

Fall 2017

Periodization Programs and their Effects on the Physiological Outcomes of Collegiate Athletes

Raymond Irish

The College at Brockport, riris2@u.brockport.edu

Follow this and additional works at: https://digitalcommons.brockport.edu/pes_synthesis

 Part of the [Health and Physical Education Commons](#), [Kinesiology Commons](#), and the [Sports Sciences Commons](#)

Repository Citation

Irish, Raymond, "Periodization Programs and their Effects on the Physiological Outcomes of Collegiate Athletes" (2017). *Kinesiology, Sport Studies, and Physical Education Synthesis Projects*. 28.
https://digitalcommons.brockport.edu/pes_synthesis/28

This Synthesis is brought to you for free and open access by the Kinesiology, Sport Studies and Physical Education at Digital Commons @Brockport. It has been accepted for inclusion in Kinesiology, Sport Studies, and Physical Education Synthesis Projects by an authorized administrator of Digital Commons @Brockport. For more information, please contact kmyers@brockport.edu.

Periodization Programs and their Effects on the Physiological Outcomes of
Collegiate Athletes

A Synthesis Project

Presented to the

Department of Kinesiology, Sport Studies, and Physical Education

The College at Brockport

State University of New York

In Partial Fulfillment

of the Requirements for the Degree

Master of Science in Education

(Physical Education)

By

Raymond B. Irish

Fall 2017

THE COLLEGE AT BROCKPORT
STATE UNIVERSITY OF NEW YORK
BROCKPORT, NEW YORK

Department of Kinesiology, Sport Studies, and Physical Education

Title of Synthesis Project: Periodization Programs and their Effects on the
Physiological Outcomes of Collegiate Athletes

Cathy Houston-Wilson 12/11/17

Instructor Approval

Date

Accepted by the Department of Kinesiology, Sport Studies, and Physical Education,
The College at Brockport, State University of New York, in partial fulfillment of the
requirements for the degree Master of Science in Education (Physical Education).

Cathy Houston-Wilson 12/11/17

Chairperson Approval

Date

Table of Contents

Title Page.....	1
Signature Page.....	2
Table of Contents.....	3
Abstract.....	4
Chapter 1 – Introduction.....	5
Chapter 2 – Methods.....	10
Chapter 3 – Review of Literature.....	13
Chapter 4 – Discussion, Conclusions, Recommendations.....	24
Appendix.....	28
Reference Page.....	61

Abstract

Many different strength and conditioning professionals are attempting to find more efficient ways to train their athletes to improve strength, power, body mass and body composition. There are many different types of training models that are used within the realm of strength and conditioning. Therefore, the purpose of this synthesis was to review the literature on periodization programs and their effects of physiological outcomes on collegiate athletes. Research has shown that both Linear and Nonlinear periodization models improved physiological outcomes of the subjects presented. With that being said, there was no sufficient evidence to which model is more efficient. Further education and studies need to be conducted for future research.

Chapter 1- Introduction

There are many different alternatives to training collegiate athletes within the resistance training realm. One training regime is known as the periodization program, periodization program is defined as the systematic planning and structuring of training variables (intensity, volume, frequency and rest) throughout designated training timeframes aimed at maximizing performance gains and minimizing the potential for overtraining or decrements in performance (Harries, Lubans, Callister 2015). Strength and conditioning coaches often look for training programs that can enhance the physiological outcomes of their athletes.

There are two different types of periodization programs, Linear Periodization and Nonlinear Periodization. Linear periodization programs involve each phase of the training program emphasizing a specific training goal whether it be strength, hypertrophy or power (Hoffman 2009). Hypertrophy is defined as muscle growth involving muscle mass (Karavirta 2011). Linear periodization, also known as LP focuses on one training goal for a block of time and then moves onto the next training block. An example would be a training block system using eight consecutive training sessions only focused on strength (Smith 2014). A key characteristic of Linear Periodization starts with training at a high volume, low intensity state with gradual increases in intensity and decreases in volume throughout training periods (Harries 2015). Nonlinear periodization programs involve the continuous variation of increased or decreased

intensity and volume throughout a training period. Nonlinear periodization allows multiple factors (hypertrophy, strength, and power) to be trained over a period of time with a higher degree of flexibility (Smith 2014). Due to this, athletes are able to focus on power and hypertrophy development simultaneously, whether it be day to day or week to week (Hoffman 2009).

Recent research has shown that Linear Progression models provided sufficient amount of evidence that the intensity in these models provided a great deal of success. Based on research while using LP, athletes were able to receive at least 72 hours of recovery for athletes while conducting workouts 3-4 days a week using moderate loads of 70-85% of a 1RM (Kerksick 2009). Majority of the studies on the impact of LP training has been done on sports such as tennis and American football. In addition, most athletes who use these periodization programs can avoid overtraining, eliminate boredom in the training routine, and optimize recovery, which is of great importance in improving performance and reducing the risk of injury (Kraemer, Ratamass, Fry 2015). Understanding the effects of using periodization program training protocols with athletes may provide insights for enhancing performance and preventing injury (Kraemer 2000).

Nonlinear Periodization models use a form of variation in which repetitions are altered each training session throughout the training day or week, creating greater variation in training stimulus, which has been suggested to produce superior physiological and performance adaptations (Painter 2012). Recent research has stated

that NLP has resulted in more efficient maximum strength improvement compared to LP (Monteiro 2009). There appears to be a lack of agreement on the LP and NLP to improve muscle strength. However, strength coaches and trainers tend to use NLP models because of their reputation of avoiding accommodation to training loads and optimizing physiological strain (Monteiro 2009). It has been proposed that these nonlinear manipulations of volume and intensity, providing more frequent changes in stimuli and periods of recovery, are more conducive to strength gains (Harries 2015).

Statement of the Problem

Collegiate athletes may benefit from periodization programs as well as NP programs. Athletes need to be training intensely but more so in a smart manner. Failure to do so can result in breakdown of play, overtraining and more importantly severe injury. The usage of Linear periodization programs and Nonlinear periodization programs have been reported to have a significant effect on athletes physiologically. Nonlinear and Linear Periodization programs have both positive and negative attributes within a certain sport. Determining which type of periodization program (Linear or Nonlinear) will assist athletes in enhancing their physiological outcomes will be reviewed.

Research Questions

1. What effects do Linear Periodization programs and Nonlinear Periodization programs have on collegiate athletes? How effective are they?
2. Is one form of training more effective specifically over the other?

3. What is the effect of these programs on different genders involved in these programs?

Purpose of the Study

The purpose of this synthesis was to review the literature on periodization training programs and their effects of physiological outcomes on collegiate athlete's athletic performance.

Operational Definitions

The following operational definitions for the synthesis:

1. Periodization Programs: The systematic planning and structuring of training variables (intensity, volume, frequency and rest) throughout designated training timeframes aimed at maximizing performance gains and minimizing the potential for overtraining or decrements in performance (Harries, Lubans, Callister 2015).
2. Linear Periodization Programs: The increase of intensity and decrease of volume over time in order to achieve peak performance at the end of the training period (Smith 2014). (The abbreviation LP will be used in the synthesis to refer to this type of periodization program)
3. Nonlinear Periodization Programs: The continuous variation of increased or decreased intensity and volume throughout a training period (Smith 2014).

4. Physiological Outcomes: an outcome that involves power, speed, balance, agility coordination, flexibility, muscular strength, lean body mass and cardiovascular endurance (Kraemer 2000).

Assumptions

The following can be regarded as assumptions for this synthesis:

1. The literature review was exhaustive.
2. Linear and Nonlinear periodization programs are accepted forms of resistance training.
3. Literature of Linear and Nonlinear periodization programs is representative.

Delimitations

The synthesis is delimited to the following:

1. Collegiate athletes
2. Male and female collegiate athletes
3. Collegiate sports

Chapter 2- Methods

The purpose of this chapter was to review the methods used to find literature on periodization programs and their effects of physiological outcomes on collegiate athlete's athletic performance. The studies collected for the critical mass of this synthesis were identified using the EBSCO host database from the College at Brockport's Drake Memorial Library as well as Google Scholar. Within the EBSCO host database, searches were conducted using the SPORTDiscus database and the search engine from the Drake Memorial Library. From these searches, a total number of 11 articles met the criteria for inclusion as part of the critical mass in this literature review. For an article to be selected to be in this literature review, they needed to meet a certain criteria. To start, the articles needed to be peer-reviewed articles. If an article has been peer-reviewed, it will most likely be of higher quality and as well as more scientifically valid. Second, the articles needed to have been published between the years of 2000 and 2017. This helped to ensure the most current and up to date information available. Many different searches were done to compile the list of 11 articles to be used in this literature review. Within the database EBSCO, the first search was periodization programs and collegiate athletes which resulted in over 1,000 results. No articles within the first search were selected. The second search nonlinear and linear periodization and collegiate athletes were used which resulted in 3 results. Within the Drake Memorial Library search engine, the first search used the phrase of periodization programs with collegiate athletes which resulted in over 200 articles listed. From those 200 articles, 4 articles were selected for the literature review. The second search that was conducted

involved physiological outcomes, periodization programs and collegiate athletes. The outcomes of the third search either had articles already selected or did not fit the purpose of the literature review. The third search was nonlinear, linear periodization programs and collegiate athletes which had 24 results, 3 articles were selected in the process for the literature review. The fourth search involved different phrases for nonlinear periodization and linear periodization. The fourth search had 37 results where 2 articles were selected due to the relevance to the literature review being conducted. Google Scholar was also used in finding peer reviewed articles as stated above. The first search was peer-reviewed, periodization programs and collegiate athletes which had 876 results within the search. No articles were selected in the first search that was conducted. The second search involved peer review, nonlinear periodization, linear periodization and collegiate athletes. The results were 105 articles, where 2 were selected. One of those 2 articles was used for definitional purposes for the introduction. The specific journals that the articles were selected from were the Journal of Strength and Conditioning Research, the American Journal of Sports Medicine, the International Journal of Sports Physiology and Performance and the Scandinavian Journal of Medicine & Science in Sports. Each article selected to be in this literature review was carefully read over twice, the first just a run through and the second was where key information was pulled. This information was later put into a grid format. This helps to make it easy to search for similarities between the many different articles. The article grid also includes articles that were not included as part of the critical mass of articles, but are in the synthesis paper.

As the purpose of this synthesis states, the critical mass of subjects in all of the studies are limited to college athletes. Some of the articles provided, did provide Intel on collegiate aged individuals, professional athletes and adults due to these subject being included within the literature. There were a total number of 842 subjects participants involved in the literature. Of the 842 subjects, 507 of the subjects were not specified. The collegiate athlete subject varying from Division III to Division I amounted to 207. Of the 207, 33 of the athletes were female and 174 were male with an average age of 18-22. Of the 174 male subjects, 25 were collegiate male soccer players, 51 were Division III collegiate male football players, 23 were Division I track and field athletes and 75 were unspecified. There were a total of 76 healthy male adults associated in the study as well as 40 male sports students. Not to mention there were 12 professional volleyball players from Spain that was included in the literature that was provided. Out of the 845 subjects in the literature, 178 of those subjects were involved in NLP groups and 103 were involved in LP groups. Out of the 845 subjects, 13 were involved in a periodization conditioning program, 9 were involved in a non-periodization program, 8 were in a single circuit resistance training group and 21 were in a control group. 510 of the subjects were not specified within the literature during a meta-analysis. Even though the subjects differentiated in age, this provides different output on these types of periodization programs.

Chapter 3- Review of Literature

The purpose of this synthesis was to review the literature on periodization training programs and their effects of the physiological outcomes on collegiate athletes athletic performance. The two different types of periodization programs associated with the literature review are Linear Periodization and Nonlinear Periodization. Specifically, maximal strength and power as well as body mass and composition will be examined for each form of training. In addition, a comparison of these forms of training will be reviewed.

Linear Periodization Programs and the Physiological Effects

Linear periodization programs can have an effect on a collegiate athlete's physiological outcome whether it is strength, power, body mass and body composition. These effects can have a tremendous effect on an athlete's performance in their sporting realm. It is important to take a look at the research provided to see how much of an impact linear periodization programs can have on the physiological outcomes of a collegiate athlete.

Maximal Strength and Power

Painter et al., (2012) tested a linear periodization and nonlinear periodization program to compare their effects on track and field athletes. There were thirty-two collegiate track and field athletes between the age of 18-22 years of age (23 men and 9 women) that were placed on a linear periodization resistance training program 3 d/wk for 10 weeks. Each training within the linear periodization group lasted an hour on average. Three training blocks were in 2-4 week sequences. The first 4 week block

focused on strength and endurance, which focused on high volume and low intensity. The second 4 week block focused primarily on strength which lowered the volume and heightened the intensity. The third block which consisted of two weeks, focused more so on high intensity and low volume. After a proper warm up procedure testing of maximal strength was determined by a 1RM on parallel squat and mid-thigh pulls using an isometric rack. Testing occurred the beginning of weeks 1,4,8 and 11 and lab view 8 software was used to record and analyze data. The results from the study showed that after the first block, the linear periodization group improved their 1RM squat and mid-thigh pull force by 14.7%, more than the NLP program. From there on within the next two blocks, a 3.9%-4.5% gain was recorded with maximal strength and power (Painter 2012).

In a similar study by Hoffman et al., (2009) researchers tested non-periodized, linear and nonlinear periodization programs on 51 Division III American collegiate football players for 15 weeks to compare their effects. The 51 collegiate male athletes were divided up into three groups. One group participated in a non-periodized training program (NP), second group participated in a traditional linear periodization program (PL) and the other group was placed on a nonlinear periodization program. The 51 collegiate football players did have experience with resistance training. Maximum strength was measured via 1RM on the bench press and squat exercise. Strength and power testing occurred PRE, MID and POST during the training cycle. The findings demonstrated that the PL group had significant strength and power improvements week 1-week 8 with the 1RM Bench Press and Squat. Vertical jump was also tested

throughout the 15 week cycle. The subjects had a small increase in strength from weeks 8-15. Vertical jump, vertical jump power and Medicine Ball throw increased significantly as well. Post program, subjects completed a questionnaire and some stated “I feel stronger and more powerful than I did at the start of the study” (Pg 16).

Kerksick et al., (2009) were interested in determining how a split body linear periodization program affected 49 college and middle-aged individuals with upper body and lower body strength as well as body composition. The split body routine consisted of two upper body days and two lower body days per week for 8 weeks. The results from the study, pertaining to maximal strength on the 1RM of the bench press and leg press increased significantly with all subjects. College aged subjects had a more significant impact than the middle-aged subjects with the 1RM on bench press at the end of the 8 week study (Kerksick, et. al, 2009).

Lastly, in a study by Gonzalez, Arija & Clemente-Suarez (2011) researchers sought to determine changes in seasonal jump performance and body composition in professional female volleyball players. Within the study, 10 female volleyball players participated in 24 weeks of training and testing while on a linear periodization program. Throughout the 24 weeks, the athletes started with general conditioning (weeks 1-4) and proceeded to hypertrophy training (weeks 5-8), maximal strength and power training (In season weeks 9-16) and ended with specific strength training (weeks 17-24). The subjects tested their strength with a 2RM on a smith machine, which was selected to limit maximal stress on the participants while they were in season. The Smith Machine assisted with keeping the participants vertical and their bar path straight

throughout the squat movement. This is due to the barbell of the smith machine being in between rails which only allow north and south-like movement. Vertical jump tests were used to determine maximum power output with various lower body exercises. The various vertical testing exercises were the squat jump, countermovement jump and the abalakov jump. Gonzalez, Arija & Clemente-Suarez (2011) describe the abalakov jump “as a countermovement jump with the inclusion of the participants using arm swing” (Pg 1494). All tests were measured using the Ergojump Bosco system (Gonzalez, Arija & Clemente Suarez 2011). The results from the study were very interesting and showed that the subjects various vertical jump maxes increased throughout the study from 4.4-7.5%, even while in season. Maximum strength the back squat (2RM) increased by 6.67% from PRE to POST with the subjects (Gonzalez, Arija & Clemente Suarez, 2011).

Body Mass and Composition

As previously mentioned Kerkick et al., (2009) also focused on the aspect of body composition and mass with the 49 college and middle-aged subjects. Using the 8-week split upper body and lower body routine. Body composition was measured using the DXA (Dual-energy X-ray Absorptiometry) each week. Body mass measurements were calculated by Hologic Software, which divided the amount of fat mass by total mass. The results stated that Body Mass tended to increase significantly between both groups (Kerkick, et al., 2009). DXA measurements showed significant and similar increases in fat free mass and lean mass between the two groups. The college-aged group also increased their fat mass more so than the middle aged group. This can be

due to the college-aged group consuming more carbohydrates throughout the 8-week study (Kerksick, et al., 2009).

Similarly, Painter et al., (2012) measured body mass and composition with Track and Field subjects within their study. Painter used an electronic scale to determine body mass changes and a plethysmography to determine body composition changes with the subjects throughout the 10 week study. Throughout the study, the linear periodization had constant increases in body mass every week. Painter et al., stated “that the linear periodization results with body mass were more efficient due to the lower repetitions associated with the groups program compared to nonlinear” (pg 165).

Gonzalez, Arija & Clemente-Suarez (2011) also examined body mass as part of their study. In addition to noting the effect of training on jump performance and maximal strength, body composition was another important factor which was examined within their 24 week study. Body composition was measured using a multi-frequency impedance plethysmograph and focused on the trunk, arms and legs of the participants. The results involving changes in body composition and body mass were moderate throughout the 24 week study. Body Mass and Body Mass Index (BMI) increased and were steady throughout the study. Muscle mass and fat free mass steadily increased slightly from PRE-POST 2 whereas fat mass and fat percentage decreased significantly.

Nonlinear Periodization Programs and the Physiological Effects

Nonlinear periodization programs are considered a different style of programming compared to linear periodization programs. Ultimately, it involves different patterns of volume and intensity daily to weekly and can result in physiological

changes, especially within a certain realm of athletics. It is important to look through the research in an in-depth manner and see how impactful nonlinear periodization models can be on the physiological outcomes of collegiate athletes.

Maximal Strength and Power

In a study used to determine the effects of nonlinear training on maximal strength and power, Kraemer et al., (2000) compared the effects of resistance training, single circuit and nonlinear periodized programs on physiological and performance adaptations in collegiate women tennis players. There were 24 female collegiate tennis players involved in the study and split up between the three groups for 9 months of training. Testing protocols involved three skin fold tests using a Lange skinfold caliper for body composition. A Wingate cycle ergometer test protocol was used to determine anaerobic power. The subjects tested their 1RM with seated leg press, bench press and free weight shoulder press to determine maximal strength. Serve velocity was tested using two Panasonic 60 Hz model video cameras to determine which training protocol translated into the sport of tennis the most (Kraemer et al., 2000). The results within the study with the nonlinear periodization group were very interesting. The nonlinear group had significant and consistent increases in power output when using the Wingate test throughout the 9 months of training. Vertical jump also increased significantly over the 9 months. The Nonlinear Periodization group also had significant increases on their 1RM on the bench press, leg press and shoulder press throughout the 9 months of training and testing (Kraemer et al., 2000).

In a similar study, Smith et al., (2013) looked at 72 Division I collegiate football players and the effects a nonlinear periodization training program could have on them during the offseason. The 72 subjects were split up into three groups. Group 1 were all first year athletes (focused on body mass prioritization), group 2 were second and third year athletes (focused on strength gains with bench and squat) and group 3 were fourth and fifth year athletes (focused on power development with vertical jump and power clean). Programs were assigned to all groups but varied based on upper body and lower body splits, exercises, volume and intensity. All groups also participated in the same tests with the counter movement vertical jump, 1RM on the bench press, squat and power clean as well as tests measuring body mass. The results from the study demonstrated that groups 1-2 saw significant increases in strength and power with their bench press, squat and power clean whereas group 3 only had significant increase in the power clean exercise. Groups 1 and 2 saw some increase in their vertical jump whereas group 3 had no increase in their vertical jump. Body mass within the group had no significant changes due to non- responders within the groups (Smith et al., 2013).

Within a study conducted by Monteiro et al., (2009), researchers searched to compare whether a Non-linear periodization model or Linear periodization model were best suitable for developing strength over a span of 12 weeks. 27 strength trained men were split up into 3 groups (Linear periodization group, Non-linear periodization group and Non-periodized group). These three groups were tested on their 1RM on the bench press and leg press every four weeks during the 12 week training program. The bench press test was performed in a standardized free-weight bench press and the leg press

was performed in a 45 degree Cybex leg press station. The results were that the NLP group had significant increases in the 1RM bench press and leg press throughout the study. The LP group demonstrated strength gains through weeks 4-8 only on the 1RM bench press and leg press (Monteiro et al., 2009).

Body Mass and Composition

Kraemer et al.,(2000), focused on the physiological and performance adaptations on collegiate women tennis players. As stated earlier, the body composition of the subjects were assessed using three skin fold measurements with a Lange skinfold caliper. The triceps, hips and thighs were used in the skinfold testing and body fat was estimated using the equation of Siri (Pg 627). The results between the control group and single set group showed no difference throughout the study. The Nonlinear Periodization group showed increase in fat free mass and significant decrease in body fat percentage throughout the study (Kraemer 2000).

Silvestre et al., (2006) conducted a study on a Mens Division I Soccer program in relation to body composition and physical performance. Within this study, the 25 male subjects were placed on a nonlinear periodization program PRE and POST their NCAA soccer season. A digital scale was used to measure body mass and body compositions were measured using a fan-beam DXA (Dual-energy X-ray Absorptiometry). The results from the study showed that body mass significantly increased for the entire team from PRE to POST season. This could be due to the significant increase in total lean tissue throughout the study as well (Pg. 968). During the season, lean-tissue mass increased in

the subjects legs, trunks but not the subjects arms. Fat percentage increased slightly from PRE to POST season as well (Silvestre et al., 2006).

Linear and Nonlinear Periodization Comparison

There have been arguments regarding whether linear or nonlinear periodization models are best suitable for maximizing strength and power as well as diminishing body fat and increasing body mass. Within the research, some studies claimed that there are hardly any differences between the two programs.

Hartman, Bob, Worth & Schmidtbleicher (2009), compared Strength-Power Periodization (Linear) and Daily Undulating (Nonlinear) Periodization models on the aspect of force development and power ability on the upper extremity. 40 male subjects were split up between a nonlinear and linear periodization group for 14 weeks and trained 3 days per week with the bench press. The subjects were tested on their 1RM, maximal movement velocity on the bench press throw (V_{max}), maximal voluntary contraction (MVC) and maximal rate of force development (MRFD). The 1RM, MVC and MRFD were measured on the isometric bench press whereas the V_{max} bench press throw was measured on a smith machine. Instruction was used to assist the subjects through the procedures and to ensure accurate measurements occurred. The results from the study showed that both groups significantly increased their performances in the 1RM bench press and the V_{max} bench press throw with no significant differences. With both groups, MVC and MRFD showed no significant changes throughout the study (Hartman, Bob, Worth & Schmidtbleicher 2009).

In a meta-analysis study conducted by Harries, Lubans & Callister (2015) researchers looked into the effects linear and nonlinear periodization programs have on strength involving 510 participants in 12 studies. Of the studies presented, they differentiated on free weight exercises, machine based exercises, single joint and multi joint exercises as well. Maximal strength was assessed through all of the studies presented in the meta-analysis. The results from the meta-analysis showed that 16 of the studies increased maximal strength significantly with linear periodization and nonlinear periodization. Within the 16 studies, 12 studies showed no significant difference in maximal strength between the two periodization programs. Body Composition was not involved in the study (Harries, Lubans & Callister 2015).

Conclusion

The purpose of this chapter was to review the literature on periodization training programs and their effects of the physiological outcomes on collegiate athlete's athletic performance. The first was to review the literature on Linear Periodization programs and their effects on maximal strength and power as well as body mass and composition of male and female subjects. The second was to review the literature on Nonlinear Periodization programs and their effects on maximal strength and power as well as body mass and body composition of male and female subjects. Lastly, literature was presented to compare the differences between linear periodization programs and nonlinear periodization programs. After completing research on both periodization models, it is concluded that both periodization programs did in fact have positive effects on the physiological outcomes on the researched subjects. Maximal strength and power

as well as body mass and body composition were shown to have little to significant improvements on collegiate athletes, professional athletes and adults while on these periodization programs. Even though this is true, there still needs to be more research provided on the effects of periodization models on collegiate athletes.

Chapter 4- Discussion, Recommendations

The effects of periodization training programs of the physiological outcomes on collegiate athletes were reviewed in this synthesis project. Based on the review, the following conclusions were discovered. Both Linear periodization and Nonlinear periodization training programs had significant improvements with male and female subjects pertaining to maximal strength, maximal power, body mass and body composition. There was no clear evidence showing that either training model was more efficient.

Discussion

As the research demonstrated, both Linear and Nonlinear periodization training programs are very effective for improving strength, power, body mass and body composition. Researchers provided sufficient information in order to establish the importance of Linear and Nonlinear periodization programs within the field of athletics. The results showed that both Linear and Nonlinear periodization programs are efficient but that does not mean that the whole program between the research was the same. It is advised that strength and conditioning professionals use different models of periodization programs to assist with increasing strength and power for their athletes. Variety is needed in order to help veer away from plateaus and to keep constant progress (Harries, Lubans, Callister 2015). It is also important to note when to use either training programs in sport. Depending on the physicality of the sport or length of season, different periodization training models could be more beneficial. For instance (Smith 2013) stated that nonlinear periodization models could be more efficient with

building strength due to the NCAA having limits on hours for Division I athletes training sessions (pg. 21). This is due to nonlinear periodization models usually having short term goals rather than linear periodization models. Another factor that comes into play is the experience of the athlete or weight lifter. Progress while on periodization programs could be significant if the lifter or athlete lacks experience. With advanced lifters, one can conclude that physiological progression can occur in small increments while on periodization programs.

Recommendations

Recommendations for future research related to periodization programs and their effects of the physiological outcomes on collegiate athletes are advised. Even though training methods are a huge topic on the minds of strength and conditioning professionals, there are still areas that lack sufficient information.

Even though the research provided detail on significant progressions with the subjects, more research needs to be conducted in order to receive a further analysis. Strength and conditioning coaches not only emphasize the importance of improving strength, power and body composition. From a strength and conditioning professional's perspective, the importance of preventing injury and rehabilitating injury with athletes is crucial as well the overall health of the athlete. As strength and conditioning coaches continue to work with athletes, research would advise the usage of linear and nonlinear periodization programs on their athletes to improve physiological results.

The first recommendation would be to conduct more studies of periodization programs on more collegiate sports involving male and females. The research conducted

was only Women's volleyball, Women's Tennis, Men's soccer, Men's Football and both Men's and Women's Track and Field. Further research needs to be implemented in order to get a better understanding of the effects periodization programs have on the physiological outcomes of collegiate athletes. It is important to entail which type of program is more suitable for which type of sport. Both types of programs showed physiological improvements on athletes, but differentials between different sports could make alter the results. For instance, a season of collegiate football may be shorter than a season for collegiate basketball. That would show that collegiate football athletes could have more time in the offseason to focus on their programs and to make physiological improvements.

A second recommendation would be to include a dietary plan within the athlete's periodization program. There is a lot of importance in the fitness world that entails dietetics being a huge contribution to improving the physiology of those that are involved in resistance and cardiovascular training. If dietetics is of importance within a periodization program, it could be possible that the physiological results could heighten. A collegiate athlete's health should be held at high standard and consuming alcohol or bad eating habits could get in the way of their physiological outcome while on training programs. A dietary plan could help shift the athlete to focus more on their training programs and improving eating habits.

Another recommendation would be to see how periodization programs work with athletes when dealing with injuries or rehabilitation. Athletes acquire injuries all of the time within training or sport. If an athlete is injured there is a process of

rehabilitation that needs to take place. Investigating which periodization training model is more suitable with the purpose of rehabilitation could be highly effective.

One last recommendation would be to see the effects of periodization programs on adolescent and adult populations. Effective training tactics do not need to be aimed toward athletes alone. More research on the population of adolescent and adult populations could lead to a more accurate result. Not to mention, research on adults and adolescent individuals using periodization programs can result in the development of knowledge and training in a safe manner.

Appendix A
Article Grid

Author	Title	Source	Purpose	Methods & Procedures	Analysis	Findings	Discussion/ Recommendations Research Notes – Commonalities/Differences
Robert A. Smith, Gerard J. Martin, Tunde K. Szivak, Brett A. Comstock, Courtney Dunn-Lewis, David R. Hooper, Shawn D. Flanagan, David P. Looney, Jeff S. Volek, Carl M. Maresh & William J. Kraemer (2014)	The Effects of Resistance Training Prioritization in NCAA Division I Football Summer Training	Journal of Strength and Conditioning Research (2014), Vol. 28(1), Pages 14-22	The purpose of this study was to investigate if the Resistance Training component of a performance program could be prioritized for specific results using a nonlinear training model, grouping athletes by eligibility year.	72 NCAA Division 1 Football players were tested on their body mass and their 1RM on Bench Press, Back Squat, Power Clean and Counter movement vertical jump. 3 groups were tested on body mass, speed and power using NLP.	Data was analyzed using a 2-way analysis of variance with repeated measures (group × time). Vertical Jump was measured using a vertec, body mass was measured using a Tanita BWB-800 Scale, 1RMs were measured using The	Group 1 and 2 saw significant increases in the bench press, back squat and power clean. Group 3 saw significant increases in only the power clean. No increases in body mass or CMVJ height occurred.	Even though no body mass changes occurred throughout the 10 week off season study. Body mass changes did occur over a 3-4 year period with one of the athletes. The groups did have significant increases in strength but group 1 had 1.5 years of experience with resistance training over Group 2. Group 3 had four years of periodized program experience. Which could be why they were limited to increases in strength. Body mass changes and vertical jump changes were expected to be unlikely because 10 weeks is not enough to

					Epley Equation $((0.033 \times \text{reps}) \times \text{weight}) + \text{weight}$		make significant changes compared to a year.
Simon K. Harries, David R. Lubans & Robin Callister (2015)	Systematic Review and Meta-analysis of Linear and Undulating Periodized Resistance Training Programs on Muscular Strength	Journal of Strength and Conditioning Research (2014), Vol. 29(4), Pages 1113-1125	The purpose of this review is to (a) systematically identify and examine all studies directly comparing linear and undulating periodized RT	510 Participants were from a nonclinical populations (age: 19-34), few being athletes (3), studies varied between gender. The study compared the use of	All Meta-analysis were performed in Revman. The inverse-variance random effects model was used for the meta-analysis procedure because of	Of the included studies, 16 reported statistically significant increases in maximal strength for both LP and NLP RT programs. 12 of these studies found no	The majority of the studies found that Nonlinear periodization programs and Linear periodization programs have both significant effects on maximal strength. But some would favor daily nonlinear and weekly nonlinear for strength training. The participant size seemed to have been drastic yet effective in conducting the research. Training

			<p>programs and to synthesize the results, (b) quantitatively compare linear and undulating periodized RT programs' effects on muscular strength using meta-analysis, (c) evaluate the risk of bias in previous studies and provide recommendations to improve the quality of future studies, and (d) review</p>	<p>an LP program and NLP program with free weights, bodyweight resistance, plyometrics, machine weights and isokinetic devices. No restriction on age was made but muscular strength comparisons were made.</p>	<p>studies being performed with varied populations and methods. Also, studies were assessed for "risk of bias" using criteria adapted from the Consolidated Standards of Reporting Trials (CONSORT) statement by 2 authors independently. ANOVA was used to chart results.</p>	<p>significant differences between the two programs. Two studies conducted found NLP to be favorable and another study found LP to be favorable.</p>	<p>experience for the participants is a huge factor with increases in strength and the authors should have placed that within the research. Athletes were involved in the study but were judo athletes, and football athletes. Needs to be more research on athletes.</p>
--	--	--	--	---	--	--	---

			the study populations in which the comparisons of these resistance training programs have been investigated .				
--	--	--	---	--	--	--	--

<p>Chad M. Kerksick, Colin D. Wilborn, Bill I. Cambell, Michael D. Roberts, Christopher J. Rasmussen, Michael Greenwood & Richard B. Kreider</p>	<p>Early-Phase Adaptations to a Split-Body, Linear Periodization Resistance Training Program in College-Aged and Middle-Aged Men</p>	<p>Journal of Strength and Conditioning Research (2009), Vol. 23(3), Pages 962-971</p>	<p>The Purpose of the study was to compare the changes in strength and body composition variables in a younger (18-22 years) and older (35-50 years) group of previously resistance-trained men after an LP, split-body resistance training program of 8 weeks duration.</p>	<p>49 participants ranging from 18-50 in age were used within the study. The study used a split training LP program of 8-10 weeks and nutrition, body composition were measured between the college aged group (18-22) and male adult group (35-50)</p>	<p>Dual energy x-ray absorptiometry scans (DXA) were used to measure body composition . Participants had to sign statements assuring they did not take performance enhancers and were not on a dietary program. ANOVA, SPSS Windows 11.5 were used for analyzing data.</p>	<p>The 8-10 week LP program significantly resulted in strength gains with the 1RM squat and Bench press between both groups. College Aged males 1RM Bench had a larger increase than the male adults. Also body mass increased between the two groups via DXA scans.</p>	<p>The study examined changes in maximal strength, anaerobic capacity, and body composition after an 8-week, split-body, LP training program in both college and male aged adults. Although different periodization models exist, available research on following a split-body program is limited. Furthermore, research concerning the physiological effects of periodized resistance exercise has been limited to trained college aged women, untrained and recreationally trained College aged men and women, and untrained elderly men.</p>
--	--	--	--	---	--	--	---

<p>Jay R. Hoffman, Nicholas A. Ratamass, Marc Klatt, Avery D. Faigenbaum, Ryan E. Ross, Nicholas M. Tranchina, Robert C. McCurley, Jie Kang & William J. Kraemer</p>	<p>Comparison between Different Off-Season Resistance Training Programs in Division III American College Football Players</p>	<p>Journal of Strength and Conditioning Research (2009), Vol. 23(1), Pages 11-19</p>	<p>The purpose of this study was to examine the efficacy of periodization and to compare different periodization models in resistance trained American football players</p>	<p>51 experienced resistance trained American football players of an NCAA Division III football team were randomly assigned to 1 of 3 groups that differed only in the manipulation of the intensity and volume of training during a 15-off season program. Group 1 participated in an NLP program,</p>	<p>Software packages (AccuPower, Frappier Acceleration, Fargo, ND) were used to calculate power. Log books were used to keep track of the subjects progress with the resistance training aspect of their program. To assess upper body power chalk was used to record distance of throws with a 3- kg</p>	<p>All groups significantly increased both 1RM squat and 1RM bench press from pre to mid study. Results were still significantly greater than pre at post, but significant strength improvements were not seen from mid to post study. No body mass changes occurred throughout the study within all</p>	<p>Even though the research showed that this was an offseason program. The student athletes did in fact have a rest period after their season but still were physically active. Meaning they were not placed on a periodization program prior to the study. Strength and power did in fact increase even with an additional week of rest occurred for the athletes (spring break). Plyometric experiments were used in week 5 which could have resulted in effecting the results of the study. These studies have showed that manipulation in intensity and volume provides a huge advantage for strength and performance gains for explosive athletes.</p>
--	---	--	---	---	---	--	---

				Group 2: LP Group 3: Planned NLP program.	medicine ball.	groups.	
William J. Kraemer, Nicholas Ratamess, Andrew C. Fry, Travis Triplett-McBride, Perry L. Koziris, Jeffrey A. Bauer, James M. Lynch & Steven J. Fleck	Influence of Resistance Training Volume and Periodization on Physiological and Performance Adaptations in Collegiate Women Tennis Players	The American Journal of Sports Medicine (2000), Vol. 28(5), Pages 626-633	The purpose of this investigation was to examine the effects of volume of resistance exercise on the development of physical performance abilities in competitive, collegiate woman tennis players.	24 collegiate female tennis players were matched for tennis ability and randomly placed into 1 of 3 groups: a no resistance exercise control group, a nonlinear periodized multiple-set resistance training group, or a	For statistical analysis use, nQuery Advisor software (Statistical Solutions, Saugus, Massachusetts) was used.	Body mass did not increase but fat loss did in fact decrease over the 9 months in the periodized group but not in the single set or control group. Serve velocity, power output and maximum strength all had significant increases in	In summary a periodized, multiple-set resistance training program produced superior increases in muscular strength, power, lean body mass, tennis performance (as measured maximal serve velocity), resulted in a superior decrease in percent body fat over a 9 month training period. The periodized training group showed continued improvement beyond that of the initial 4 months of training. The periodization program associated with the study was nonlinear.

				single-set circuit resistance training group. The study lasted 9 months while competing in tennis. Maximal vertical jump, Serve velocity, dynamic strength (Bench press, leg press and shoulder press) and power output were recorded with all groups		the periodized group but in had little to no increases in the single set and control group.	
--	--	--	--	---	--	---	--

--	--	--	--	--	--	--	--

Hartman Hagen, Andreas Bob, Klaus Wirth & Dietmar Schmidtbleicher	Effects of Different Periodization Models on Rate of Force Development and Power Ability of the Upper Extremity	Journal of Strength and Conditioning Research (2009), Vol. 23(7), Pages 1921-1932	The purpose of our study was to compare the effects of 2 different periodization models on strength and power variables under dynamic and static conditions in the bench press	40 male sports students, signed a risk document and were assigned to either a SPP (13) group or DUP (14) group and a control group (13). From there they performed the bench press 3 days per week for 14 weeks based on their program. Measurements of the v _{max} bench press throw and 1RM	The Shapiro Wilk normality test was used to quantify the deviation of the actual data and its Gaussian distribution. ANOVA was used to help compare both groups and test times of dependent variables.	Both groups ended up significantly increasing their 1 rep max on the bench press by 14.63/11.02% and the v _{max} bench press throw, with no significant comparison. With MVC (maximal voluntary contraction or power output) there were no significant changes between the groups. With MVRC or explosive	Many training interventions with durations between 9 and 24 weeks, performed with subjects experienced in resistance training, have demonstrated the established positive effect of periodization on the development of the dynamic maximum strength ability. For power sports, nonlinear periodization programs or in other words undulating periodization programs can get the highest results out of power like sports due to enhancements of power and dynamic strength. Sports students is not a good enough target for the study even though age and sport is involved. Collegiate athletes may not be associated with sport students.
---	---	---	--	--	--	--	--

				bench were recorded during tests. MRFD or explosive strength were measured with isometric bench press. 1RM was used to measure strength for final testing		strength, there were no significant changes.	
--	--	--	--	---	--	--	--

<p>Keith B. Painter, Gregory G. Haff, Mike W. Ramsey, Jeff McBride, Travis Triplett, William A. Sands, Hugh S. Lamont, Margaret E. Stone & Michael H. Stone</p>	<p>Strength Gains: Block Versus Daily Undulating Periodization Weight Training Among Track and Field Athletes</p>	<p>International Journal of Sports Physiology and Performance (2012), Vol. 7(2), Pages 161-169</p>	<p>The purpose of this study is to compare block periodization to Daily Undulating Periodization in Division I track and field athletes.</p>	<p>32 Division I Track and Field athletes (23 men and 9 women) ages 18-22 were divided into two groups performing either a block periodization program or daily undulating program for 10 weeks. Additional trainings were identical for each group. Excel sheets were used for different programs and</p>	<p>Data was analyzed using the SPSS version 16.0. Multiple 2x4 repeated measurements with ANOVA were made to determine statistical differences between the groups. A 2x10 ANOVA was used to determine volume load for each of the 10 week training sessions.</p>	<p>Both the Undulating group and Block group increased body mass throughout the 10 weeks. There were no significant differences between the group yet the block periodization group was more efficient.</p>	<p>The primary finding was that the block periodization group ended up having more efficiency with improvement pertaining to the 1 rep max parallel squat (1RMSQ) compared to the nonlinear, undulating periodization group. The thought process is typically that Undulating programs contain more variety whether it be daily or weekly. Which can result in maximal strength improvement. Much research has been made and some believe block or linear periodization programs are better. But they both are quite efficient depending on the groups and variations of volume and intensity.</p>
---	---	--	--	--	--	---	--

				distributed. Practice data was kept for each group throughout the Testing consisted of hydration status, body composition , 1-RM parallel squat, and isometric midhigh pulls (MTPs).			
Artur G. Monteiro, Marcelo S. Aoki, Alexandre L. Evangelista, Daniel A. Alveno, Gizele A. Monteiro, Ivan da Cruz Picarro & Carlos Ugrinowitsch	Nonlinear Periodization Maximizes Strength Gains in Split Resistance Training Routines	Journal of Strength and Conditioning Research (2009), Vol. 23(4), Pages 1321-1326	The purpose of our study was to compare strength gains after 12 weeks of nonperiodized (NP), linear periodized	27 healthy males were recruited from a college weight training class and had experience with weight	Data normality was measured through Shapiro-Wilk test. Standard visual inspection and all	Within the Pretest there were no significant differences between the groups. Only the NLP group had a	The main findings were that the NLP model was more effective in increasing maximum strength than both the LP and NP models. Furthermore, the LP model did not outperform the NP model, as was hypothesized within the study. Based on this

			<p>(LP), and nonlinear periodized (NLP) resistance training models using split training routines.</p>	<p>training. Subjects were tested pre training and post training with the bench press and leg press. Bench press was performed in a standard cybex free weight bench press station. The leg press was performed in a 45 degree cybex leg press machine. Skinfold testing was</p>	<p>variables presented normal distribution. Mixed models were used to estimate differences in strength gains between training groups for both the leg press and the bench press. Post HOC test was used just in case of <i>F</i> values.</p>	<p>significant increase in maximum strength with the bench press after 12 weeks compared to the LP and NP group (including 1RM). NLP also had a significant increase of strength on the leg press. LP had strength increases only after week 8. The comparison between groups showed NLP</p>	<p>assumption, it would seem logical to assume that as variability is added to training stimuli, greater adaptations should occur. In this manner, it might be expected that the LP model would enhance strength more than the NP model. Yet within the study conducted, the NLP group developed strength on the leg press and bench press from 28-43%. Athletes are used to doing split training routines so undulating periodization or nonlinear periodization may seem more ideal for certain athletes.</p>
--	--	--	---	--	--	--	---

				used to measure fat loss and determine body mass. Training sessions of A were upper body and B were lower body variations.		had significant improvements while the LP and NP did not have significant changes.	
Ricardo Silvestre, William J. Kraemer, Chris West, Daniel A. Judelson, Barry A. Spiering, Jakob L. Vingren, Disa L. Hatfield, Jeffrey M. Anderson & Carl M. Maresh	Body Composition And Physical Performance During A National Collegiate Association Division 1 Men's Soccer Season	Journal of Strength and Conditioning Research (2006), Vol. 20(4), Pages 962-970	The purpose of this study was to examine changes in body composition and physical performance tests resulting from a competitive season in soccer.	25 male collegiate soccer players from the University of Connecticut were tested before and after their 2003- 2004 season. DEXA measurements were	Descriptive statistics were calculated for all test variables. A t-way analysis was calculated to determine the main effects (pre and post) and/or they altered the	Body mass for all subjects increased significantly with total fat mass unchanged. Body power only had significant improvements across the season for only total body	The body mass increase that occurred was lean tissue for the competitive soccer players. Even though increase in body mass can somewhat be detrimental to performance, it was lean tissue. In previous studies from Kraemer, overtraining seemed to be an issue with collegiate soccer players. A nonlinear periodization model was used in the study to assist with that

				<p>used to determine body composition and lean mass. Physical performances were 40 yard sprints (Browser wireless timing system, vertical jump using a vertec and lower/total body power. Weight training sessions followed a unplanned nonlinear periodization format.</p>	<p>test variables. In the event of an F score, pairwise differences were analyzed.</p>	<p>power (17.3%) and lower-body power (10.7'/f)</p>	<p>issue to improve physical performance. No significant differences were found in season and out of season.</p>
--	--	--	--	---	--	---	--

<p>Jose M. Ravé-González, Alfredo Arijá & Vicente Clemente-Suarez</p>	<p>Seasonal Changes in Jump Performance and Body Composition in Women Volleyball Players</p>	<p>Journal of Strength and Conditioning Research (2011), Vol. 25(6), Pages 1492-1501</p>	<p>The purpose of this study was to determine the contribution of different preseason and in-season strength and power training regimens to jump performance and to body composition during a 24-week volleyball league competition period</p>	<p>12 professional women's volleyball players participated in the study. Vertical jump (used an ergo jump bosco system to measure), Maximum Muscular strength (squats measured on a smith machine), body composition (using a segmental multifrequency bioimpedance analyzer for</p>	<p>A repeated-measures analysis of variance was initially performed to identify differences in jump height and body composition over time (SPSS for Windows, v. 16.0, Inc., Chicago, IL, USA). A Bonferroni post hoc test was used to compare PRE, POST, POST 1, and POST 2.</p>	<p>With the vertical jump, subjects squat jump increased by 6.24% from PRE to Post. Countermovement jump increased by 7.5% from PRE to Post, The ABA Jump increased by 4.44% and maximum strength with the 2RM back squat increased 6.67%. Body mass increased 0.55%,</p>	<p>The resistance training model was split into 4 mesocycles (ranged 4-8 weeks) and resulted in positive results with increases in vertical jump and maximal strength as well as improvements in body composition, etc. In season, the goal was to maintain strength and progress and there were improvements in vertical jump and an increase in other neuromuscular performances occurred. In season, body mass did decrease. In conclusion, the present research showed a linear periodized program for professional volleyball female players that positively affected neuromuscular capacity and body composition during pre and in-season over a 6-month period.</p>
---	--	--	--	--	--	---	--

				measurements), physical conditioning (Linear periodization program was used for resistance training for in season and off season).		muscle mass increased 0.96% and fat percentage decreased by 7.29%.	
--	--	--	--	--	--	--	--

References

- González-Ravé, J. M., Arija, A., & Clemente-Suarez, V. (2011). Seasonal changes in jump performance and body composition in women volleyball players. *The Journal of Strength & Conditioning Research*, 25(6), 1492-1501.
- Harries, S. K., Lubans, D. R., & Callister, R. (2015). Systematic Review and Meta-analysis of Linear and Undulating Periodized Resistance Training Programs on Muscular Strength. *Journal of Strength and Conditioning Research*, 29(4), 1113-1125. doi:10.1519/jsc.0000000000000712
- Hartmann, H., Bob, A., Wirth, K., & Schmidtbleicher, D. (2009). Effects of Different Periodization Models on Rate of Force Development and Power Ability of the Upper Extremity. *The Journal of Strength and Conditioning Research*, 23(7), 1921-1932. doi:10.1519/jsc.0b013e3181b73c69
- Hoffman, J. R., Ratamess, N. A., Klatt, M., Faigenbaum, A. D., Ross, R. E., Tranchina, N. M., Kraemer, W. J. (2009). Comparison between Different Off-Season Resistance Training Programs in Division III American College Football Players. *The Journal of Strength and Conditioning Research*, 23(1), 11-19. doi:10.1519/jsc.0b013e3181876a78
- Karavirta, L., Häkkinen, A., Sillanpää, E., García-López, D., Kauhanen, A., Haapasaari, A., & ... Häkkinen, K. (2011). Effects of combined endurance and strength training on muscle strength, power and hypertrophy in 40-67-year-old men. *Scandinavian Journal of Medicine & Science in Sports*, 21(3), 402-411.
- Kerksick, C. M., Wilborn, C. D., Campbell, B. I., Roberts, M. D., Rasmussen, C. J., Greenwood, M., & Kreider, R. B. (2009). Early-Phase Adaptations to a Split-Body, Linear Periodization Resistance Training Program in College-Aged and Middle-Aged Men. *Journal of Strength and Conditioning Research*, 23(3), 962-971. doi:10.1519/jsc.0b013e3181a00baf

- Kraemer, W. J., Ratamess, N., Fry, A. C., Triplett-Mcbride, T., Koziris, L. P., Bauer, J. A., Fleck, S. J. (2000). Influence of Resistance Training Volume and Periodization on Physiological and Performance Adaptations in Collegiate Women Tennis Players. *The American Journal of Sports Medicine*, 28(5), 626-633. doi:10.1177/03635465000280050201
- Monteiro, A. G., Aoki, M. S., Evangelista, A. L., Alveno, D. A., Monteiro, G. A., Piçarro, I. C., & Ugrinowitsch, C. (2009). Nonlinear periodization maximizes strength gains in split resistance training routines. *The Journal of Strength and Conditioning Research*, 23(4), 1321.
- Painter, K. B., Haff, G. G., Ramsey, M. W., McBride, J., Triplett, T., Sands, W. A., & Stone, M. H. (2012). Strength Gains: Block versus Daily Undulating Periodization Weight Training among Track and Field Athletes. *International Journal of Sports Physiology & Performance*, 7(2), 161-169.
- Silvestre, R., Kraemer, W. J., West, C., Judelson, D. A., Spiering, B. A., Vingren, J. L., & ... Maresh, C. M. (2006). Body Composition and Physical Performance during a National Collegiate Athletic Association Division I Men's Soccer Season. *The Journal of Strength & Conditioning Research*, 20(4), 962-970.
- Smith, R. A., Martin, G. J., & Szivak, T. K. (2014). The Effects of Resistance Training Prioritization in NCAA Division I Football Summer Training. *Journal of Strength and Conditioning Research*, 28(1), 14-22. doi:10.1519/JSC.0b013e3182977e56