Effects of Autoregulatory Progressive Resistance Exercise Periodization Versus Linear Periodization on Muscular Strength and Anaerobic Power in Collegiate Wrestlers

By

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The University of Wisconsin-Whitewater, 2015
Under the Supervision of Dr. Steven J. Albrechtsen

The main purpose of this study was to observe the effects of the autoregulatory progressive resistance exercise (APRE) protocol versus linear periodization (LP) on anaerobic and strength performances in collegiate wrestlers. Subjects were randomly assigned to APRE periodization or traditional LP during eight weeks of post-season training from approximately mid-March through mid-May 2015. Subjects participated in two exercise trials to measure muscular strength and anaerobic power, with one exercise trial at the beginning of the eight-week post-season training program and one exercise trial at the end of the eight-week post-season training programs. Both the APRE and LP groups improved their peak and average power from pre-test to post-test in both the upper body and lower body Wingate tests. However, there were no signigicant differences in lower body peak power p=0.3954), lower body average power (p=0.1181), upper body peak power (p=0.3046), or upper body average power (p=0.9426). When comparing the

two groups in the one repetition maximum for the squat, there was no statistical significance (p=0.3061), even though the APRE group increased by 11.42% and LP by 8.03%. In the one repetition maximum for the bench press there was a statistical significance (p=0.0179) with the APRE group increasing strength performance by 11.76% compared to LP group which increased strength performance by only 6.3%. While both APRE and LP increased anaerobic power performances, it seems that the APRE protocol was more efficient at increasing muscular strength along with anaerobic power increases.

Chapter 1

Introduction

Strength improvement has been the goal for athletes wanting to gain a competitive advantage over the competition for decades. Along with the athletes, many coaches and strength and conditioning professionals seek out the best way in which to achieve such an advantage. To gain this competitive edge most coaches strive to implement some form of planning for training their athletes. For strength and conditioning professionals, periodization has become the most effective way to train athletes. Periodization has evolved into two roughly separate models: linear or classic periodization and nonlinear periodization. Since each strength and conditioning professional has their own training philosophies and ideas, periodization can take on many different forms. Many professional can agree that there is no universally agreed upon model of periodization for increasing sport performance.

Most strength and conditioning professional tend to work with younger athletes as there are limited opportunities to work at the professional level. These coaches find themselves working with high school or more predominately with college athletes. College athletes have a wide range of skill, strength, and experience; which can make it difficult to pick a periodization model that fits each athlete and team. As a strength and conditioning professional, it is important to understand the level of skill and strength an athlete has in order to train him or her properly.

Brief History of Periodization

Periodization is the planned distribution or variation in training means and methods on a periodic or cyclic basis (Baechle & Earle, 2008). The concept of periodization was first proposed in the late 1960s by Russian physiologist Leo Matveyev. Matveyev analyzed the results of Soviet athletes in two Summer Olympics and compared which athletes were successful or not successful and their training schedules. From this research, Matveyev was able to create a periodized training model that he split into three major divisions: preparatory, competition, and transition (Verkoshansky & Siff, 2009).

Before Matveyev, the roots of periodization can be seen in the work of Canadian biologist Hans Selye. Selye described how the human body reacted to stress, known as the General Adaption Syndrome (GAS). Selye outlined a three-stage response to stress. The first being the alarm phase, followed by the resistance phase, and ending in the exhaustion phase (Selye, 1956). The alarm phase is experienced when the body has a new or more intense stress applied. The resistance phase is when the body begins to adapt to the stimulus and tries to return to normal its status. The exhaustion phase occurs when the stress persists for an extended period of time and the body loses it ability to adapt to the stressor (Baechle & Earle, 2008).

In the late Seventies, Garhammer (1979) applied Selye's GAS response to resistance training and exercise conditioning. Garhammer concluded that in order to improve performance one must try to maximize the benefits of the first two stages of GAS and avoid the third phase. Further research lead Stone, O'Bryant, Garhammer, McMillan, and Rozenek in 1982 to propose an addition to Matevey's models of

periodization. Stone et al. added a "first transitional phase " between the preparatory and competition phases. This lead to the conventional periodization model using four distinct periods instead of three. The 1982 model was then adopted by the National Strength and Conditioning Association (NSCA). In the NSCA's book, *Essentials of Strength Training and Conditioning*, the chapter on periodization provided an example of what is now called linear periodization.

Table 1

Example of Linear Periodization

Weeks	Repetitions	Sets
1-6	8-12	8-12
7-11	5-6	5-6
12-16	2-4	2-4
17	1-2	1-2

This type of periodization is still being used and modified today as an effective training model for athletes.

Periodization for Performance

Linear periodization (LP) has been defined as the traditional model of periodization. It is the basic standard for periodized models. Miranda et al. (2011) define linear periodization as a gradual build up of intensity as the repetitions and sets decrease over time. Linear periodization has been hypothesized to improve athletic strength and

performance more than non-periodized programs. In a study done by Joao et al. (2014), nine elite powerlifting athletes were able to significantly increase their strength in all exercises and at each assessment compared to the pre-training values following a linear periodized model. Joao et al. (2014) explained that this increase in muscle strength was due to the exercise-specific neuromuscular adaptations within the central nervous system. This resulted in an increase in the frequency of the firing of nerve impulses via the exercise-specific motor units.

Linear periodization has been scrutinized in the last decade as an inferior periodization model when compared to nonlinear models. Nonlinear models, such as daily undulatory periodization (DUP), have become quite popular. DUP consists of each week cycling through one day of volume training, one day of strength training, and one day of maximal power training (Miranda et al., 2011). This type of training has been hypothesized to improve strength and performance superior to linear periodization. Miranda et al. (2011) demonstrated that linear periodization was just as effective in increasing strength as daily undulatory periodization.

Most notably the difference between linear and nonlinear periodization is the amount of volume and intensity changes within each model. One study conducted by Ramalingam and Yee (2013) demonstrated the effects of linear periodization versus daily undulating periodization with both models being equal in volume and intensity. The study observed how each model would effect muscular endurance. At the end of the twelve-week program no significant differences occurred between the two groups. Both were effective at increasing muscular endurance.

As athletes become more advanced so should their training methods. As most athletes become stronger and more skilled they require more extensive training protocols. One form of periodization that transformed from linear periodization was the block training method. Block periodization has been a very effective form of training for advanced athletes. Current studies done by Painter et al. (2012) and Garcia-Pallares, Garcia-Fernandez, Sanchez-Medina, and Izquierdo (2010) demonstrate that block periodization is more effective at improving performance for highly trained athletes rather than beginner or intermediate athletes. Garcia-Pallares et al. (2010) took world-class kayakers and split them into two groups. One group followed the block periodization model and one group followed the traditional model. At the end of the two programs, block periodized kayakers displayed greater gains in paddling speed, power output, and stroke rate. The authors concluded at the end of the study that "The results suggest that block periodization may be more effective for improving performance for highly trained athletes. Also block periodization may be more effective since it requires less volume and training hours. A block periodized design could be a more useful strategy than traditional periodization to maintain the residual training effects as well as to achieve greater improvements in certain variables related to kayaking performance" (Garcia-Pallares et al., 2010). The study exhibits that forms of periodization must change in order to accommodate the athlete's skill and level of play.

History of APRE

Autoregulatory exercise has just as long of a history as periodization. Dr. Thomas L. DeLorme, an army physician, experimented with a new rehabilitation technique.

Delorme used strength training in order to recover form a childhood illness. From this experience he reasoned that such training would prove to be beneficial to injured servicemen. In his efforts to help, DeLorme created a new protocol that consisted of multiple sets of resistance exercises in which patients lifted their ten-repetition maximum. DeLorme refined the system by 1948 to include three progressively heavier sets of 10 repetitions, and he referred to the program as "Progressive Resistance Exercise" (Todd, Shurley, &Todd, 2012). Delorme's method of exercise created a standard in rehabilitation practice for years.

Continuing on Delorme's path was Kenneth Knight, (1979), who created another variant of the DeLorme system which he called the Daily Adjustable Progressive Resistance Technique (DAPRE). This form of exercise, used in rehabilitation, offered a combination of training and testing for the patient. The protocol required four sets of exercise to be performed beginning with a set of ten repetitions at 50% of ones anticipated sixrepetition maximum (6RM). Set two consistedof six repetitions at 75% of the anticipated 6RM, while set three was performed with the anticipated 6RM. The number of strict, full repetitions with this weight was used to determine the appropriate load for set four, according to an adjustment table (Knight, 1985).

Mel Siff's Protocol

Following Knight, a physiologist named Mel Siff introduced a new form of DAPRE called the APRE protocol. The system was outlined for the purpose of increasing strength. Siff's protocol employs a 3RM (strength/power), 6RM (strength/hypertrophy), and 10RM (hypertrophy). Siff expanded the protocol by providing a program for

subsequent days. He explained that set four is used to determine the next session's 6RM (10RM or 3RM), according to the adjustment table (Verkhoshanky & Siff, 2009).

Table 2

Sets and Repetitions for 6RM, 10RM and 3RM Phases

Set	6RM Workout	10RM Workout	3RM Workout
0	Warmup	Warmup	Warmup
1	10 reps/50% 6RM	12 reps/50% 10RM	6 reps/50% 3RM
2	6 reps/75% 6RM	10 reps/75% 10RM	3 reps/75% 3RM
3	Reps to failure/6RM	Reps to failure/10RM	Reps to failure 3/RM
4	Adjust reps to fail	Adjust reps to fail	Adjust reps to faile

APRE for Performance

Early research in autoregulation was done almost exclusively in rehabilitation settings. Knight (1985) was one of the first to use a form of APRE known as daily adjustable progressive resistance exercise (DAPRE) on athletes for knee rehabilitation. Knight took 21 male athletes who were immobilized for three to six weeks and applied the DAPRE method in order to strengthen the surrounding muscles. In his case study, he found that the DAPRE technique was effective in increasing the patient's strength without overtraining the muscles. This was the first real evidence that autoregulation was an effective form of exercise for increasing strength based on individual progression.

Table 3

Adjustments for the Fourth Set

Adjustment for 6RM		Adjustment for 10RM		Adjustment for 3RM	
Reps	Set 4	Reps	Set 4	Reps	Set 4
0-2	Minus 2.5-5 kg	4-6	Minus 2.5-5 kg	1-2	Minus 2.5-5 kg
3-4	Minus 0-2.5 kg	7-8	Minus 0-2.5 kg	3-4	Leave
5-7	Leave	9-11	Leave	5-6	Plue 2.5-5 kg
8-12	Plue 2.5-5 kg	12-16	Plue 2.5-5 kg	7+	Plus 5-10 kg
13+	Plus 5-10 kg	17+	Plus 5-10 kg		

A more recent study by Horschig, Neff, and Serrona (2014) demonstrated the same results as Knight (1985). Using the updated APRE method designed by Siff, Horschig et al. (2014) were able to successfully increase the strength of a high school football player during his recovery from an anterior cruciate ligament reconstruction surgery. Horschig et al. concluded that the APRE method of periodization provided an individualized progressive resistive protocol that can be used to safely and effectively increase strength in both healthy populations and individuals recovering from injury. Each of these studies demonstratethe effective use of autoregulation in athletic rehabilitation and further strengthened the current knowledge regarding periodization with the APRE protocol. The studies also demonstrated that healthy individuals could possibly benefit from this type of training.

Mann, Thyfault, Ivey, and Sayers (2010) were the first to apply the APRE protocol was applied to athletes for the purpose of increasing athletic performance and strength. Mann et al. conducted testing that took two periodized models and pitted them against each other. Two random groups of football players were assigned to either the APRE protocol or to linear periodization. After six weeks in two separate years, the athletes in the APRE protocol had larger improvements in increasing strength. This was one of the only studies tocompare APRE with any other type of periodization and needs to be further researched in order to truly understand the capabilities of APRE for increasing sport performance.

Anaerobic Power and Capacity

Many sports such as football, basketball, gymnastics, sprinting, and wrestling use anaerobic metabolism extensively during competition. It is important for a strength and conditioning professional to understand what anaerobic metabolism is and how to effectively train the anaerobic system for competition. Wilmore and Costill (2004) defined anaerobic activity as an energy expenditure that uses anaerobic metabolism (without the use of oxygen) that lasts less than 90 seconds, utilizing an exhaustive effort. One way in which to measure anaerobic metabolism or activity is through the Wingate Anaerobic Test (WanT). There are two major energy sources present during the WanT. The first is the adenosine triphosphate-phosphocreatine (ATP-PCr) system, which lasts for three to 15 seconds during maximum effort. The second system is anaerobic glycolysis, which can be sustained for the remainder of the all-out effort.

The WanT measures an athlete's peak power, anaerobic capacity and reduction of power. Defined by Zupan et al. (2009), the WanT is a thirty-second all out exhaustive ergometry test where the athlete pedals against a resistance that is set at a certain percentage of his or her body weight. The power output is measured throughout the test by the number of revolutions the athlete can achieve on the ergometer during those 30 seconds. The peak power recorded is the maximal power output achieved for five seconds of the test, usually the first five seconds. The anaerobic capacity is the average power over the entire 30 seconds of the test. The lowest power output is an average of the lowest five seconds during the test, usually the last five seconds. Finally, the difference in power output from the highest to the lowest is recorded as the fatigue index (FI) (Zupan et al., 2009).

Many coaches and strength and conditioning professionals measure muscular strength with some type of maximal strength testing, such as the one-repetition maximum, the five-repetition maximum, or repetition maximum testing. These measurements help coaches determine and observe individual improvements. Yet, for most sports muscular strength isn't necessarily the goal of the athlete. Anaerobic metabolism plays a great part in an athlete's performance for many sports. It then makes sense for the strength and conditioning professional to focus on improving the athlete's anaerobic system. Having the ability train and evaluate an athlete's anaerobic performance would be more beneficial in increasing their performance.

Purpose of the Study

With most athletes not reaching elite levels until very late in their career, it should be clear that less intense models need to be used first in order to advance the athletes. Research has shown that linear periodization is an effective method for many athletes, especially at the novice level. However, there is still limited knowledge of other promising models or protocols of periodization for sports performance such as autoregulatory progressive resistance exercise. More importantly there is very little knowledge on the APRE protocol and its effectiveness on strength and anaerobic performance. The main purpose of this study was to observe the effects of the APRE protocol versus linear periodization on anaerobic and strength performances in collegiate wrestlers. The hypothesis is that autoregulatory progressive resistance exercise periodization will be more effective than linear periodization on improving anaerobic and strength performances in collegiate wrestlers.

Chapter 2

Methods

Subjects

Eighteen male collegiate wrestlers from the University of Wisconsin – Whitewater participated in this research prooject. The safety of exercise was established through the completion of the Physical Activity Readiness Questionnaire (PAR-Q) by each subject. Demographic information, including name, contact information, birthdate, height, weight, and experience in wrestling were obtained from each subject.

Procedures

Subjects were randomly assigned to the autoregulatory progressive resistance exercise periodization group (APRE) and the linear periodization group (LP) during eight weeks of post-season training from approximately mid-March through mid-May 2015. Subjects participated in two exercise trials to measure muscular strength and anaerobic power, with one exercise trial at the beginning of the eight-week post-season training programs and one exercise trial at the end of the eight-week post-season training programs. Each exercise trial involved six assessments of muscular strength and anaerobic power performed at ten-minute intervals. Right and left grip strength were assessed based on the best of three trials using a grip strength dynamometer. Lower body power was determined through the standard Wingate Anaerobic Power Cycle Ergometer Test involving 30 seconds of lower body exercise on a computerized cycle ergometer.

Upper body power was determined through a modified Wingate Anaerobic Power Cycle Ergometer Test involving 30 seconds of upper body exercise on a computerized cycle ergometer. The one-repetition maximum for the back squat was estimated from a three-to-five repetition test using 85% of the one-repetition maximum previously measured during the wrestling season. The one-repetition maximum for the bench press was estimated from a three-to-five-repetition test using 85% of the one-repetition maximum previously measured during the wrestling season. T-tests were used to determine statistical significance. Paired t-tests were used to compare pre-tests and post-tests within each group. Unpaired t-tests were used to compare the differences between the two groups. Statistical significance was accepted at $P<0.05$.

Chapter 3

Results

Table 4 summarizes the demographic data for the two groups, the autoregulatory progressive resistance exercise periodization group (APRE) and the linear periodization group (LP).

Table 4

Demographic Data

Group	Age (yrs)	Weight (lbs)	Height (in)	Wrestling (yrs)
APRE (n=9)	20.4 ± 1.6	176.4 ± 28.2	69.6 ± 2.6	9.9 ± 3.4
LP (n=9)	20.0 ± 1.1	172.1 ± 26.7	69.5 ± 1.7	10.3 ± 2.6

Note: n = number of subjects. Data are mean plus or minus standard deviation.

Table 5 presents the data for lower body peak power from the pre-test and post-test and the difference between the pre-test and post-test for each group. From the pre-test to the post-test peak power increased significantly for both the APRE group (p=0.0011) and LP group (p=0.0003) while there was no statistical significance for the differences in peak power between the pre-tests and post-tests for the two groups (p=0.3954). Table 6 presents the data for lower body average power from the pre-test and post-test and the difference between the pre-test and post-test for each group. From the pre-test to the post-test average power increased significantly for both the APRE group (p=0.0001) and LP

group (p=0.0001) while there was no statistical significance for the differences in average power between the pre-tests and post-tests for the two groups (p=0.1181).

Table 5

Lower Body Peak Power

Group	Pre-Test Peak Power (W/kg)	Post-Test Peak Power (W/kg)	Peak Power Difference (W/lg)
APRE (n=9)	9.21 ± 0.99	10.34 ± 1.02	1.13 ± 0.67
LP (n=9)	8.98 ± 0.92	10.39 ± 1.05	1.41 ± 0.69

Note: n = number of subjects. Data are mean plus or minus standard deviation.

Table 6

Lower Body Average Power

Group	Pre-Test Average Power (W/kg)	Post-Test Average Power (W/kg)	Average Power Difference (W/lg)
APRE (n=9)	6.93 ± 0.58	7.88 ± .58	0.95 ± 0.38
LP (n=9)	6.67 ± 0.63	7.89 ± .50	1.22 ± 0.31

Note: n = number of subjects. Data are mean plus or minus standard deviation.

Table 7 presents the data for upper body peak power from the pre-test and post-test and the difference between the pre-test and post-test for each group. From the pre-test to the post-test peak power increased significantly for both the APRE group (p=0.0001) and LP group (p=0.0001) while there was no statistical significance for the differences in

peak power between the pre-tests and post-tests for the two groups (p=0.3046). Table 8 presents the data for upper body average power from the pre-test and post-test and the difference between pre-test and post-test for each group. From the pre-test to the post-test average power increased significantly for both the APRE group (p=0.0092) and LP group (p=0.0001) while there was no statistical significance for the differences in average power between the pre-tests and post-tests for the two groups (p=0.9426).

Table 7

Upper Body Peak Power

Group	Pre-Test Peak Power (W/kg)	Post-Test Peak Power (W/kg)	Peak Power Difference (W/lg)
APRE (n=9)	3.87 ± 0.64	6.04 ± 1.05	2.17 ± 1.01
LP (n=9)	4.55 ± 1.13	6.03 ± 0.99	1.48 ± 1.67

Note: n = number of subjects. Data are mean plus or minus standard deviation.

Table 8

Upper Body Average Power

Group	Pre-Test Average Power (W/kg)	Post-Test Average Power (W/kg)	Average Power Difference (W/lg)
APRE (n=9)	2.49 ± 0.39	3.25 ± 0.29	0.76 ± 0.30
LP (n=9)	2.60 + 0.41	3.35 ± 0.48	0.75 ± 0.28

Note: n = number of subjects. Data are mean plus or minus standard deviation.

Table 9 presents the data for the estimated one-repetition maximum in the squat from the pre-test and post-test and the differences between the pre-test and post-test for each group. From the pre-test to the post-test one-rep maximums in the squat increased significantly for both the APRE group (p=0.0021) and LP group (p=0.0036) while there was no statistical significance for the differences between the pre-tests and post-tests for the two groups (p=0.3061). Table 10 presents the data for the estimated one-repeition maximum in the bench press from the pre-test and post-test and the differences between the pre-test and post-test for each group. From the pre-test to the post-test one-repetition maximums in the bench press increased significantly for both the APRE group (p=0.0001) and LP group (p=0.0016). There was a statistical significance for the APRE group between the pre-tests and post-tests for the two groups (p=.0179).

Table 9

Estimated One-Repetition Maximum in the Squat

Group	Pre-Test Est One-Rep Max (lbs)	Post-Test Est One-Rep Max (lbs)	One-Rep Max Difference (lbs)
APRE (n=9)	277.22 ± 34.19	308.88 ± 43.78	31.67 ± 21.21
LP (n=9)	276.66 ± 75.45	298.88 ± 72.14	22.22 ± 16.41

Note: n = number of subjects. Data are mean plus or minus standard deviation.

Table 10

Estimated One-Repetition Maximum in the Bench Press

Group	Pre-Test Est One-Rep Max (lbs)	Post-Test Est One-Rep Max (lbs)	One-Rep Max Difference (lbs)
APRE (n=9)	207.77 ± 29.80	232.22 ± 28.84	24.44 ± 4.64
LP (n=9)	237.77 ± 63.05	252.77 ± 69.44	15.00 ± 9.68

Note: n = number of subjects. Data are mean plus or minus standard deviation.

Table 11 presents the data for right grip strength from the pre-test and post-test and the difference between the pre-test and post-test for each group. Table 12 presents the data for the left grip strength from the pre-test and post-test and the difference between the pre-test and post-test for each group. From the pre-test to the post-test right grip strength and left grip strength there was statistical significance for the increases in the APRE group ($p=0.0196$ and $p=0.0273$, respectively) an the LP group ($p=0.0373$ and $p=0.0127$, respectively) while there was no statistical significance for the differences between the pre-tests and post-tests for the two groups ($p=0.7656$ and $p=0.8197$, respectively).

Table 11

Right Grip Strength

Group	Pre-Test Grip Strength (kg)	Post-Test Grip Strength (kg)	Grip Strength Difference (kg)
APRE (n=9)	53.55 ± 6.67	58.88 ± 5.32	5.33 ± 5.43
LP (n=9)	54.00 ± 9.89	58.55 ± 8.91	4.55 ± 5.48

Note: n = number of subjects. Data are mean plus or minus standard deviation.

Table 12

Left Grip Strength

Group	Pre-Test Grip Strength (kg)	Post-Test Grip Strength (kg)	Grip Strength Difference (lbs)
APRE (n=9)	51.11 ± 7.86	56.22 ± 7.59	5.11 ± 5.69
LP (n=9)	50.88 ± 8.14	55.44 ± 6.71	4.56 ± 4.28

Note: n = number of subjects. Data are mean plus or minus standard deviation.

Chapter 4

Discussion

The purpose of this study was to investigate the effect of autoregulatory progressive resistance exercise periodization group (APRE) and linear periodization group (LP) on anaerobic power and muscular strength in collegiate wrestlers during post-season. The post-season is an important time for athletes to focus on building mass and strength for the next season. More specifically for wrestlers, strength training after the season ends is important for not only regaining lost weight, but for regaining and improving strength performances that might have been lost in season due to weight loss.

The results of this research project showed that both groups increased their performances in all aspects of testing. In lower body Wingate testing, both the APRE group and LP group increased their peak power and average power. Within each group these were statistically significant increases ($P<0.05$). However, there were no statistical significances in the differences between between groups ($P>0.05$). In upper body Wingate testing, both groups also increased their peak power and average power, and both increases were statistically significant ($P<0.05$). Like lower body Wingate testing, the differences between groups in upper body peak power and average power were not statistically significant ($p>0.05$).

One reason why both groups remained similar in their power performances could be due to the periodization models being geared more toward building strength. While

power movements were involved in both programs, the main movements that were emphasized were large multijoint strength exercises. The squat and bench press exercises were the main movements that were manipulated. These exercises tend to be used to build strength and not power in athletes. Another reason may be the emphasis of the APRE protocol specifically on strength. While there are many ways in which LP can be applied, the program used in this study was more strength oriented. Even though the programs were strength oriented, both groups did exhibit improvements in power performances. These improvements demonstrate that increases in muscular strength can be effective in increasing power as well.

When looking at strength tendencies, it can be seen that both groups increased. Grip strength in both groups increased significantly ($P<0.05$), yet when comparing the differences between the two groups there was no statistical significance for either right grip strength or left grip strength ($P>0.05$). Both groups increased their estimated one-repetition maximum in the squat and bench press. Within each group, these increases were statistically significance was reached for the squat and bench press ($p<0.05$). The differences in one-repetition maximum in the squat were not statiscally significant between groups ($p>0.05$), even though the APRE group had an average increase of 11.42% compared to the 8.03% average increase for the LP group. The increases in the one-repetition maximum in the bench press were sttistically significant for both the APRE group and the LP group as well ($p<0.05$). When comparing the two groups, the APRE group had a statistically significant increase ($P<0.05$) over the LP group. The APRE group increased on average by 11.67% compared to the LP group at 6.30%.

The results of this study promote the effectiveness of APRE over LP. APRE may be more efficient at increasing muscular strength due to the self-progression and the constant adjustment of repetitions. APRE creates the ability for an athlete to self-regulate their training and, in theory, that athlete could never repeat the same repetition and intensity structure. The APRE protocol also has the ability to promote muscle hypertrophy as well as strength gains. Greater muscle hypertrophy adds to greater muscle recruitment. This could explain why the APRE protocol was able to create greater muscular strength than LP. LP seems to be more of a constant training program which in turn creates a period were the body begins to adapt leading to reduce effectiveness. This could explain why LP is constantly being manipulated in order to advance its effectiveness.

Limitations

The potential limitations for this study were that training volume and intensity could not be equalized. This could possibly be the reason for the change in strength performances between the two groups. Another limitation is that there was no nutritional and supplemental interventions. Athletes were able to control their own diets and supplement usage which in turn could cause some athletes to outperform others. Overall, there was a small number of participants which limited the conclusions that may be drawn. However, the data presented should not be ignored, more importantly, it should elicit further studies in the future.

Future Suggestions

It is recommended that further studies be performed concerning the effectiveness of APRE on the development of anaerobic power and muscular strength. Future studies involving larger numbers of participants and longer time frames for training should provide important additional results. It is also recommended that studies on APRE be used to examine differences between trained and untrained people. This would create a better understanding of the broader effectiveness of APRE.

Practical Applications

The results of the study suggest that APRE is more effective than LP in increasing muscular strength. While both APRE and LP increased anaerobic power performances, the APRE protocol was more efficient at increasing muscular strength along with anaerobic power. From these results, it is suggested that with the addition of the APRE protocol periodization models would be more effective in increasing muscular strength performances. Due to the nature of the APRE protocol and the effectiveness, athletes could use this method pre-season and post-season to help jump-start strength improvements. More advanced athletes who are familiar with the APRE protocol could use the APRE method as a year-around training program in order to increase muscular strength.

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