisms and reasoning behind improvements in strength and power adaptations due solely to training variation are somewhat unclear. According to Selye's (1974) General Adaptation Syndrome, a system will adapt to a stress to which it is unaccustomed (i.e., overload principle). Greater overload may result in greater adaptations, if the system is able to recover from the increased stimulus. It has been shown that greater volumes and training intensities result in strength greater adaptations, up to a certain level. These strength increases are presumably due to greater overload of the neuromuscular system (Rhea, Alvar, Burkett, & Ball, 2003). Based on this line of reasoning, variations in training, independent of increases in training volume and intensity, may increase the overload the neuromuscular system experiences by continually applying an unaccustomed stress. Because the training variation provides recovery points embedded in the training cycles, the

Table 1. Results for the overall effects and moderating variables

Moderator variable	*F* test	*p*	ES	*SD*	*n*	*P*
Overall			0.84	1.41	39	*
PER	$F(1, 1197) = 15.11$	< .01	1.28[a]	1.14	650	*
Non-PER			1.03[b]	0.98	549	*
PER moderators						
Gender	$F(3, 646) = 33.20$	< .01				
Not Reported			0.22[a]	0.26	26	*
Men			1.02[b]	1.02	273	*
Women			0.99[b]	0.74	94	*
Both			1.75[c]	1.25	257	*
Age	$F(1, 648) = 13.27$	< .01				
< 55 years			1.34[a]	1.15	567	*
> 55 years			0.85[b]	1.05	83	*
Training status	$F(2, 647) = 40.23$	< .01				
Untrained			1.59[a]	1.20	383	*
Trained			0.78[b]	0.86	93	*
Athletes			0.84[b]	0.89	174	*
Length of study	$F(2, 646) = 2.77$	.07				
1–8 weeks			1.15	0.98	280	*
9–20 weeks			1.39	1.25	353	*
20–40 weeks			0.96	1.02	13	*

Note. ES = effect size; *SD* = standard deviation; *n* = number of effect sizes; PER = periodized training; Non-PER = nonperiodized training.
[a,b,c]Effects with different superscripts differ significantly from one another at $p < .05$ as determined by Scheffé post hoc tests.
*Effect is significantly different from zero.

neuromuscular system may be able to handle the increased overload and respond with greater PER adaptations than nonvaried training. The role of such neuromuscular concepts and adaptations should receive more research attention. This analysis examined the moderating effects of training status, gender, age, and length of the training program on the ES magnitude for PER training; however, it is important to note that all the categories specified experienced large treatment effects following PER training.

Training status moderated the ES for PER training. The moderating analyses indicate that PER training is most effective in untrained populations (ES = 1.59) while recreationally trained participants (ES = 0.78) and athletic populations (ES = 0.84) experience smaller, but still large, treatment effects with PER training. Based on the inability of some PER training studies to reach statistical significance, Fleck (1999) concluded that PER might not be needed in untrained populations until some level of strength base has been developed. However, results from this analysis demonstrate that untrained individuals benefit dramatically from PER training. This finding is further supported by recent evidence indicating that untrained individuals experience greater strength gains with multiple-set (up to four sets) than single-set training programs (Rhea, Alvar, & Burkett, 2002; Rhea, Alvar, et al., 2003). A pervasive notion exists that untrained individuals will experience maximal strength gains regardless of their method or amount of training because they are unaccustomed to training. It is evident that untrained populations experience greater strength gains than trained individuals; however, both populations respond to more complex training programs (i.e., PER and multiple-set programs) with additional strength and power improvements.

It has long been thought that PER training was most effective for athletes and its use was less important in other populations. However, these meta-analytic findings reveal that PER training is effective in all populations. Why PER would elicit a smaller effect in athletic populations compared with untrained populations is unclear. The smaller potential for strength and power increases in highly trained individuals may make it more difficult to identify differences between treatments. Furthermore, the length of the training programs in athletes may also account for these findings, as longer periods of training (e.g., a full training year or sports career) may result in a larger treatment effect in athletic populations. Another factor may be the type of PER schedule athletes follow. Most of the studies using competitive athletes as participants have prescribed to the classic, linear PER program. Recently, it was shown that daily undulating periodization (DUP) elicits greater strength gains than the classic, linear schedule (Rhea, Ball, Phillips, & Burkett, 2002). DUP is characterized by daily changes in volume, intensity, or other variables. For instance, training intensities of 70, 85, and 95% of 1RM would be used on Monday, Wednesday, and Friday, respectively. In contrast, linear periodization generally makes these changes every 4 weeks (e.g., 70% of 1RM Weeks 1–4, 85% of 1RM Weeks 5–8, and 95% of 1RM Weeks 9–12). The cited comparison of these training programs supports the idea that frequent training adjustments facilitate strength and power adaptations. While this study (Rhea, Ball, et al., 2002) involved recreationally trained participants who had previously followed a linear schedule, it demonstrated that more frequent training variations are more effective. It is possible that athletes may become accustomed to the classic, linear PER schedule and changing the periodization schedule may improve the effectiveness of PER training. The DUP effects should be examined more closely in athletic populations to test such a hypothesis.

It has been suggested that further analysis is needed to examine PER effectiveness in women and those of varying age groups (Fleck, 1999). The current analysis found that women respond to PER training with similar strength gains (ES = 0.99) compared to men (ES = 1.02). PER was also shown to be more effective than Non-PER in various age groups. Age categories were collapsed into two groups (older and younger than 55 years of age), and analyses indicated that both groups experienced greater strength gains with PER training (ES = 0.85 and 1.34, respectively). While younger individuals benefited to a greater degree than older individuals, it was clear that individuals of all ages experienced larger strength gains with PER than Non-PER training. It should be noted, however, that fewer ESs were available for training programs involving women and individuals over the age of 55 years; however, sufficient ESs were available to examine these characteristics as moderators.

An inherent weakness in the body of research attempting to identify the superiority of PER over Non-PER is the short-term nature of the comparison studies. In fact, the concept of PER involves a long-term training program meant to elicit continued strength gains throughout months or years of training. Therefore, research incorporating short-term training interventions may be underestimating the importance of varying a training program. Another factor left out of many short-term PER research studies has been the inclusion of scheduled periods of active rest throughout the training program. Active rest, a vital component of PER, includes approximately 1 week of physical activity excluding resistance training incorporated throughout the training year to ensure adequate recovery from the previous training cycle (Fleck & Kraemer, 1996a). Due to the short-term nature of many studies in this area, this important component of PER training is often neglected. Therefore, the differences observed in these studies and in this review may be underestimating the actual value of PER.

Considering the limitations in the research literature with regard to study length, the differences in the magnitude of strength gains between PER and Non-PER would be expected to become greater as training time was extended, with active rest periods included. While the ES difference for length of training did not reach statistical significance (i.e., $p < .05$), a trend toward ES significance emerged ($p = .07$). In this meta-analysis, PER training programs lasting less than 8 weeks were less effective (ES = 1.15) than programs lasting 9–20 weeks (ES = 1.39). The ES for programs lasting more than 20 weeks was somewhat smaller (ES = 0.96), but this may be due to fewer ESs available in this category (n = 13). It may also indicate the need to alter the PER schedule after about 20 weeks of training to prevent an accustomization to the training schedule and a plateau in adaptations. Previous investigators have suggested that people experience the benefits of PER training over long periods (Fleck, 1999). While the current analysis provides some insight into this issue, the relative paucity of studies lasting longer than 20 weeks warrants further research to evaluate the benefits of PER in chronic intervention studies.

Conclusion and Applications

This analysis has identified the benefits of PER training for muscular strength and power. Further research is needed to examine various periodization schedules (i.e., nonlinear or daily undulating) and identify more specific guidelines for the frequency and direction of changes in volume and intensity for increased strength and power (Rhea, Ball, et al., 2002; Rhea, Phillips, et al., 2003). Research should also attempt to examine the effects of periodized resistance training on other fitness areas, such as local muscular endurance and muscular hypertrophy.

These data have demonstrated that men and women of all ages and varying training experiences will evidence greater strength gains when following a PER training program. Exercise specialists should provide individuals with training programs that involve planned variations in volume, intensity, frequency, and exercises performed. For greater fitness adaptations, progression to greater volumes and intensities of training should also accompany training variation.

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