

The Science and Practice of Periodization: A Brief Review

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SUMMARY

PERIODIZATION REPRESENTS AN OPTIMAL STRATEGY FOR ORGANIZING STRENGTH AND CONDITIONING PROGRAMS. THE SELECTED STRATEGY, HOWEVER, SHOULD BE BASED ON THE LEVEL OF THE ATHLETE AND THE CONSTRAINTS OF THE COMPETITIVE SEASON. A COMMON THEME THROUGHOUT ALL THE PERIODIZATION PROTOCOLS IS THE NEED TO MANIPULATE VOLUME LOADS, PROGRESS FROM GENERAL TO SPORT-SPECIFIC TRAINING, AND DISSIPATE FATIGUE. SIGNIFICANT TO THE LATTER, THE USE OF PRECOMPETITION TAPERS APPEARS EVIDENTLY BENEFICIAL. ALTHOUGH ENOUGH ANECDOTAL EVIDENCE EXISTS TO VALIDATE THE USE OF PERIODIZATION, FURTHER SCIENTIFIC INVESTIGATION IS REQUIRED TO UNDERSTAND ITS USE AND LIMITATIONS TO ELITE LEVEL ATHLETES ACROSS EXTENDED PERIODS (E.G., >4 YEARS). UNTIL SUCH TIME, HOWEVER, ITS USE IS RECOMMENDED AND ADVOCATED BY THE RESEARCH HEREIN.

INTRODUCTION

Periodization is regarded as a superior method for developing an athlete's peak performance (16,26,71–73). However, because an athlete's peak performance can only be maintained for 2–3 weeks (74), the

ability to coordinate this with a competition date long into the future (e.g., the Olympics) is a fundamental skill to all strength and conditioning (S&C) coaches and the one that may only be attained after competency of the science and practice of periodization. Furthermore, and despite an apparent lack of scientific rigor to govern its application (8,16,21,64,71), periodization is widely practiced (11–13,67) and recommended (26,27,64). The aim of this article, therefore, was to provide the S&C coach with a brief overview of periodization so as they may be cognizant of its theory and methodology. It is hoped that this will further facilitate its implementation and successful application.

DEFINING PERIODIZATION

Periodization may be defined as a training plan, whereby peak performance is brought about through the potentiation of biomotors and the management of fatigue and accommodation. This is principally achieved through the logical yet creative variation of training methods and volume loads (50). Significant to the latter point, and oftentimes the landmark of periodization, volume and intensity (volume loads) share an inverse relationship (Figure 1) with the only notable exceptions being during periods of planned overreaching (Figure 2).

Plisk and Stone (64) suggest that periodization is applied on a cyclic or periodic basis, structured into macro-, meso-, and microcycles, which progress from extensive to intensive (or

from high volume to high intensity) workloads (Figure 1). These cycles are often defined by their allotted period, with a macrocycle typically referring to a year, a mesocycle to a month, and a microcycle to a week. There is, however, large variability in the time course of each, with, for example, macrocycles running ≥ 4 years in the case of Olympic S&C programs. Moreover, mesocycles are often divided into 4 ± 2 -week blocks, as this appears to provide the optimal time frame for adaptation (51,64,74,84,87).

Periodization is also often defined by its progression from general to special tasks (Figure 1, note the incorporation of technique-/sport-specific biomotors as the program progresses and competition nears) (64). This is further supported by Bompa and Haff (5) who reported 2 major phases of periodization: the preparatory phase and the competitive phase (Figure 1). In addition, the preparatory phase has 2 subphases: general physical training (GPT) and sport-specific physical training (SSPT). The objective of the GPT is to improve the athlete's work capacity and maximize adaptations in preparation for future workloads (5). The SSPT serves as a transition into the competitive phase, whereby physical capacity is developed specific to the physiological profile of the sport

KEY WORDS:

periodization; fitness; fatigue; recovery; preparedness; summated; undulating; conjugate; taper

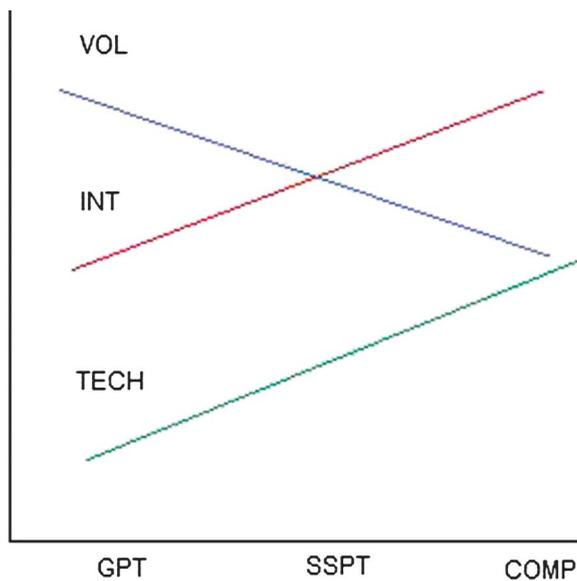


Figure 1. The inverse relationship between volume and intensity. In general, as the periodized program advances and competition nears, intensity increases, whereas volume decreases. VOL = volume; INT = intensity; TECH = technique; GPT = general physical training; SSPT = sport-specific physical training; COMP = competition.

and where sport-specific biomotors are perfected (5). During the competitive phase, Nadori and Granek (59) suggest that as a minimum objective, the work capacity developed during the SSPT should be maintained (Table 1).

The importance of the preparatory phase is highlighted by Zatsiorsky and Kraemer (87) who use the analogy “soon ripe, soon rotten.” This, along with data by Fry et al. (19) and work by Stone et al. (74), suggests that the average training intensity is inversely

correlated with the time a performance peak can be maintained and the height of that performance peak (Figure 3).

As a final note into defining the essence of periodization, the S&C coach should be cognizant of the fact that the science and practice of periodization is largely based on the hypothesis-generating studies, anecdotal evidence, and related research (8,16,21,64,72). In addition, most studies involved only short-term experimental periods (e.g., 5–16 weeks) and subjects with limited

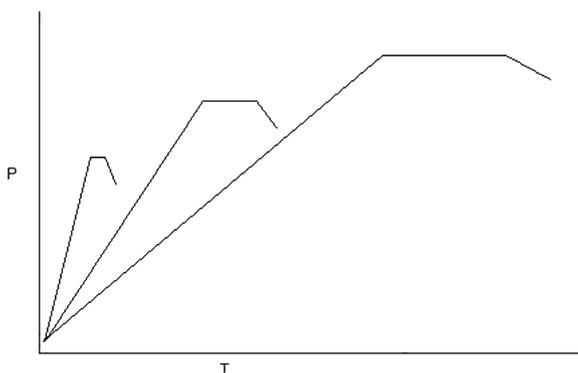


Figure 2. Training intensity is inversely correlated with the time a performance peak can be maintained and the height of that performance peak. (information attained from Stone et al. (74)) P = performance; T = time.

training experience (8,16,21,64,72). These contentious issues have been raised in a review paper by Cissik et al. (8), and readers are recommended to this for further analysis. However, and despite these challenges to an evidence-based ideology, it should be noted that enough anecdotal evidence, case study reports, and empirically similar research exist to advocate its use across all population groups.

RECOVERY AND ADAPTATION

Mesocycle blocks are usually arranged in a 3:1 loading paradigm (Figure 4), whereby the load gradually increases for the first 3 microcycles (weeks) before an unloading phase in the fourth (creating the typical undulating appearance of periodized programs). The unloading phase reduces fatigue, thereby allowing adaptations to take place (26,27,64). The significance of appropriately planned work to rest ratios (with respect to training sessions) may be evidenced by the articles of Nadori and Granek (59) and Plisk and Stone (64) who suggest that the greater the number of progressive loading steps, the greater the number of unloading steps required, for example, a 4:2 paradigm. It should also be noted that because training adaptations take place during recovery periods (27), the need to reduce accumulated fatigue cannot be understated. As an anecdotal example, one of the major differences between professional and semiprofessional athletes is that after training, the professional athlete returns home and rests, whereas the semiprofessional athlete goes off to work. This, of course, has implications for the recovery–adaptation relationship, especially if the work is of a physical nature.

The importance of recovery phases for the purposes of adaptation is well established (26,27). The S&C coach must therefore ensure that work to rest ratios are appropriately planned (e.g., using the 3:1 step loading paradigm) to avoid excessive fatigue and a reduced stimulus for adaptation. According to Stone et al. (74), this trade-off is described by 3 principle theories: (a)

Table 1
The principle phases and subphases of periodization

Training phase	Preparatory phase		Competitive phase
	GPT	SSPT	
Phase objective	↑ aerobic and anaerobic capacity; ↑ neuromuscular functioning	Develop and perfect sport-specific biomotors	Maintain biomotor conditioning
Information attained from Bompa and Haff (5).			
GPT = general physical training; SSPT = sport-specific physical training; ↑ = increase.			

the Selye general adaptation syndrome (GAS), (b) the stimulus-fatigue-recovery-adaptation theory (SFRA), and (c) the fitness-fatigue theory (Fit-Fat).

GENERAL ADAPTATION SYNDROME

The GAS paradigm describes the body’s physiological response to stress, which, according to Selye (66), is the same despite the stressor. The GAS assumes 3 distinct phases during stress, which, for the following example, will be an exercise training session. The alarm phase (phase 1) represents the recognition and initial response to the session. This may be in the form of fatigue, stiffness, or delayed onset of muscle soreness for example. The resistance phase (phase 2) is then initiated in which the body is returned to either its pre-exercise session

homeostasis or its new adapted higher state (i.e., supercompensation occurs). Finally, and assuming that the accumulation of stress is too great (e.g., the absence of an unloading week), the exhaustion phase (phase 3) occurs, and this may be considered synonymous with overtraining (74). The GAS is depicted in Figure 5.

STIMULUS-FATIGUE-RECOVERY-ADAPTATION THEORY

The SFRA concept (80,81,83) suggests that fatigue accumulates in proportion to the strength and duration of a stimulus. Then, after the stimulus, for example, an exercise session, the body is rested, enabling fatigue to dissipate and adaptations (often referred to as supercompensation) to occur. This concept also suggests that if the stress is not applied with sufficient frequency

(also known as density), detraining (also known as involution) will occur. Moreover, involution time is influenced by the length of the preparation period (74), with the greater the duration of a training program, the greater the residual effects (Figure 3) (87). In addition, and by virtue of this, the subsequent preparation phases inherent to bi- and tricycles can progressively decrease. The significance of preparation has been previously discussed within this article. The SFRA concept is illustrated in Figure 6.

The SFRA concept is also used to describe the supercompensation observed after periods of planned overreaching (81,83). For example, the accumulation of fatigue from the sequential execution of similar training sessions (i.e., a concentrated primarily unidirectional loading of strength/power training) is superimposed on one another (Figure 7). This, therefore, leads to excessive fatigue and acutely (almost equal to 4 weeks) diminished strength and power capabilities. However, after the return to normal training (and by virtue of a delayed training effect phenomenon), they then rebound beyond their initial values (20,69). This strategy, however, is reserved for elite level athletes, whose window for adaptation is small, and therefore requires more intense interventions to bring about a supercompensation response (5). Planned overreaching strategies are briefly discussed later in this article.

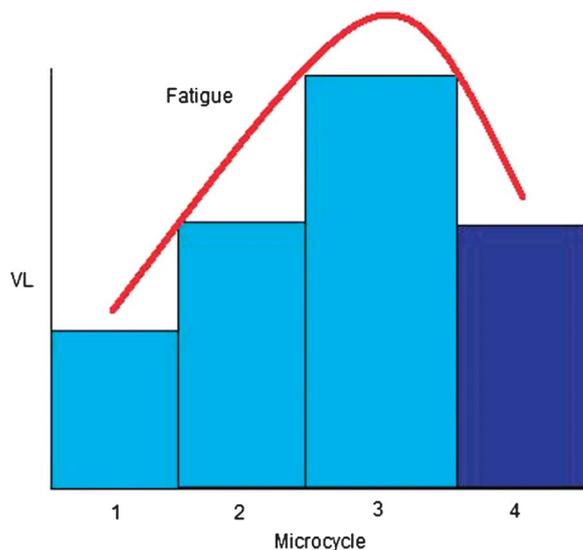


Figure 3. A 3:1 loading paradigm (information attained from Bompa and Haff (5) and Stone et al. (74)) VL = volume load.

FITNESS-FATIGUE PARADIGM

Currently, this is the most prevailing theory of training and adaptation (7,64,74) and is considered the basic

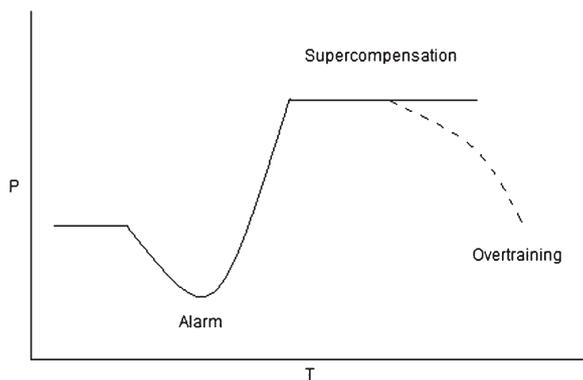


Figure 4. The GAS paradigm that suggests that the body's response to stress is always the same despite the stressor. Here, the body undergoes an alarm phase and a resistance phase before supercompensation is experienced. P = performance; T = time.

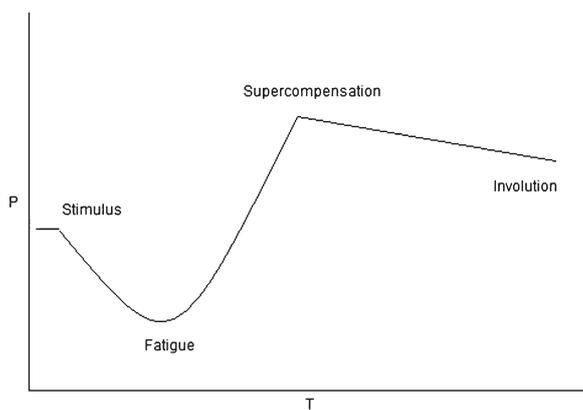


Figure 5. The stimulus-fatigue-recovery-adaptation theory concept suggests that fatigue accumulates in proportion to the strength and duration of a stimulus, and then after rest, fatigue is dissipated and supercompensation occurs. P = performance; T = time.

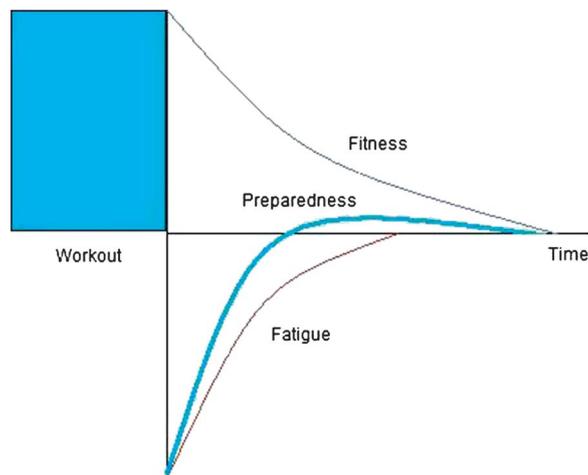


Figure 6. The fitness-fatigue paradigm suggests that fitness (top curve) and fatigue (bottom curve) occur concurrently, and only when fatigue has dissipated, does fitness gains become apparent and athlete preparedness (blue line) becomes apparent and optimized (x-axis, time).

tenet of a taper (discussed later in this article) (56). According to this paradigm, athlete preparedness may be evaluated based on the principle after-effects of training: fitness and fatigue (87). Unlike the GAS and SFRA concepts, which assume that fitness and fatigue share a cause and effect relationship, the Fit-Fat model suggests that they demonstrate an inverse relationship. This, therefore, implies that strategies that maximize fitness and minimize fatigue will have the greatest potential to optimize athlete preparedness (74). The Fit-Fat concept is illustrated in Figure 8.

An additional key difference between the Fit-Fat concept and the aforementioned models is that it differentiates between the actions of various stressors, such as neuromuscular and metabolic stress (7) and therefore implies that the aftereffects of fitness and fatigue are exercise specific (74,87). This suggests that if the athlete is too tired to repeat the same exercise with an acceptable quality (as measured by power output or form for example), they may still be able to perform another exercise to satisfaction (Figure 9). This, for example, provides the basic tenet to hypertrophy programs incorporating 3- to 5-day splits and concurrent training involving both aerobic and resistance workouts.

THE PRINCIPLE OF DIMINISHING RETURNS

Monotonous volume loads and training methods can predispose an athlete to accommodation and stagnation (70,74). Zatsiorsky and Kraemer (87) refer to this as the principle of diminishing returns, whereby the nervous system is no longer challenged to adapt. It is therefore of the utmost importance to incorporate variability within the design of periodized S&C plans. This ideology serves as the rationale for the regular application of novel and seminovel tasks (exercise deletion and re-presentation) (74). Additional methods of incorporating variability other than exercise selection include changes in volume, intensity, and frequency (5) or any combination

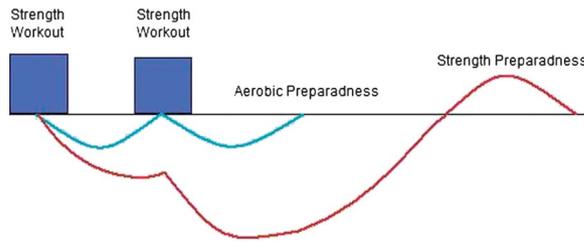


Figure 7. Athlete preparedness based on the specific form of fatigue. In this scenario, while the athlete is too fatigued to effectively undertake any additional strength training sessions so acutely, they are able to work and adapt their aerobic system with relatively less recovery (information attained from Zatsiorsky and Kraemer (87)).

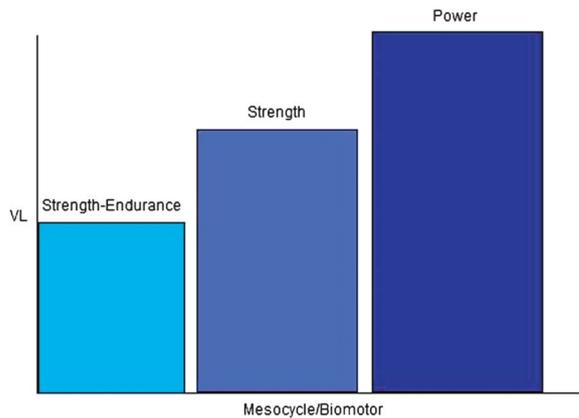


Figure 8. Basic model of periodization entailing little variation and relatively flat workloads within each mesocycle.

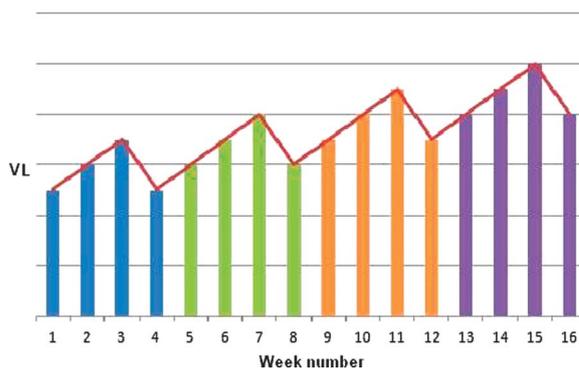


Figure 9. The traditional approach to the design of periodized training, which is attributed to the work of Matveyev (50), (y axis, volume load; x axis, week).

of these. As a final word of caution, however, the reader should note that too much variability could reduce the opportunity for the body to adapt to the given stimulus and reduce the development of skill acquisition (5).

APPLICATION OF PERIODIZATION BASIC MODEL OF PERIODIZATION

The type of periodized model used should reflect the S&C training age of the athlete and not their competition age or rank. It is considered prudent

therefore to initiate S&C programs with basic periodized models. These generally entail little variation and relatively flat workloads (74) with the main emphasis being on the logical and therefore potentiated progression of biomotors (e.g., strength endurance → strength → power). Figure 7 illustrates a basic model.

As an example of this basic strategy, the athlete essentially completes a hypertrophy/strength endurance phase for 4 microcycles (or 1 mesocycle), a strength phase for 4 microcycles, and then a power phase for 4 microcycles (Table 2). Each phase (dependent on the prescribed volume loads) may be further separated by an unloading week, as may also happen after the power phase and before the competition. In addition, heavy and light days may still be prescribed. This strategy, considered appropriate for athletes with an S&C age of zero, introduces them to S&C (i.e., the merits of and the required discipline) and periodization (i.e., the need to systematically alter the emphasized biomotors and a quality over quantity approach) and enables them to get a “feel” for gym-based training interventions and developing their associated technique. As a final note on this basic model (which is applicable to all models), to ensure the athlete gets the most out of each phase, the S&C coach should ensure that they are technically sound to perform the exercise of each phase before progressing onto it. For example, power cleans and snatches may be part of the power phase; however, the athlete should start practicing and developing them in the strength endurance phase to ensure effective training by the time they are called into use.

INTERMEDIATE MODEL OF PERIODIZATION

As the athlete’s S&C age advances and adaptations begin to plateau, greater variability becomes paramount. In addition, because of the enhanced work capacity of the athlete, greater volume loads are required and thus the need for planned recovery sessions. The periodized program therefore begins to evolve

Table 2
Example sessions used as part of a basic periodized model

Example hypertrophy session	Example strength session	Example power session
Intensity: 3 × 10 at 10–12 RM, <2 mins between sets and exercises	Intensity: 4 × 4 at 4–6 RM, >2 mins between sets and exercises	Intensity: 5 × 3 at variable loads, >3 mins between sets and exercises
Exercises: Squats, SLDL, bench press, lat pull-down, shoulder press (note: weightlifting may have to be developed within the warm-up)	Exercises: Squats, SLDL, bench press, weighted chins (note: weightlifting may have to be developed within the warm-up)	Exercises: Snatch, jump squats
SLDL = stiff leg deadlift.		

into wavelike increases in volume loads (50,51) that typically fluctuate at the microcyclic level (71,72). This is referred to as summated microcycles and is usually represented as the 3:1 paradigm previously discussed. In addition, and because of the need to incorporate variability, each microcycle can possess multiple biomotors (e.g., strength, power, and speed work), some for the purpose of maintenance and potentiation and others for the purpose of development and adaptation. Additional methods of incorporating variability and thus adaptation include intersession variability (e.g., heavy and light days and exercise deletion and re-presentation methods) and intrasession variability (e.g., cluster training and postactivation potentiation protocols). Figure 10 illustrates this traditional approach for designing periodized programs, which is attributed to Matveyev (50,51). An example of intermediate periodized program is illustrated in Table 3.

ADVANCED MODEL OF PERIODIZATION

Again, as the athlete's S&C age advances and the windows of adaptation begin to diminish, more advanced strategies are required, which incorporate yet more variability and greater volume loads. The majority of the emphasis, however, is now placed on the prescription of volume loads through advanced strategies such as the conjugated system (also known as the coupled successive system; Figure 10) (82). Because this places the athlete dangerously close to the overtraining syndrome, athletes undertaking this system must be able to tolerate

very-high-volume loads (64), and the S&C coaches applying these interventions must be highly skilled.

The conjugate system involves periods of planned overreaching followed by periods of restitution (64). Plisk and Stone (64) suggest that this is best implemented in the blocks of 4 microcycles with only one primary emphasis (e.g., strength), with maintenance loads allocated to other abilities (e.g., speed). This system aims to saturate the emphasized training stress, causing significant fatigue and concurrent decreases in performance. Then, during the following restitution blocks, the emphasis is reversed (Figure 2). For example, the volume load for strength training markedly drops, whereas that for speed work is moderately increased. By virtue of a delayed training effect phenomenon, the athlete's strength capabilities undergo supercompensation. A practical example of the conjugate system, adapted from the

work of Plisk and Stone (64) and Stone et al. (74), is illustrated in Table 4. Here, it can be seen that volume load is manipulated by simply increasing (accumulation) or decreasing (restitution) the number of sessions in each block.

Significant support for the conjugate system may be gleaned from studies investigating the response of the endocrine system to prolonged (≥ 3 week) and severe increases in volume load (20,28,30,61,65). In general, these studies report significant decreases in resting/pre-exercise testosterone concentration and the testosterone to cortisol ratio, followed by supernormal levels and corresponding performance improvements upon returning to normal volume loads with a subsequent taper. These findings are considered significant as the testosterone concentration and the testosterone to cortisol ratio are considered indices of the anabolic/catabolic state of the body (19,64).

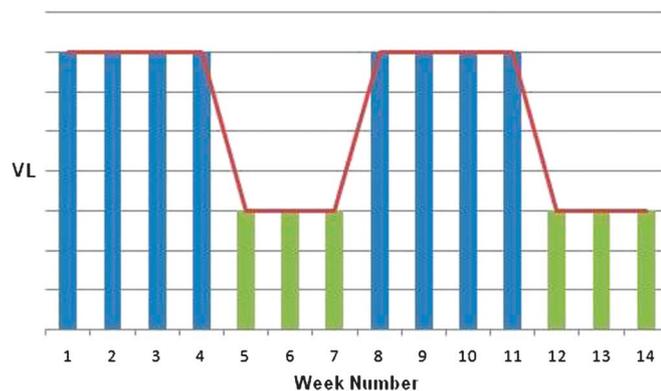


Figure 10. The conjugate sequence system pioneered by Verkhoshansky (82). This system involves periods of planned overreaching followed by periods of restitution.

Strength session 1	Strength session 2	Power session 1	Power session 2
*Squat snatch (4 × 2)	*Squat clean and split jerk (4 × 2)	*Squats (3 × 3)	*Front squats (3 × 3)
Dumbbell chest press (4 × 4)	Lat pull down or chins (4 × 4)	Power snatch from hang → power split snatch from hang (5 × 3)	Power clean from hang and split jerk (5 × 3)
Bent over row or seated row (4 × 6)	Dumbbell chest press (4 × 4)	Squat jumps (5 × 3)	*Dumbbell chest press (3 × 3)
Back squats (4 × 4)	Stiff leg dead lift or Nordics (4 × 6)	—	—

*Develop/maintain technique and strength/power.
→, progress to (sets × reps).

As a word of warning, however, practitioners should limit the duration of these concentrated blocks, so that an overtraining syndrome does not develop (64). In addition, S&C coaches should be attentive to the potential signs and symptoms of overtraining with each passing week (17,37,70). Finally, and significant to the former point, it should be noted that the hormones identified above are not indicative of the overtraining syndrome (37).

MAINTENANCE PROGRAMS

MAINTAINING PEAK PERFORMANCE FOR 35 WEEKS

The traditional periodization strategies above are concerned with the athletes

who need to peak for a single or acute (<2 weeks) phase of competitions, for example, track athletes and martial artists. These athletes may engage in mono-, bi- or tricycled periodized programs depending on the multitude of significant competitions within that year. Some athletes, especially team sport athletes from rugby and soccer, for example, must reach their peak as part of the preseason training and then maintain it for periods of up to 35 weeks. In collision sports such as rugby and soccer, this maybe a thankless task (32,41) with success somewhat dependent on the ability to maintain strength levels (2,3).

For example, in a study by Kraemer et al. (43), it was shown that both

starting and nonstarting soccer players experienced reductions in sport performance over an 11-week period. Although more pronounced in the starters, the fact that performance reductions were observed in all players indicates that performance adaptations may be independent of total match play and that the volume load of practices/S&C sessions should be carefully evaluated. Of significance, however, was the fact that a catabolic environment (↑ cortisol, ↓ testosterone) was initiated in the preseason and not obviated throughout the competition phase. This may, therefore, have determined the metabolic status of the players as they entered the competitive period. Although this may be exclusive to the training approach of collegiate soccer, or those that require athletes to get into shape quickly, the need for athlete restoration, particularly as they enter the competitive phase, can be noted.

Further challenges associated with the maintenance programs may be gleaned from studies undertaken by Kraemer et al. (40) and Aldercrentz et al. (1). These investigators reported that sprint running increases circulating concentrations of cortisol and decreased concentrations of plasma testosterone. For sports such as football, rugby, and soccer, which may be categorized as high-intensity intermittent exercise, with

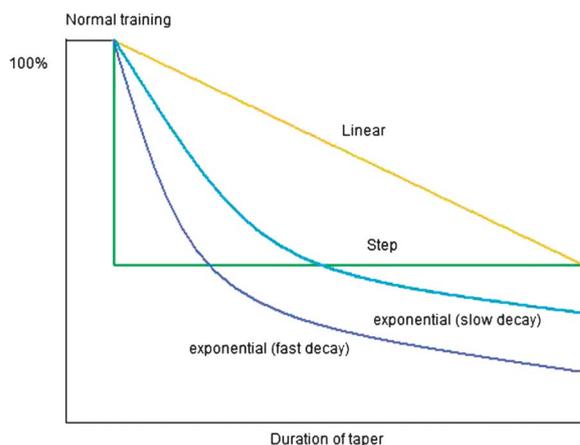


Figure 11. Schematic representation of the 3 principle tapering strategies (information attained from Mujika and Padilla (56)).

Table 4
A practical example for applying and adapting the conjugate system (64,74).

Training emphasis	Accumulation block 1	Restitution block 1	Accumulation block 2	Restitution block 2
Duration, wk	4	3	4	3
Strength and power training	16 sessions at 4 d/wk	6 sessions at 2 d/wk	16 sessions at 4 d/wk	6 sessions at 4 d/wk
Speed and agility training	8 sessions at 2 d/wk	9 sessions at 3 d/wk	8 sessions at 2 d/wk	9 sessions at 3 d/wk

a prevalence of repeated bouts of maximal effort sprints (15,45,46), it is likely that an adverse metabolic environment will present itself if training programs are not appropriately periodized.

NONTRADITIONAL APPROACH TO PERIODIZATION

It has been suggested that although the classical form of periodization (discussed above) is appropriate during the off- and preseason, a nontraditional form of periodization is more viable to team sports during the in-season (23,33,42–44). At times, this may be out of necessity because of its suitability to the academic sports training calendar and its ease of administration within long seasons (33,42,44). This form of periodization involves changes in volume loads and biomotor emphasis on a session-to-session basis. An example of a nontraditional periodized program is illustrated in Table 5. One of the merits of this system is suggested to be the ease with which sessions can be quickly tailored to the competition schedule of the athlete (26). If, for example, a competition is suddenly cancelled or arranged, then the athlete can switch to the heavy or light training day, respectively. In addition,

a microcycle and a mesocycle can be defined by the number of completed sessions or rotations, respectively, of the prescribed program.

It should also be noted that athletes are required to lift repetition maximum loads, which entails going to failure (with the exception of ballistic lifts e.g., plyometrics and weightlifting). This is in contradiction to several authors who suggest that consistently training to failure will result in neural fatigue and potential overtraining (25,62,68,70). However, Gamble (23) argues that although this may be the case for strength/power athletes, it appears to not be an issue for team sports athletes. For example, a yearlong mesocycle employing this form of periodization was successfully completed without noting any ill effects and increases in both strength and power among professional rugby players (23). Moreover, in a roundtable discussion of periodization (26), it was suggested that the variation in the recruitment of motor units (through the different volume load prescriptions) provided variation in neuromuscular recruitment. For example, on a light day, an athlete would not recruit the same motor units

as on a heavy day, thus providing the higher motor units with active recovery (26). However, one may speculate that the lower threshold motor units will always be subjected to the training stress, an assumption supported by the size principle of the motor unit recruitment as described by Henneman et al. (31).

Finally, for the purposes of maintenance, a training frequency of 2 days per week is often recommended for training during the competitive phase (12,14,23,26,67). However, including even 2 S&C sessions a week to team sport players involved in regular competition may prove difficult. Gamble (23) suggests that the issue of limited training time may be addressed by combining S&C training into sport practice. For example, speed, agility, and plyometrics training can be included into team practices, and metabolic conditioning can be maintained through game-related conditioning methods. In addition, the skill element specific to each, particularly the latter, example encourages its use by the sports coaches (22). Furthermore, this tactical metabolic training approach can be structured according to work to

Table 5
Example microcycle completed as part of a nontraditional periodization strategy.

Day	Monday	Wednesday	Friday
Volume load	3 × 10 at 10 RM	4 × 4 at 4 RM	5 × 3 at variable loads
Example exercises	Squats, bench press, bent-over row	Squats, bench press, weighted chins	Clean and jerk, snatch, jump squats

Note that a mesocycle may be considered complete after a set number of rotations. In addition, athletes can rearrange this order depending on competition scheduling.

Information attained from Haff (27).

rest ratios of the specific sport (24,63) and dominant energy systems.

THE TAPER

The progressive increases in the volume load of periodized S&C programs are likely to accumulate excessive fatigue and overstress the neuroendocrine system. This will reduce the stimulus for adaptation (as previously discussed) and lead to adverse circulating hormonal concentrations (18). However, a reduction in training with a concomitant optimal anabolic environment (or reduced catabolic processes) induced by a taper could potentially enhance performance (36). The taper describes a reduction in the volume load (e.g., in the volume, intensity, and/or frequency) of training in the final days before important competition, with the aim of optimizing performance (6). It should be stressed, however, that the objective of the taper is to dissipate the accumulated fatigue (enabling performance-enhancing adaptations to become apparent) rather than advance the athletes level of fitness (56). Significant improvements after

tapering have been reported for runners (35), rowers (39), triathletes (4,48) swimmers (10,38,58), cyclists (49,60), and weightlifters (52). Table 6 summarizes the possible performance gains after a taper (47,56,57,86) as summarized by the literature review of Wilson and Wilson (85).

TAPER STRATEGIES

There are principally 3 types of taper: a step taper, a linear taper, and an exponential taper (Figure 11). A step taper involves an immediate and abrupt decrease in training volume for example, decreasing the volume load by 50% on the first day of the taper and maintaining this throughout. A linear taper involves gradually decreasing the volume load in a linear fashion for example, by 5% of initial values every workout. The exponential taper decreases volume at a rate proportional to its current value (half-life), for example, by 5% of the previous session values every workout. In addition, exponential tapers can have fast or slow decay rates.

More recently, Bosquet et al. (6) suggested an additional taper, referred to as a “2-phase taper,” which involves a classical reduction in the training load, followed by a moderate increase during the last days of the taper (Figure 12). The objective of this strategy is to reduce the athlete’s fatigue before the reintroduction of more prolonged or intense efforts. The efficacy of the 2-phase taper maybe gleaned from anecdotal observations of the progressive improvement in performance often observed in an athlete from the first round of a competition to the final (76). This form of taper, however, requires further investigation.

THE OPTIMAL TAPER STRATEGY

As previously mentioned, a taper involves a reduction in the volume load of either of (or a combination of) the moderators or training, that is, intensity, volume, and frequency. The optimal manipulation of these variables may be best evidenced from the meta-analysis conducted by Bosquet et al. (6), which examined 27 research articles investigating the adaptations

Table 6
Summary of performance gains after a taper

5–6% improvements in criterion competition performance gains.
Up to 20% increases in neuromuscular function (i.e., strength and power).
10–25% increases in cross-sectional area of muscle tissue.
1–9% improvements in $\dot{V}O_2\max$ (this is likely a consequence of hypervolemia, up to a 15% increase in RBC production and increases oxidative enzyme activity).
Up to an 8% increase in running economy.
Serum TST may increase by 5%, with a corresponding 5% decrease in cortisol.
Catecholamines may be reduced by up to 20%.
Reduced creatine kinase concentrations (suggestive of decreased muscle damage after a workout).
A 10% increase in anti-inflammatory immune cells, with a concomitant decrease in inflammatory cytokines.
Increased muscle glycogen stores (17–34%; often proportional to the reduction in volume load) especially after CHO loading. However, care should be taken to match energy intake with the reduced energy expenditure that characterizes the taper.
Reduced RPE, depression, anger, and anxiety and increased vigor.
Decreased sleep disturbances.
Information attained from the review of Wilson and Wilson (85).
RBC = red blood cells; TST = Testosterone; CHO = Carbohydrate; RPE = rating of perceived exertion respectively.

in actual competition or field-based criterion performance of competitive athletes after a taper. Table 7 summarizes their findings (measured as effect sizes [an effect size is an objective way of identifying the meaningfulness of results and is commonly used within a meta-analysis because their values are standardized. The formula subtracts the mean of one group from the mean of another and divides the difference by the SD]), for which the scale proposed by Cohen (9) was used for their interpretation. Accordingly, the magnitude of the difference was considered small (0.2), moderate (0.5), or large (0.8).

The results of the study by Bosquet et al. (6) revealed that the optimal taper is 2 weeks in duration and consists of exponentially reducing the volume of training by 41–61%, while maintaining both the intensity and the frequency of sessions. This outcome is in agreement with the previous investigations (56) and confirmed the reports of others, which suggest that volume is the optimal variable to manipulate (34,56).

The reader should also note the large variability between studies, as suggested by 95% confidence intervals (Table 7). It is therefore likely that not all athletes will respond favorably to this taper prescription. For example, based on their review of research, Wilson and Wilson (85) concluded that the reduction in volume should be dependent on the accumulated fatigue gained through the preceding training program, that is, greater volume reductions are necessary when previous training durations are longer and more intense. For example, in trained athletes, Mujika and Padilla (56) found benefits from reducing the volume by 50–90% for aerobic events (49,60) and 50–70% for anaerobic events (55,77). However, Thomas and Busso (75) suggested an optimal volume reduction in the range of 30–40% for untrained athletes. The latter investigators attributed this lower percentage to the reduced capacity of untrained athletes to sustain greater volume loads (and therefore fatigue) during the preceding training program.

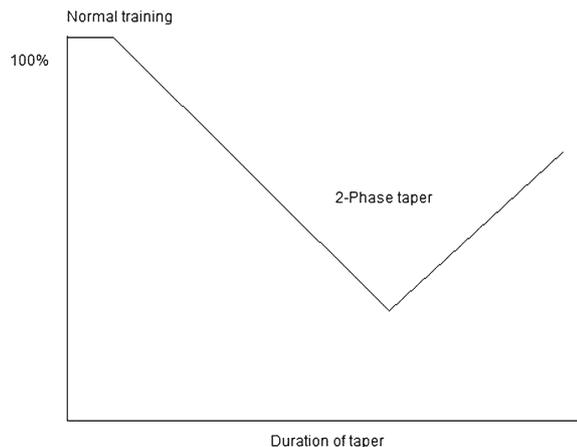


Figure 12. The 2-phase taper (Information attained from Thomas et al. (76)) VL = volume load.

Table 7 Effect of training variables on the effect size of taper-induced performance adaptations			
Variable	Effect size	95% CI	p
↓ in volume			
≤20%	−0.02	−0.32, 0.27	0.88
21–40%	0.27	0.04, 0.49	0.02
41–60%	0.72	0.036, 1.09	0.0001
≥60%	0.27	−0.03, 0.057	0.07
↓ in intensity			
Yes	−0.02	−0.037, 0.33	0.91
No	0.33	0.19, 0.47	0.0001
↓ in frequency			
Yes	0.24	−0.03, 0.52	0.08
No	0.35	0.18, 0.51	0.0001
Duration of taper, d			
≤7	0.17	−0.05, 0.38	0.14
8–14	0.59	0.26, 0.92	0.0005
15–21	0.28	−0.02, 0.59	0.07
≥22	0.31	0.14, 0.75	0.18
Pattern of taper			
Step	0.42	−0.11, 0.95	0.12
Progressive	0.30	0.16, 0.45	0.0001
Information attained from Bosquet et al. (6).			
CI = confidence intervals; d = days; p = significance value; ↓ = decrease.			

Moreover, Banister et al. (4) found a fast decay taper (which has the greatest reduction in volume) to be more beneficial than a slow decay taper. However, this again must be considered with respect to the preceding prescription of volume loads. Because the athletes in this study had previously engaged in very intense training and, therefore, were likely to have accumulated excessive fatigue, it may be the case that the necessity to induce a large drop in volume dictated that a fast decay taper would be more beneficial, especially given the time frame to do so, that is, 2 weeks. It is reasonable to further speculate that had the volume load of training been less, a slow decay or even a progressive taper (had the volume load been lower still) would have been more beneficial. Therefore, it may be hypothesized that the fatigue induced by training dictates both the duration and type of taper. For example, if the desired reduction in volume load is >60%, then taper durations in excess of 2 weeks may be justified. Similarly, smaller reductions ($\leq 20\%$) in volume load may require less than 2 weeks. This hypothesis may be corroborated by the work of Mujika and Padilla (56) who found optimal results ranging from 1 to 4 weeks in duration for anaerobic and aerobic activities. Because of the significance of assessing fatigue when deciding on the most appropriate taper strategy, Bosquet et al. (6) suggest that the profile of mood states (53) can be considered as a viable tool. However, using this to formulate tapering strategies requires further investigation.

The need to maintain (and oftentimes increase) the intensity and frequency may be corroborated by the investigations of Hakkinen and Kallinen (29) and Kubukeli et al. (47). In the former investigation, it was found that when volume is held constant, elite strength athletes increase their strength and cross-sectional area to a greater extent when their volume was divided into 2 daily sessions, rather than a single session. In the latter study, the group that divided the 3 sets of each exercise across 3 sessions (on separate days)

showed 38% greater increases in strength than performing the same 3 sets in a single training session. It may be concluded, therefore, that by distributing volume into smaller more frequent units, optimal conditions for muscular hypertrophy and strength and power gains are induced (85). One theoretical rationale is that higher frequencies maintain the feel of technical skills (47) and help maintain/increase intensity (85). The importance of maintaining training intensity during periods of a taper has also been underlined by other authors (34,54,55,56).

EVERY LITTLE BIT HELPS

Although the review of Wilson and Wilson (85) highlighted the performance improvements after a taper well in excess of that reported by Bosquet et al. (6), it should be noted that the latter investigation was confined to competitive athletes only. Therefore, despite reporting only a mean improvement of 1.96% (and hence only moderate effect size), for elite level athletes, this represents a significant supercompensation. For example, Mujika et al. (58) reported that after a taper, swimming performance increased by 2.2%, and this was comparable to the difference between a gold medal and a fourth place (1.62%) or between a bronze medal and an eighth place at the 2000 Sydney Olympics.

CONCLUSIONS

In summation, periodization represents an optimal strategy for organizing S&C programs. The selected strategy (i.e., basic, intermediate, advanced, and maintenance/nontraditional), however, should be based on the level of the athlete and the constraints of the competitive season. A common theme throughout all the periodization protocols is the need to manipulate volume loads, progress from general to sport-specific training, and dissipate fatigue. Significant to the latter moderator of enhanced performance, the use of summated microcycles and precompetition tapers seems evidently beneficial. Moreover, the use of a taper seems to produce an additional

supercompensation effect after the rigors of its preceding training program.

Although enough anecdotal evidence exists to validate the use of periodization and its various systems of use, its critics are justified in demanding more scientific rigor to understand its use and limitations to elite level athletes across extended periods (e.g., >4 years). Until such time, however, its use is recommended and advocated by the research herein.



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