**Flexible Nonlinear Periodization in a Beginner College Weight Training Class**

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**ABSTRACT**

McNamara, JM and Stearne, DJ. Flexible Nonlinear Periodization in a Beginner College Weight Training Class. *J Strength Cond Res* 24(8): 2012–2017, 2010—The purpose of this study was to determine the effect of a flexible nonlinear (FNL) periodized weight training program compared to a nonlinear (NL) periodized weight training program on strength and power. Sixteen beginner weight training students were randomly assigned to an FNL group (*n* = 8) or an NL group (*n* = 8). The exercise program included a combination of machines and free weights completed in 30 minutes, twice per week, for 12 consecutive weeks. Both groups were assigned the same total training volume of 3,680 repetitions and the same total training repetition maximum assignments of 10, 15, and 20. The FNL group, however, was allowed to choose which day they completed the 10, 15, or 20 repetition workout. This was the only difference between the groups. Pre- and post-test measures included chest press, leg press, and standing long jump. The FNL group significantly improved by an average increase of 62 kg (*p* < 0.05), whereas the NL group only increased by an average of 16 kg in the leg press. The FNL group did not significantly differ in chest press or standing long jump performance when compared to the NL group. The conclusion from this study is that an FNL periodization program may be a highly effective method of training for improving leg strength. Coaches can immediately implement an FNL program by evaluating the readiness of an athlete immediately before his or her training session, then adjusting the assigned exercise intensity accordingly.

**KEY WORDS** resistance, strength, power, leg press

**INTRODUCTION**

Sport-specific training programs are created in an attempt to optimize physical performance. One of the first recorded progressive resistance training programs was credited to Milo of Croton, who lifted a growing calf every day. The calf grew heavier each day, forcing Milo to lift more as the months went by (10). Since then, the basic principles of training, which include overload and periodization, have been used by athletes and coaches to improve physiological conditioning and athletic performance (4).

The classic strength periodization model typically employs the use of macrocycles, mesocycles, and microcycles to organize the training program (3). Essentially, this type of exercise strategy starts with high volume and low intensity and then progresses to low volume and high-intensity training (6). Over a period of several months athletes slowly adapt to the training loads and intensities. The periodized method of training has been shown to be more effective than a nonperiodized program for men and women over a wide range of ages and training experience (16). This system is logical as long as the athlete recovers and responds appropriately to the training stimulus. However, if an athlete overtrains or does not respond appropriately to the workout program, the precalculated training loads become inaccurate. The variability of the human element presents a complex problem when it comes to optimizing most training programs.

Nonlinear (NL) or undulating periodization has been shown to be a more effective system of improving physical training than the classic strength periodization model (12,15). Instead of making gradual adjustments over long periods as in the classic strength periodization program, more rapid fluctuations occur. Working within an NL periodization model, an athlete may train hypertrophy, strength, and power in the same week (17). This system may be more effective for several reasons: overtraining may be avoided, boredom may be relieved, and adjustments to an intense travel schedule can be made to accommodate an individual’s physiological and psychological readiness for a particular workout.

More recently, the premiere method of training athletes has been reported to be a flexible, nonlinear (FNL) workout program (9). This training system follows many of the same concepts, goals, and strategies of traditional strength
periodization and NL or undulating periodization. However, the distinguishing feature of an FNL program is that the athlete’s physiological or mental readiness to exercise is determined immediately before the workout. For example, a coach may ask an athlete the number of hours of sleep he or she accumulated the night before, what type of food nourishment he or she consumed, how much energy he or she currently has, or how he or she feels using a psychological inventory. Athletes can also undergo maximal strength or power testing immediately prior to each workout to determine their current performance level on that day. Athletes who are well rested, properly nourished, and performing well on pre-workout testing may be given a lower repetition maximum or high power output workout. Alternately, athletes who are not well rested, poorly nourished, and performing inadequately on pre-workout maximal testing might be given a workout that utilizes lighter weights and that is less intense than previously planned. To our knowledge, no published studies to date have attempted to use an FNL periodization exercise program to increase strength and power.

**METHODS**

**Experimental Approach to the Problem**

When choosing the most appropriate independent variables for the study, it seemed reasonable to compare an FNL workout to one that was similar in nature and structure. It was therefore logical to simplify the FNL program to the point where it differed only slightly from the NL program. In this way the NL group could act as a pseudo-control group because all workout variables were controlled for except order. The NL program was similar in all of the required workout parameters except order of workout choice. This provided the greatest control and stability of extraneous factors that could possibly affect internal validity and performance results. It was also reasoned that a true control group that was not exercising at all would lend little further insight into the effectiveness of an FNL program.

The logical validity of the strength measures was supported by 2 assessments. First, leg press and standing long jump tests measure leg strength, whereas chest press tests measure upper-body strength because those are the muscles directly involved in the respective lifts. Second, the National Strength and Conditioning Association (NSCA) has endorsed the premise that the leg press exercise is an accurate measure of leg strength, chest press is an accurate measure of upper-body strength, and standing long jump assesses maximum muscular power and high speed strength (2).

Intrarater reliability was considered to be very high because the tester was a Certified Strength and Conditioning Specialist with 8 years of maximal and submaximal strength and power testing experience. The tester had adequate training, was attentive to every test, and followed standard procedures for test administration and scoring. This same person evaluated all students for both pre- and post-testing on all measures of upper- and lower-body strength and power. The tester’s reliability on the dependant measures was established through a same-day, test–retest method to establish internal consistency. The interclass correlations were 0.99 for chest press, 0.99 for leg press, and 0.98 for standing long jump. In addition, other research studies have found high test–retest interclass correlations of 0.95 or higher for chest press (10), 0.96 for leg press (13), and 0.95 for standing long jump (11).

A research design that tests the effectiveness of an FNL strength training program is difficult to create. This is because an FNL program is based on the somewhat unpredictable daily changing needs and requirements of each athlete or individual. For example, an athlete may perform poorly on a strength evaluation immediately before a workout, and as a result, the planned workout suddenly will be changed to accommodate the athlete’s current level of physiological functioning. Individualizing workouts shortly before they occur creates a difficult problem related to control, predictability, and standardization of a research design.

To solve the problem of controlling the research environment and protocol, the researchers standardized the volume, intensity, and number of required exercises. The FNL and NL groups were assigned the same total volume and intensity over the course of the study. The only difference between the FNL and NL group was that the FNL group could choose from several workouts based on how they felt immediately before they were to begin their exercises. For example, they could choose between a 10, 15, or 20 repetition maximum workout. In this way the FNL program accommodated to the daily changing psychological and physiological needs of each subject.

**Subjects**

Prior to the investigation subjects were informed of the experimental risks and signed consent documents according to Institutional Review Board guidelines. After informed consents were obtained, students completed additional health history questionnaires. A total of 16 students (male, \( n = 12 \), female, \( n = 4 \)) between the ages of 18 and 23 years participated in this study. The FNL group consisted of 1 female and 7 males. The NL group consisted of 3 females and 5 males. One female in the NL group was not able to perform the standing broad jump pretest because of soreness in her knees. Both groups consisted of beginner lifters with limited experience. The FNL group had an average of 1.4 years of strength training experience prior to participating in the study, and the NL group had 1.3 years experience.

**Procedures**

All training was conducted and all data were collected in a college strength training class over the course of 1 semester. The class was structured to optimize safety, student learning, and physical performance and to allow for the implementation of both an FNL and NL periodized workout program. To begin, the usual classroom procedures of ensuring student safety were followed. After having students complete health
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history questionnaires and sign informed consents, they were pre-tested on bench press, leg press, and standing long jump. Pre- and post-testing followed the NCSA protocol (1) for determining an estimated 1 repetition maximum. An exercise-specific warm-up was followed by sets of increasing weight loaded onto the bar. When the lifter completed as many repetitions as he or she could with maximal effort, the test was complete. A training load and conversion chart then were used to estimate each lifter’s repetition maximum. In the standing long jump, students followed the standard anaerobic testing protocol and procedures commonly used in field testing (7). Before attempting any jumps, each student warmed up and was then given instructions on the task. A demonstration was provided and each student was allowed 3 attempts. The problem of “sandbagging” or misrepresenting one’s ability early on was avoided by informing students that they would not be graded on the amount of weight they could lift; they were simply encouraged to do their best. The instructors emphasized that proper lifting technique was most important and encouraged students to focus on form and alignment. After initial testing was completed, all students were given a workout program listing each machine to be used and the number of sets, reps, and required lifting intensity.

The semester lasted 16 weeks, but only 12 weeks were used for the actual training program. This allowed for 2 weeks of instruction and pre-testing prior to the start of the study and 2 weeks of post-testing and final exams at the end. During the 12 consecutive weeks of training each student was assigned a 30-minute workout to be completed twice a week for a total duration of 60 minutes per week. Because each class was 50 minutes long, the first 15 minutes were used to teach students important concepts related to fitness and strength training, which included understanding intensity, duration, frequency, repetition maximums, and perceived exertion. This helped to ensure that students were accurately completing the exercises and workout intensity throughout the program. Students were also carefully monitored by the course instructor to ensure that they fully completed each workout to the best of their ability.

Both groups were assigned the same total workout load for a duration of 12 consecutive weeks. The 12 weeks were divided into 3 segments of 4 weeks each. Each 4-week segment consisted of 8 total workouts. The workouts consisted of 10, 15, or 20 repetition maximum sets. Exercises for the lower body included leg press, prone leg curl, free weight squats, deadlifts, and lunges. Exercises for the upper body included chest press, bench press, seated rows, lat pulldowns, dumbbell shoulder press, and seated rear deltoid. For the midsection the following exercises were performed: back extensions, reverse back extensions, abdominal crunches, and leg raises. During the first 4-week segment, both groups performed 7 sets of 7 different exercises. During the second 4-week segment both groups performed 10 sets of 10 exercises, and for the last 4-week segment each group performed 15 sets of 15 exercises. The first segment included 2 exercises for the legs, 3 for the upper body, and 2 for the midsection. The second 4-week segment included 4 exercises for the legs, 4 for the upper body, and 2 for the midsection. The third and final 4-week segment consisted of 5 leg exercises, 6 upper-body exercises, and 4 midsection exercises.

Normally in a traditional periodized program the workouts would have progressed from lighter weights to heavier ones with a reduction in volume. The workouts for the NL group did not follow this linear path of higher to lower repetitions, but instead followed a varied program. In this way, a student may have completed an unpredictable variation and combination of 10, 15, or 20 repetition maximum workouts over the course of any given week. For example, during the first 4-week segment the NL group performed the 3 workouts at a 20 repetition maximum schedule for 3 of the workout days, a 10 repetition maximum schedule for 3 of the workout days, and a 15 repetition maximum schedule for 3 workout days.

Both the FNL and NL group were given the same total volume, intensity, exercise number, and required exercises. During the first 4-week segment all subjects in all groups performed a total of 56 sets of exercises. During this time 805 total repetitions were performed by each person in each group. During the second 4-week segment 80 total sets were performed for a total of 1,150 repetitions. The third week consisted of 120 sets totaling 1,725 repetitions. Both groups were assigned the same total training volume of 3,680 repetitions and the same total intensities performed at 10, 15, and 20 repetition maximum effort. The only difference was that the FNL group was allowed to choose between a 10, 15, or 20 repetition maximum workout immediately prior to starting. They chose the workout they felt most comfortable with on that particular day. To assist them with this process, the students were instructed to monitor and record their energy level at the beginning of the workout by estimating how much energy they felt they had on a scale from 0 to 10. Zero represented no energy, and 10 indicated that they were fully motivated and had maximum energy to work out.

Some further disclosure regarding the option of the FNL group to choose any workout they wanted is worthy of note. Because the FNL group had to complete the same number of 10, 15, or 20 repetition maximum workouts as the NL group over the course of each 4-week segment, they eventually became more restricted in choice of workouts as the weeks progressed. Through the process of elimination, students in the FNL group might not have been able to choose the order of the last few workouts in that 4-week period. For example, a student may have decided to complete the 10 repetition maximum workout 3 times in a row. To ensure that each student (regardless of group) completed the same total volume, he or she would then need to choose from 1 of the remaining workouts on his or her list. If this were the case, students would be required to complete the workouts that they were previously avoiding. Although the order of the workouts was different, both the FNL and NL groups were...
required to complete the same number of 10, 15, or 20 repetition maximum workout days.

**Statistical Analyses**

To determine if both groups were the same at the start of the study, pre-test scores on leg press, chest press, and standing long jump were compared between groups using multiple independent *t*-tests. The level of significance was set a priori at *p* ≤ 0.05 for all analyses. After the initial analysis, a repeated measures multivariate analysis of variance (MANOVA) was run to determine if there were any significant differences between the control and experimental groups on leg press, chest press, and standing long jump. The level of significance was set a priori at *p* ≤ 0.05 for all analyses. Cronbach’s alpha was used to determine the correlation of scores on all 3 dependent measures for each group separately. In addition, interclass correlations were calculated on the dependant variables of both groups separately. Finally, all data for both groups were simultaneously compared to determine Cronbach’s alpha, the Guttman split-half coefficient, and the interclass correlations of both groups on pre-test and post-test measures. Intrarater reliability was also determined using the same day test–retest method for all 3 dependent measures.

**RESULTS**

To validate that the NL and FNL groups were similar prior to the initiation of training, *t*-tests comparing participants’ pre-test scores on the leg press (*t* = 0.28 (14), *p* = 0.79), chest press (*t* = 0.81 (14), *p* = 0.43), and standing long jump (*t* = 1.24 (14), *p* = 0.24) showed no significant differences. Multivariate ANOVA results indicated that the FNL group showed significant improvement post-intervention on leg press when compared to the NL group (*F* = 7.7 (1), *p* = 0.015) (Figure 1). However, the FNL group showed no significant differences post-intervention when compared to the NL group in the chest press (*F* = 0.81 (1), *p* = 0.38) or standing long jump (*F* = 3.71 (1), *p* = 0.08). Reliability and stability of test measures was demonstrated via the Guttman split-half technique (*r* = 0.93) and (*r* = 0.84) and the calculation of Cronbach’s alpha for the FNL group (*r* = 0.85), NL group (*r* = 0.93), and both groups simultaneously (*r* = 0.90) on all 3 dependent measures. Further stability of the data was established by means of interclass correlations on leg press, chest press, and long jump for the FNL group (*r* = 0.52, 0.81, 0.96) and NL group (*r* = 0.88, 0.98, 0.98). Intrarater reliability using the same-day test–retest method was high for the chest press (*r* = 0.99), leg press (*r* = 0.99), and standing long jump (*r* = 0.98).

Descriptive statistics were calculated to determine the distributional characteristics of the FNL and NL groups. The ranges of performances for the 2 groups can be found in Table 1.

**DISCUSSION**

To our knowledge, this was the first study to compare the effectiveness of an FNL workout to an NL workout. We found that the FNL program resulted in superior performance in the leg press exercise when compared to the NL group. We did not see the same positive results in the chest press and standing long jump when comparing the FNL and NL groups.

The superior leg press performance demonstrated by the FNL group may be a result of the inherent nature of the workout program. An FNL periodization program has the potential to provide significant restorative properties, enhancing an athlete’s physiological and psychological recovery processes. For example, the athlete may gain positive psychological benefits because, to an extent, he or she can control the difficulty of his or her workout. Furthermore, if an athlete is tired on a particular day, he or she can choose a workout with lighter weights, and this may allow for appropriate physiological restoration to occur also. Using this type of self-regulation also adheres to the principle of individualization, which is a significant principle of training and is effective for improving athletic performance. In summary, the concept of an FNL program of physical training that adjusts to daily fluctuations in fatigue, psychological readiness, and conditioning level is logical and in the current study resulted in significant improvement in leg press strength.

There was no improvement in standing long jump when comparing between groups. These results are consistent with strength and power studies and are also in keeping with current investigations concerning the specificity of training.

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**Table 1.** Ranges of 1 repetition maximum performances for leg press, chest press, and standing long jump.

<table>
<thead>
<tr>
<th>Group</th>
<th>Leg press (kg)</th>
<th>Chest press (kg)</th>
<th>Long jump (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexible</td>
<td>91–280</td>
<td>27–182</td>
<td>125–282</td>
</tr>
<tr>
<td>Nonlinear</td>
<td>73–239</td>
<td>23–146</td>
<td>92–236</td>
</tr>
</tbody>
</table>

**Figure 1.** Superior leg press performance using a flexible nonlinear (FNL) periodized workout program compared to a nonlinear (NL) periodized one. *p* = 0.02. Pre-test and post-test mean leg press results are shown by group.
Research shows that there will be little transfer to power type movements such as the standing long jump when training programs are restricted to a narrow force velocity range (2,8). In the current study, the training program that each student performed was based on low-velocity lifts and therefore not specific to activity reflecting explosive anaerobic power gains. Hence the principle of specificity was not followed and as a result it is reasonable to assume that no progress would be made.

Chest press performance was not significantly different between groups. One possible reason for this result is that the upper body received more overall volume than the lower body and may have been overtrained. It is possible that the FNL program was not robust enough to compensate for the accumulated load. In both the FNL and NL group the number of upper-body exercises progressed from 5 at the beginning of the exercise program to 10 during the final 4 weeks of the program. This is in contrast to the assigned lower-body exercises, which were fewer in number. The lower-body exercises began with 2 at the beginning of the program and progressed over time to 5 during the final 4 weeks of the program.

There are some possible drawbacks to the hypothesis that an FNL nonlinear periodization program will produce better results when compared to an NL program. For example, athletes may learn that if they are tired or fatigued on a particular day, they will be given an easier workout to perform. This may turn into a learned behavior that could be consciously or unconsciously used as an excuse when the athlete is not tired or overtrained but simply unmotivated to put in his or her full effort. It is also possible that poor eating and sleeping habits might be seen as a reward to the immature or undisciplined athlete. Athletes may be given an easier workout because they failed to eat properly or get enough sleep the night before. It is therefore possible that an FNL periodization program may be more effective in a highly motivated athletic population.

In conclusion, it is important to remember the role that basic physiological adaptation plays in all training and workout regimens. As homeostasis is interrupted, the body adapts in a number of different ways. The stress of physical exertion, for example, can result in fatigue followed by compensation given that an adequate period of recovery is provided and that the stress is not too great (2). Selye’s general adaptation theory (5) suggests that certain physical stressors can cause a reaction in the body and that this reaction can be detrimental, resulting in serious harm and even death, or the body will adjust and successfully manage the stress. As a general theory it is valuable and informative, but in the modern world of sports, personal training, and athletics, coaches and fitness professionals are often more concerned with stress in a more controlled non–life-threatening context. In the pursuit of training and competition, optimal performance is the goal. However, there are many factors such as psychology, physiology, diet, sleep, external life stressors, and religious beliefs that can potentially affect performance. As a result, the quest for the optimum response to a program of training will likely remain somewhat elusive. Accounting for individual variability—which is the goal of an FNL program—may allow for a more effective and efficient method of training.

**Practical Applications**

FNL periodization is a new strategy that should theoretically maximize athletic performance in numerous sports and physical performances. Anyone using this method will be exposed to a highly personalized program that adjusts workload and intensity to correspond with daily strength and energy levels. Athletes will no longer be forced to risk injury and overtraining as they attempt to force a fatigued body though a high-intensity workout. With an FNL workout regimen, adequate rest is provided until the athletes demonstrate that they are physically and mentally ready for heavy loads or high intensity. With this new system of training, athletes should reach higher levels of physical performance by maximizing adaptation and potentially reducing injury from overtraining.

A simple way to implement an FNL program is to take any number of physical or psychological measures prior to the assigned workout. For example, number of sleep hours, resting heart rate, energy level, or even resting blood pressure could be taken. In addition to these measurements, or as a replacement, maximal performance testing can be used such as vertical jump, standing long jump, or maximum bench press. After the measurements are taken, the strength professional would then compare results to the expected performance. If they are lower than expected, a reduction in intensity, volume, or duration would then be used to offset the discrepancy between readiness and assigned workout objectives. It should be noted that this system of training is not used to avoid high stress workouts; instead it is used strategically to time the more intense workouts appropriately so the body is able to efficiently exploit the principle of adaptation, resulting in a higher level of functioning and performance.

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