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Research Article

A Theoretical Comparison Between Periodization and Non-Periodized Training

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Abstract

This article concerns periodized and non-periodized training protocols, now widely used to enhance athletic performance conditioning. Periodization is a systematic training protocol that structures training into specific phases. Periodization directly involves optimizing performance results by changing training variables such as intensity, volume, and exercise selection interpretation over time. Periodized training systems are also widely used to manage fatigue levels and reach peak performance at certain moments. On the other hand, however, a non-periodized training outlook involves a regular interchange, where training variables remain unchanged or change consistently. It may offer a more straightforward and more uncomplicated way of approaching training sessions but, as a result, may lead to flat progress. Hence, to clarify a more transparent approach to enhancing performance, this review article provides a more comprehensive theoretical comparison in depth between these methodologies, to try to delve into both conceptual frameworks' understanding, advantages, disadvantages, limitations, and practical applications. This article also aims to represent more literature on the background. While trying to uncover some shadowed parts of the theoretical framework, this article examines some of the impact of periodized strength training on neuromuscular adaptation, muscle hypertrophy and other structural changes, supported by a review of key research findings. Furthermore, the historical development of periodization theory is discussed, outlining the evolution from early practices to contemporary models and assessing its relevance in modern athletic training. The comparison highlights how each approach influences performance, adaptation, and recovery, emphasizing the need for further research to better understand and apply these training methodologies in diverse athletic contexts. The review concludes that while periodization offers structured progression and helps prevent performance plateaus, non-periodized training provides flexibility and may suit specific training scenarios where simplicity is preferred.

Keywords:
Resistance Training, Periodization, Strength and Conditioning, Performance, Maximum Strength.

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Introducti

The amount of weight or force a muscle can hold is defined as muscle strength. The importance of muscle strength in sports performance is its relation to peak performance; when an athlete tries to perform better, muscle strength plays a crucial role (1, 2). Muscle strength is important for not only in sports but also in the overall health and physical fitness of individuals (1, 3). Enhancing muscular strength is often a primary goal in resistance training (RT), a practice widely utilized by various populations including young athletes striving for peak performance, older adults seeking to maintain their independence, and individuals of all ages aiming to improve their general physical fitness (3,4). Resistance training (RT) has been widely studied so far for its potential effectiveness in enhancing strength and muscle mass. (1,4). One of the most important parts of training is the structure of that specific training program, which is a critical determinant of the outcomes of RT. There are various ways to determine RT, one of which is periodized training, which has been frequently cited as an effective method for optimizing strength development (5). Periodization in overall outlook means systematic planning and changing variation of training variables such as intensity, volume, and exercise selection specificity over regular periods, with the aim of maximizing enhancing performance and preventing training or performance plateaus. The benefits of periodized training model is beyond strength gain (6). It is subliminally impacting other areas such as power, motor performance, power endurance, and maybe muscle hypertrophy (6). However, it is important to note the influence of the periodized training model on muscle hypertrophy.

The possibility of increasing muscle size remains a topic of ongoing debate, with some studies performing significant benefits while others report mixed results (6, 7, 10).

Periodized strength training involves planned manipulation of training variables at regular and clear gaps to provoke physiological adaptations (8). This planned conditioning approach is designed to enhance the efficacy of training programs over both, the short-term or a mesocycle (weeks to months), and the long-term macrocycle (years to entire athletic careers) (10, 8). By systematically altering the training load, periodization in all desires to prevent overtraining, reduce the risk of injury, and optimize peak performance (8,9). For competitive athletes and skilled performers, this timing of peak performances is necessary, mainly when aligned with major competitions or events where optimal physical condition is needed (9).

The concept of periodization has a lengthy background in sports training literature. It is well known to be welcomed by coaches, sports scientists, and athletes, as well as the structured and scientific approach to training (8, 9, 10). Historically speaking, periodization has its roots in the practices of Eastern European sports scientists, who, in the mid-20th century, developed the first formal models of periodized training "Matveyev"(9). These training models have since evolved, incorporating new research findings and adapting to modern sports performance's changing demands (10, 12). Even though it is widely accepted and applied, periodization could not escape criticism from scientists; recent commentaries have questioned mixed aspects of periodization, including the mechanisms by which it may enhance performance,

the amount of individualizing degree to which it should become, and the suitability of its application across different sports and populations (6,10, 11).

Analyzing these critiques is crucial for advancing our achievements in sports science and training methodologies, as it may help clarify misconceptions and boost our understanding of periodization and sports performance (10). This review is written aiming to strengthen and delve into the background literature of the fundamental principles in periodization, with focus on block periodization (BP), a well-known model which it emphasizes the use of concentrated training blocks to attain specific performance goals (8, 12). By searching deep enough into the development of periodization and the underlying mechanisms behind it, this review would also respond to recent critiques and provide a balanced perspective on this matter, particularly for competitive athletes and strength and conditioning coaches. Through this comprehensive exploration of the literature, this review will try to assess the tangible impact of periodized versus non-periodized training on different aspects of muscular adaptation, including strength, hypertrophy, and motor performance, and will consider the implications for long-term athletic development and performance optimization (1, 5, 8, 10, 12).

Training Variables

The training variables manipulated in periodized training would such foundations include but are not limited to the number of sets, repetitions per set, exercises performed, rest periods, resistance used, type of muscle action (eccentric, concentric, isometric), and training frequency (2).

The implication of muscle strength is highly likely to involve the most intensity, which refers to the weight lifted or repetition maximum (RM), with the highest intensity being the one-repetition maximum (1, 5). Training volume is another variable, which is the total number of repetitions influenced by the number of sets, repetitions per set, and exercises performed (10). Repetition per set stands for the amount of repeated particular movement per each single set. Exercise performance is the way in which biomechanical joint angles are changed to inhibit specific muscles (7, 8). The rest period stands for the amount of time that an individual would require or be asked by the coach to wait before starting a new movement or set. Training frequency is the repetition of total training sessions, which can be defined in both meso or micro cycles and varies in a day period or week. Lastly, one of the most important is muscle action, which is related to dynamic or static movement; this variable can define the neuromuscular results (1, 8, 10). Periodized strength training protocol would also change the training program at regularly planned head breaks to optimize the goal for strength, power, motor performance, and muscle hypertrophy (7). This method, a periodized outlook of a long-run training program, is set for enhancing training efficacy both in the short-term mesocycle (weeks, months) and long-term macrocycle (years, athletic careers) (8, 12).

Untrained Individuals and Short-Term Studies

Some studies may have used untrained individuals as subjects, where initial strength gains are predominantly neural through a phase known as anatomical adaptation (11). Thus, short-term studies may not particularly point to the signalling pathway as a physiological or neurological aspect that underlies significant differences between periodized and

non-periodized training due to similar neural adaptations (12).

The superior program might only show faster neural gains without significant differences in muscle hypertrophy (12).

Trained Individuals

For highly adapted trained individuals, the implication of gaining muscle strength is different, as strength gains occur at a slower rate compared to moderately trained subjects, and as moderate is way slower compared to untrained individuals, potentially it is due to neural adaptation (13). Therefore, it may be essential to note that using outcomes from studies that involved untrained individuals to trained athletes may be problematic (12). It is also important to mention that the methodological barriers may prevent researchers from circumventing genetic dominance (13).

Periodization Overview

Defining Periodization

Periodization may be defined as a planned and intentional change in a training system that involves training variables for optimizing performance, managing fatigue, and preventing stagnation (14). The periodized model would involve cyclic variations in volume, intensity, and exercise selection to promote peak fitness for targeted competitions (12). Training cycles include the macrocycle (usually a year), mesocycle (a month), and microcycle (a week) (11, 15). Taper periods, as one of the most critical parts of periodization, include the space rest that helps athletes to peak for competitions by reducing training volume while maintaining or slightly increasing intensity (12, 16). (Table 1)

Table1. Periodization Models

Type of Block Periodization	Description	Example
Single-Factor BP	- **Concentrated Load (CL)**: Focuses on a single fitness characteristic, such as strength. - Residual effects from one CL can enhance the next training phase.	- **Example Block Sequence**: Strength development → Specialized power training → Technique enhancement.
Multifactor BP	- **Combination of Factors**: Addresses multiple aspects of fitness, such as strength, endurance, and speed, often within the same or overlapping phases.	- **Example**: Training for both strength and endurance concurrently with careful planning to avoid noncompatibility and excessive volume.
Common Periodization Models	- **Linear Periodization (LP)**: Involves progressing from high volume/low intensity to low volume/high intensity. **Reverse-Linear Periodization**: Progresses in the opposite direction of LP, starting with low volume/high intensity and moving to high volume/low intensity. **Undulating Periodization (UP)**: Features more frequent variations in loading, which may help prevent adaptation and stagnation. - Recent studies suggest UP might be more effective for maximal strength gains compared to LP.	- **Example**: LP is often used in traditional strength training programs, while UP is used to avoid plateaus and continuously challenge the muscles.

Physiological Basis

Effective training programs must frequently puts overload to the neuromuscular system to prevent fatigue and stagnation. Variations in training stimuli are essential for optimizing strength adaptations by forcing the neuromuscular system to adapt to unaccustomed stress (17). Studies show that periodized training helps maintain effectiveness by preventing stagnation, as evidenced by research indicating improved strength gains during periodized training compared to non-periodized programs (18).

Periodization Theory: Origins and Legacy

Historical Background

Periodization historically came from a management background in recent years, first developed by a manager supervisor, Frederick Winslow Taylor. Taylor's 1911 publication, The Principles of Scientific Management, introduced a systematic approach to productivity and efficiency that was rooted in empirical analysis and optimization (16, 21, 23). Taylor's methodology, which emphasized the search for the "one best way" to perform tasks, influenced a wide range of fields, including sports training (22). As he wanted to achieve more productivity and performance, he introduced a management foundation for what we know as the best performance outcome. Later on, however, Matveyev expanded this theoretical foundation and made it usable in sports, as we know as linear periodization, but it was not the end of the story (12). As time passed by, Bompa made great improvements in the literature and improved our knowledge about it, and in recent years, strength and conditioning terms in the United States, in 80, made the foundation we are talking about (2, 8, 9). Numerous researchers have worked on and developed periodization, but one of the most active professors, Dr. Mike Stone from East Tennessee University, expanded the term as we are dealing with it (12, 16, 21).

Early Developments: The foundational ideas of periodization can be traced back to early training practices, which involved cyclical changes in training intensity and volume (12). It Started as far as we are aware from Philosopher Galen in 200 AD, with the idea of training sequential within strength and power (11, 12).

Matveyev's Contributions: Matveyev, who is often known as "Father of Periodization," the concept he worked on in the 1960s is what we know today as a periodized training model. His model was developed through a vast investigation of Soviet Union athletes (9). He was focused on the importance of cyclical load variations and peak performance timing periods. Matveyev's model back in the day included phases like general preparation, special preparation, competition, and transition (8, 9, 12).

Evolution and Expansion: The ideas developed by Metveyev were grown and adapted over time by many researchers to enhance performance, including the introduction of block periodization (16). Later on, This model, developed by coaches like Vladimir Issurin, focuses on concentrated training blocks that emphasize specific attributes to improve performance outcomes. In the 80s to '90s, the concept as we know it almost developed fully however evolution has not stopped even in this concept, and now even this theoretical understanding has new insights (12, 16).

Global Adoption: The periodization idea earned well-known acceptance beyond the Soviet Union; it has gained its own influential contributions from researchers and coaches in various countries, but not just limited to one geographic area. In the United States, early adopters included Garhammer and Counsilman, who applied periodization principles to strength training and swimming, respectively (11,12).

Problems with Traditional Periodization

However, traditional periodization, with all significance in its growth, has faced criticism from several sports scientists, including Verkoshansky and Issurin, who have highlighted specific problems with its conventional approach (12,16).

Performance Peak Maintenance: The performance itself can be achieved through a lower standard of practice in a highly competitive stance; however, when it comes to athletic literature, it is important to note that peak performance requires quite the opposite level of readiness in terms of training variations. The state ready-to-go would be requested at the top level (2, 11). The conflict here comes from the fact that in peak performance, a lower intensity or volume of training is needed before any competition situation, called the taper phase, and then again, after a short recovery, the body would be required to go back to performance at training sessions (7). Fitness fatigue and training after long periods of time being overreached can shatter the neuromuscular and neurophysiological adaptation because the process would take a long time to achieve, and in as little as four to eight days, the body would lose its adaptations. Besides, the peak performance state would not be sustained for more than three weeks, with a consistency level of top peak performance. This definition, of course, would not be applicable for all sports field performances as some top-performance athletes would stay in the ready-to-go phase for almost half of the year (13, 14). However, their periodization and fitness fatigue axis levels are carefully monitored by the equipped team to maintain their neuromuscular fatigue as low as possible and readiness as high as possible, but this topic may always be a considerable discussion between whom they defend periodization as a solid only way of reaching peak performance (12, 13).

Simultaneous Training Increases: Traditional periodization often involves in enhancement of increasing multiple fitness factors simultaneously (9, 11, 14), which can lead to several issues:

Decline in Fitness Factors: Fitness aspects such as cardiovascular and flexibility at first line would interchangeably decided with a lower volume of training; this is an important issue for blocking while training periodization is being pictured because other factors in fitness level would influenced by just one small change in volume; whilst the individual here athlete is in the taper phase (11,14), however, there are some ways such as chiropractic or electric muscle stimulants machine that may provoke neuromuscular and neurophysiological aspect of a muscle readiness to prevent or at least decrease the impact of taper phase (12, 15).

Fatigue Management: High training volumes can lead to excessive fatigue, reaching and over-training following continues, and non-stop peak performance readiness. It would complicate the recovery phase and mechanism and may potentially lead to impairing adaptation and performance at a glance (11, 14).

Incompatible Adaptations: Fitness variables can compass each other; for instance, achieving a higher endurance in cardiovascular fitness can hinder maximum strength and muscle hypertrophy or maximum power; as a result, developing each variable for each specifically needed fitness requirement may negatively impact other required performance variables (17). However, this issue may not be considered an impactful and problematic one because adaptations through years of practice might be regarded as enough, even at a low level for some fields (12, 17). For example, in some fields, track and field body composition or maximum sprinting speed might not be an issue, so these variables are just trained as low a healthy level, not at the competition level for competition (12).

Team Sports Considerations: Traditional periodization models such as block periodized training systems may not be applicable for team sports and long-run competition events (15). as a traditional known system is designed to help reach athletic performance at a previously known time to face one or two highly compatible competitions and maintaining performance for high frequent event competition like team sports leagues may put an enormous amount of pressure, as a stressor on athletes (16).

Influence on Periodization

Trylor's principle as a manager in the early 19's can be considered in a proper manner of Metveyev's infrastructure of periodization, the management overview of Taylor that could be seen even now as a convenient way to approach the best way possible to enhance and discipline a very detailed and complicated process of sports performance. Taylor's method was initially a diligent way to maximize worker performance through detailed systematic planning (16, 23, 24). Early definitions of performance were aimed at the same as Taylo's view to regulate the complicated world of performance and sports science overall. This way of strategy planning was basically grounded in the idea that a structured and scientifically based system could produce optimal athletic outcomes (12).

Evolution of Periodization

As time passed, periodization, as a solid background and foundation, became more flexible and more evidence-based understanding rather than a firm formula that can be applied to every individual with the same need (20, 21). This happened despite the fact that it does have a deep-rooted background coming from a management point of view, not a biological-based specific plan for individuals' needs (22).

Periodization in recent years due to these adaptations to individual needs has become more diligent and has adapted vastly to different types of needs for every individual in every unique performance or competition (19).

Key Considerations in Programming

Multijoint Exercises: Multijoint or compound exercises, such as squats and bench presses, generally induce greater physiological adaptations both in physiological and neuromuscular systems, and are more efficient at improving sport-related performance compared to isolation exercises. They should be prioritized in training due to their broad impact on multiple muscle groups and overall strength (21).

Exercise Order: The order of exercises within a training session affects outcomes. For instance, one way to specify is to use major multi-joint exercises performed first to maximize performance and reduce injury risk; this way of approach can use completely opposite as well, meaning using isolated movement first and then using multi-joint to impact one specific muscle only. Starting with smaller muscle exercises can lead to fatigue that negatively impacts the implementation of exercises later in one session and overall (22).

Session Order: Using variables as a tool for ordering a session which has a standard goal can be challenging because combining endurance and strength can cause a conflicting effect on the physiological aspect of that aim, especially in terms of explosive power-strength movements and high-velocity movements. As a result, for athletes who have the ability to reach multiple sessions per day, it might be better to consider separate sessions between variables they want to target, doing strength-specific movements on one session and another with proper recovery background hitting other required variables (21).

Intensity and Volume Management: Using training models such as high-intensity interval training steady, state interval training, or even low-interval low-interval training with different approaches through just one intensity variable can maximize the result wanted, but the controversy is that using two or three different systems such as using these cardiovascular stimuli as with resistance training can prevent to reach finale picture goal. On the other hand, using each unique system can minimize overlapping and enhance overall performance by knowing what would be required to reach the top performance level in planning (17, 21).

Wave-like Loading: One way to tackle variation intensity in this matter is using a wave like in a linear system; intensity and volume can be used like sine and cosine with parallel or even mixed and opposite use, which can result in improvement in recovery and reaching higher performance. However, it is important to consider higher complexity needs closer monitoring and planning specificity for individuals to not face over-reaching, which frequently leads to overtraining in cases without controlled observation (21,22).

Combination Training: Combining heavy and light training days can be effective and considered a highly influential way to maximise both recovery off-session and performance in training sessions. Light days should involve reduced loading and volume and avoid training to failure to maintain a broad spectrum of training impulses. This approach would help both coaches and individuals manage fatigue more properly and improve performance adaptations in a way that would lead to better results (12, 20).

Concentrated Load (CL): Concentrated loading, is the involve phases of high intensity or volume, that can lead to short-term performance decrements however it may often lead to long-term gains. This technique is used to induce a supercompensation effect, which is the body's response to the prior training sessions (22, 27).

Planned Over Reaching (POR): Planed over-reaching can be used for a very short period of time with very high-intensity or high-volume training sessions that lead to a tapper for highly competitive athletes. POR is especially aimed at pushing the body to go beyond known stressors compared to normal capacity, which can be experienced through normal training sessions. However, it should be monitored very closely by experts as it may result in unwanted injuries or even nervous fatigue (22).

Criticisms and Misconceptions

Periodization vs. Programming: Periodization stands for a much bigger concept of focused planning over the comprehensive structure of training. But programming would generally involve the specifics of exercise selection within a session, loading and rest periods. The misconception within these two concepts can lead to lowering training efficiency (21,26).

Flexibility and Individualization: Some critics argue that traditional periodization is inflexible. However, modern periodization can be adjusted for individual needs, training states, and external factors like competition schedules. The flexibility within periodization allows for adaptation and customization (27).

Importance of Hypertrophy: In terms of the value of hypertrophy phases in strength training there would be some critics. However, hypertrophy contributes to strength gains by increasing muscle mass even if small, which supports higher force production and power output over time. But it has to be note the fact that it require closley observed monitoring because hypertrophy may results in slowing the movement and needed some time for further adaptation (27, 28).

Need for Variation: Variation in training is important because it prevent plateaus and overreaching. Some evidence suggests that constant training without variation can lead to decreased performance and increased injury risk. Periodization and variation help in managing these issues effectively (27).

Contemporary Perspectives

Modern sports science recognizes the need to balance structured planning with individualized approaches. While periodization remains a valuable tool, its application must consider the variability in individual responses and the dynamic nature of training adaptations. This perspective aligns with recent critiques of periodization models, which suggest that overly rigid adherence to historical paradigms may not fully address the complexities of athletic training (25). The focus is now on creating responsive and context-specific training solutions that accommodate individual differences and evolving scientific insights (27).

Contemporary Perspectives

Fiber Size Changes

The magnitude of muscle hypertrophy following anaerobic training is closely associated with muscle fiber type. Both Type I and Type II muscle fibers can be recruited during resistance training, with recruitment frequency influencing the extent of hypertrophic responses. According to the size principle, activation of high-threshold motor units triggers a cascade of regulatory processes that promote protein synthesis. Typically, Type II fibers exhibit greater increases in size compared to Type I fibers (27, 28). The potential for hypertrophy may be influenced by the proportion of Type II fibers present in an individual's muscles (29, 30).

Fiber Type Transitions

Muscle fibers are arranged on a continuum from oxidative to less oxidative types (e.g., Type I, Ic, IIc, IIac, IIa, IIax, IIx). Anaerobic training can induce transitions from Type IIx to IIa fibers, with changes in myosin heavy chain (MHC) expression (31, 32). Research indicates that high-intensity resistance training combined with aerobic endurance training can lead to nearly full transitions from Type IIx to IIa fiber profiles (33). Initial changes in fiber type often occur within the early stages of a resistance training program (34). Conversely, detraining can result in an increase in Type IIx fibers and a decrease in Type IIa fibers (35). The transformation between Type I and Type II fibers is less likely due to differences in MHC isoforms and oxidative enzyme content (36).

Structural and Architectural Changes

Resistance training affects muscle architecture, including pennation angle and fascicle length. Pennate muscles, which have fascicles that attach obliquely to the tendon, exhibit increased pennation angles and fascicle lengths in response to resistance training (37, 38). This adaptation enhances force transmission to tendons and bones. Sprint and jump training further influence fascicle length, with sprinters showing increased lengths in the gastrocnemius and vastus lateralis (39).

Other Muscular Adaptations

Resistance training increases myofibrillar volume, cytoplasmic density, and sarcoplasmic reticulum density, while decreasing mitochondrial density and capillary density relative to muscle area (40, 41). Sprint training enhances calcium release, aiding in speed and power production (42). Anaerobic exercise also improves buffering capacity, which helps delay fatigue and improve muscular endurance (43). Additionally, anaerobic training increases the storage capacity of high-energy compounds like ATP and creatine phosphate, with significant increases observed after several months of training (43,44,45).

Conclusion

Periodized and non-periodized training represent distinct approaches with unique theoretical foundations, advantages, and limitations. Periodized training offers structured progression and potential benefits in preventing plateaus and optimizing peak performance, while non-periodized training provides simplicity and flexibility. The historical origins of periodization theory, rooted in the principles of scientific management, highlight its evolution and the need for contemporary adaptations. Practitioners should consider individual goals and training needs when selecting a training strategy. Further research is needed to elucidate the effects of different periodization models, muscle fiber changes, and the role of training variation versus specificity in maximizing strength and muscle hypertrophy. By understanding these concepts, athletes and coaches can better design training programs to achieve optimal results.

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Compliance with ethical standards

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Author contributions

Conceptualization: M.A.; Methodology: M.A.; Software: M.A.; Validation: M.A.; Formal analysis: M.A.; Investigation: M.A.; Resources: M.A.; Data curation: M.A.; Writing - original draft: M.A.; Writing - review & editing: M.A.; Visualization: M.A; Supervision: M.A; Project administration: M.A.; Funding acquisition: M.A.

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