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Periodization Strategies

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AUTHORS' NOTE: THE ISSUE OF program planning is based on professional practice knowledge, rather than scientific evidence. Although an effort is made to present relevant research findings where appropriate, most of the concepts discussed in this article are intuitive or anecdotal.

Many strength and conditioning practitioners have embraced periodization theory over the last two decades. Different interpretations are now commonly applied in practice and discussed in professional publications or meetings. Yet despite its popularity, some people still seem to struggle with the concept. Periodization originated in Eastern Europe, and therefore is perceived by many in the West as a foreign idea (refer to Siff [58] and Graham [20] for historical reviews). Although this has enhanced its mystique, the concept often seems disconnected from our knowledge and experience. Likewise, a working understanding of periodization involves a fair bit of scientific theory and jargon, some of which may not translate well. This has made some straightforward issues appear complicated and has alienated its share of coaches or athletes.

The intent of this article is threefold: (a) to relate periodization to a familiar idea (game theory); (b) to discuss the decision-making challenges involved in designing periodized training programs; and (c) to present some examples of applied strategies. Note that there are definite gaps in our current knowledge because periodization theory is based largely on empirical evidence; related (e.g., overtraining) research; and a few mesocycle-length variation studies. Most of these involved experimental periods no longer than 2–3 months and/or subjects with limited training experience, whereas no actual multiple-mesocycle or integrated studies (e.g., combined strength/power and speed/endurance training) on advanced athletes have been published in English.

Nevertheless, the available evidence supports two conclusions (67, 68): first, periodization seems to be a superior approach to strength/power training even over the short term, especially in previously trained subjects. Second, optimal results are achieved by manipulating training variables in appropriate sequence(s) and combination(s), rather than simply accomplishing a given amount of work. Our objective in this article is to discuss the practical issues involved in applying these conclusions.

Periodization and Game Theory

On one hand, periodization can be defined as planned distribution or variation in training methods and means on a cyclic or periodic basis (1, 8, 11, 17, 18, 20, 27, 38, 39, 53, 58, 60, 67, 68, 81, 87, 88). The basic goals are to exploit complementary training effects at optimal times, manage fatigue, and prevent stagnation or overtraining. This involves long-term, intermediate, and short-term planning. Accordingly, periodized training programs are typically structured into macro-, meso-, and microcycles that progress from extensive to intensive workloads as well as general to special tasks. Corresponding decisions should be

Table 1
Continuum of Classic Training Methods for Specialized Strength Development

Maximal strength

Brief maximal efforts [intra/intermuscular coordination; rate of force development]
Relative intensity: 75–100%
Action speed: slow to explosive
Volume: 15–25 reps/session @ 95–100%; 20–40 reps/session @ 90–95%; 35–85 reps/session @ 80–90%;70–110 rps/session @ 75–80% (≤8 reps/set for low skill movements; ≤3 reps/set for high skill movements)
Density: full (up to 8 min) recovery between sets

Repeated submaximal efforts [hypertrophy]
Relative intensity: 80–90%
Action speed: slow to explosive
Volume: 5–10 sets per exercise
Density: 1–4 min recovery between sets; 24–48 hours between sessions

Combination methods

Speed-strength

Submaximal accelerative efforts [power; rate of force development]
Relative intensity: 30–85%
Action speed: explosive/maximal
Volume: 3–7 sets per exercise; 1–3 reps/set @ 85%; 3–5 reps/set @ 80–85%; 5–8 reps/set @ 70–80%; 8–15 reps/set @ <70%
Density: 2–8 min recovery between sets; daily sessions

Reactive-ballistic efforts [stretch-shortening cycle; stiffness regulation]

Contrast methods [acute after-effects; potentiation]

Strength-endurance

Extensive interval [low/moderate intensity endurance capacity; recoverability]
Relative intensity: 30–40%
Action speed: brisk/continuous
Volume: 3–6 sets per exercise; 20–30 reps per set
Density: <5 min recovery between sets

Intensive interval [high intensity endurance capacity; recoverability]
Relative intensity: 50–60%
Action speed: explosive
Volume: 3–6 sets per exercise; 20–45 second duration per set (rep count is irrelevant)
Density: 1–3 min recovery between sets

Note: Objectives are indicated in brackets. Source: Plisk (50, p.75).

made with respect to several factors, including the biological responses to training stimuli, the athlete's developmental status, and the specific demands of his or her sport.

Game theory, on the other hand, is the science of strategic thinking (5, 7, 9, 10, 26). (Game theory came of age a half century later when John Nash, John Harsanyi, and Reinhard Selten shared the 1994 Nobel prize for their pioneering analysis of game theory as a foundation for understanding complex economic issues.) This theory originated when the principles of certain parlor games (e.g., chess, poker) were first applied to economics. Its play-like connotations do not do justice to the real-world significance of game theory. Since mathematician John Von Neumann and economist Oskar Morgenstern first published their *Theory of Games and Economic Behavior* (86), its novel insights and diverse applications have made game theory enormously important. In fact, it has evolved into a "unified field theory" used to explain and predict many phenomena in the social sciences. Note that a game is any situation of strategic interdependence where one player's decisions or actions interact with another's. Such games can be very real, the players need not be persons, and their interactions need not be adversarial. Indeed, convergence, not conflict, of interest is the rule, rather than the exception, in many circumstances. Therein lies the relevance of this concept to training program design.

In terms of game theory, periodization is the use of planned unpredictability to manipulate or outmaneuver another player. The other player in this case is the body's adaptive mechanism. The underlying goals are to influence your counterpart to adjust or redirect its actions in probable ways and prevent it from accommodating your tendencies. This brings us to a critical distinction: in contrast to athletics, where a competitive strategy is used to achieve a "win-lose" outcome, the key in training is a cooperative strategy aimed at a "win-win" result. Although the basic principle of game theory applies in either case, complementing, rather than defeating, another player is the strategy of choice in this situation. In this sense, periodization is a form of "coopetition" (5, 46).

Coaching Strategy

Coaching is often described as the science of total preparation. In some respects (e.g., game planning, play calling), it can also be described as the art of systematic unpredictability. The trick is to mix your plays with no demonstrable pattern in order to prevent your adversary from effectively countering your tactics. This involves a randomized plan intended to thwart an opponent's ability to anticipate your next move or concentrate its resources at a single point of attack. As Dixit and Nalebuff (10) put it, "The right amount of unpredictability should not be left to chance" (p. 170).

The essence of periodized program design is to skillfully combine different training methods in order to yield better results than can be achieved through exclusive or disproportionate use of any 1 of them. To use a baseball analogy, an adept pitcher uses off-speed pitches (e.g., breaking ball, change-up) to set up his or her fastball, rather than relying on a single tactic—even a dominant one. Likewise, strength and conditioning professionals can use a "mixed methods" strategy that exploits certain physiological responses and achieves specific objectives. The first step in the planning process is to classify one's training tactics into a rational system. Tables 1 and 2 outline two reasonable taxonomies of strength and endurance development methods, respectively, that can be used as a sort of "playbook." These schemes reflect general agreement in the literature, making them useful examples.

In light of recent economic events, modern portfolio theory offers an instructive and timely lesson as well. (This theory was formally introduced by Markowitz (37); he shared the 1990 Nobel prize with Merton Miller and William Sharpe for their pioneering work in the theory of financial economics.) Contrary to the gambling venture it is sometimes believed to be, there is a science to

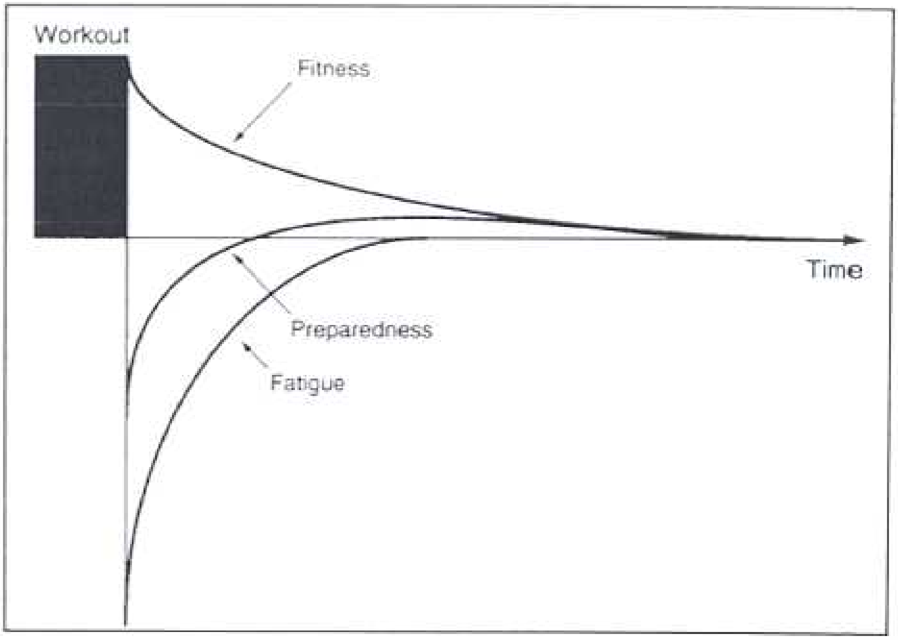

Figure 1. *Fitness-fatigue theory.* **An athlete's preparedness is determined by the summation of positive (fitness) and negative (fatigue) responses. In contrast to the "supercompensation" theory based on a cause-and-effect relationship between these two processes, this model proposes that immediate training effects are characterized by their opposing action. Reprinted by permission from Zatsiorsky (92, p. 16).**

investment finance. A central premise of this theory is that asset allocation is the main determinant of portfolio performance. Although there is a limit to the feasible risk/reward combinations for different allocation strategies, optimal results are achieved through multilevel diversification: distributing resources between as well as within asset classes, sectors, industries, styles, regions, and so on. Even if each chosen investment is fundamentally sound, failure to diversify properly yields the greatest risks and poorest returns of all. The salient point is that a portfolio can behave differently than the assets comprising it when skillfully blended into an appropriate strategy (results may actually be enhanced by including "high risk" assets that have a low correlation with one another).

Decision-Making: Trade-Offs and Implications

Periodized program design is a type of multilevel diversification. The strength and conditioning coach can direct the adaptation process toward specific goals by varying the load (methods) and/or content (means) of training within—as well as between—macro-, meso-, and microcycles (and training sessions). In fact, the available tactics are so numerous that the issue really becomes one of avoiding haphazard strategies.

The risk/reward trade-off discussed above is also a useful analogy. Consider how the following paradoxes influence the decisions involved in program design: fitness vs. fatigue, intensity vs. volume, specificity vs. variation, strength vs. endurance, and periodization vs. programming.

Fitness vs. Fatigue

The prevailing theory of training adaptation is the fitness-fatigue paradigm (Figure 1; 92). According to this theory, an athlete's preparedness is defined as the summation of two after-effects of training: fatigue and fitness. In contrast to the "supercompensation" theory based on a cause-and-effect relationship between these factors, the fitness-fatigue model proposes that they have opposing effects. This has a simple but profound implication for program design and implementation: preparedness can be optimized with strategies that maximize the fitness responses to training stimuli while minimizing fatigue.

Since fatigue is a natural consequence of training stress, especially with high-volume loads, and adaptations are manifested during subsequent unloading periods, fatigue management tactics are integral to a sound program. These can be implemented at different levels (8, 17, 18, 27, 53, 58, 81, 85):

- Macrocycle: Active rest/transition periods after competitive periods.
- Mesocycle: Restitution microcycles after overreaching microcycles, concentrated blocks, or stressful competitions.
- Microcycle: Maintenance/restitution workloads or recovery days; daily training routines distributed into modules separated by recovery breaks; and additional intrasession relief breaks (rather than a "repetition maximum" approach where each set is completed in continuous fashion, it can be advantageous to subdivide assigned workloads into clusters separated by rest-pauses; note the consistency of this approach with the brief maximal efforts, submaximal accelerative efforts and reactive-ballistic efforts methods described in Table 1; 21, 58, 92)

Note that rational program design is one prong of a restoration plan that should also address nutrition, sleep, and regenerative/therapeutic techniques.

Intensity vs. Volume

The idea of a trade-off between intensity and volume seems pretty basic, but it has important ramifications because the interaction of these variables drives many of the decisions made when designing training programs. Periodization involves fluctuating emphasis on these variables such that adaptation is steered toward specific objectives, but it is rather meaningless to consider one independently of the other; hence the practical value of the volume load concept as an indicator of training stress (63, 67–69).

Volume load prescription should be viewed in the context of productive workload ranges. At the lower end is the stimulus threshold required to trigger desired effects, whereas at the upper end is a point of diminishing returns, beyond which further application yields no beneficial or perhaps even detrimental effects. These tend to be moving targets as an athlete's adaptivity and fitness improves with long-term development.

Primary emphasis is generally placed on training quality (i.e., intensity), which can be expressed in quantitative terms such as impulse or power output during task execution. In practice, such parameters are useful indicators of stimulus intensity and corresponding training effect. The central issue regarding programming strategy is the method by which increased intensity is achieved. Variable rather than linear workload progressions tend to yield superior results (8, 17, 18, 27, 29, 38, 39, 53, 58, 60, 67, 68, 81, 92) and can be accomplished through different tactics.

By definition, high work volumes are associated with the development of endurance qualities (Tables 1 and 2). But work volume also fulfills several other important functions when rationally applied with respect to intensity. In terms of general preparation, extensive volume loads establish a functional base of work capacity, influence the duration and stability of corresponding training effects, and are an important prerequisite for intensive efforts involved in special/technical preparation.

Two basic tactics are often associated with extensive work volumes: high-repetition sets with corresponding reductions in workload, or increased number of sets and/or exercises. There are other tactics, however, that should also be considered. For example, volume loads can be adjusted by periodically manipulating density variables (training session distribution and frequency) in order to achieve certain objectives. This issue will be revisited in the *Applied Strategies* section.

Specificity vs. Variation

Zatsiorsky (92) points out that a sound periodization plan is a trade-off between the conflicting demands for fluctuation (according to the law of variability) vs. stability (to satisfy the demand for specificity; pp. 108–135). Optimal effects are achieved through systematic variation in training content and/or workload, whereas monotonous loads or tasks (e.g., entirely activity-specific movements) can predispose an athlete to accommodation or stagnation problems. This is the rationale for regular application of novel stressors. In practice, the challenge is to structure these into appropriate variation "bandwidths."

A basic principle of training is that adaptation becomes increasingly specific to the demands imposed on an athlete as his/her preparation level improves. Specificity exists on several fronts, including biomechanical, coordinative, and energetic, each of which is a useful criterion for selecting and prioritizing training tasks. After completing a needs analysis, the relative emphasis placed on different means and methods should be influenced by the athlete's developmental status, especially with regard to critical or sensitive periods (8, 27, 81, 82, 83, 84). Preadolescence seems to be the optimal window for enhancing the "coordinative abilities" upon which motor skills are based. Although these are still trainable to an extent during and after adolescence, training should shift toward a greater emphasis on strength/power improvement upon reaching puberty. This issue has intriguing implications in all aspects of program planning but receives little attention in the West.

Strength vs. Endurance

Certain types of endurance training can hinder strength and power development when performed concurrently, at least in previously untrained subjects (33, 35, 58, 81). This creates a dual problem:

- High levels of these qualities must be developed in specific combinations in order to optimize athletic performance. Even brief, explosive "power sports" require special endurance qualities in order to achieve the prescribed volume loads in training. And, of course, most transitional sports involve a blend of submaximal activity and repetitive, intense bursts of power output with limited relief allowance.
- Although advanced athletes can tolerate greater training stress than novices, cumulative fatigue can be problematic when developing multiple fitness qualities simultaneously. Unfortunately, such compatibility studies on trained subjects are lacking.

The challenge in practice is to integrate strength and endurance training effects (Tables 1 and 2) such that they enhance, rather than interfere with, one another. In basic applications, this may be achievable with fairly simple training and recovery tactics. For qualified athletes, however, advanced strategies are valuable in minimizing cumulative fatigue and compatibility problems.

Periodization vs. "Programming"

If there is one self-limiting tendency among strength and conditioning professionals, it is that we often focus on numerical models, rather than underlying strategy, when designing programs. This may be an artifact of the repetition per set counting mentality that was prevalent before periodization became popular in the West. In any case, it poses an interesting problem: a given training stimulus (input) results in a response (output) that is not entirely predictable.

According to Siff (58, p. 326), "The use of numerical computations as the sole descriptor of loading often overlooks the fact that apparently objective measures like this do not take into account the athlete's subjective perception of the intensity and overall effects of the loading." He recommended a combined objective-subjective approach referred to as "cybernetic periodization" where zones of workload intensity are planned in advance, but tactics are adjusted as necessary based on technique evaluation by the coach as well as performance feedback from the athlete regarding perceived effort/fatigue.

This is not meant to dissuade practitioners from calculating a thoughtful game plan. The salient point is that volume load parameters, repetition and set schemes, and so on are secondary to training goals and objectives. Furthermore, rather than applying them rigidly, intuitive factors can be used to make prudent adjustments during implementation.

Summary

Strategic decision making would be unnecessary if the pieces of the program design puzzle fell together automatically. The art of periodization involves resolving some challenging paradoxes as part of a coherent plan.

Cyclic Program Structure: Basis & Guidelines.

The cyclic structure of early periodization models was usually based on the competitive calendar more so than on adaptive processes because information regarding the latter was limited. As our knowledge base has expanded, it has become apparent that there are opportunities to augment training effects by exploiting certain biological phenomena. For example, by using appropriate sequencing or timing strategies, the after-effect of one training stimulus can modulate the response to another. This is a fundamental objective of contemporary periodization: to systematically converge the cumulative or interactive effects of different means and methods (i.e., to set up one play with another). Such tactics are particularly valuable when training time is restricted and/or an athlete is approaching

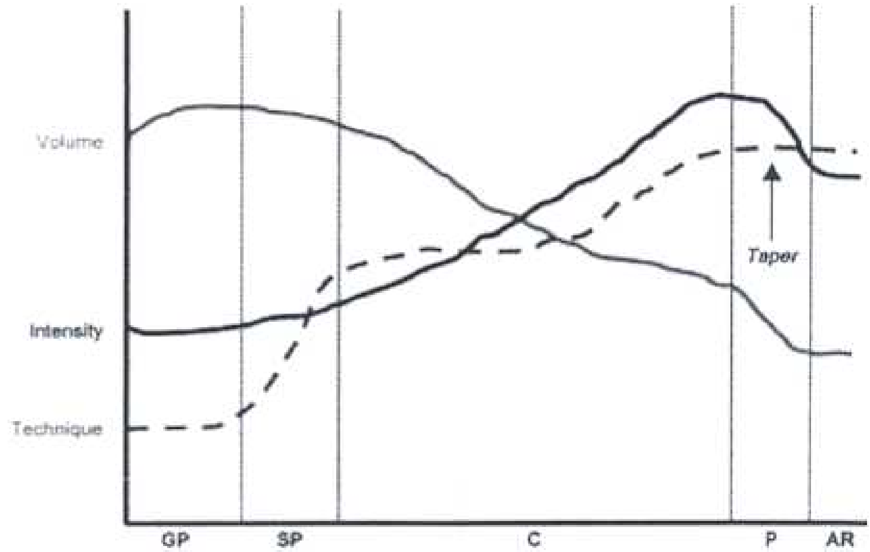

Figure 2a. *Generalized periodization model of strength-power training (basic application).* The main premise is a wave-like shift from high-volume, low-intensity training to low-volume, high-intensity training over the mesocycle or macrocycle. GP = general preparation; SP = special preparation (first transition), during which emphasis shifts from extensive to intensive methods and technique training; C = competition; P = peaking; AR = active rest (second transition) consisting of unstructured/recreational activities where both intensity and volume are reduced and restitution is the main objective. Adapted from Stone et al. (65, 66).

PHASE: Objective / *Variable*	GENERAL PREPARATION: Strength-Endurance	SPECIAL PREPARATION: Basic Strength	COMPETITION: Strength & Power	PEAKING/ACTIVE REST: Peaking/ Maintenance
Intensity	low to moderate	high	high	very high to low
Volume	high	moderate to high	low	very low
Repetitions	8-20	4-6	2-3	1-3
*Sets**	3-5	3-5	3-5	1-3
Sessions/Day	1-3	1-3	1-2	1
Days/Week	3-4	3-5	3-6	1-5
Intensity cycle†	2-3/1	2-4/1	2-3/1	—

Figure 2b. *Generalized periodization scheme of strength-power training (basic application).* Strength-endurance is a more accurate objective of the GP phase than hypertrophy because increased anaerobic capacity is its primary objective; body composition changes—although important—are secondary. Basic strength, strength and power, and peaking/maintenance reflect a continuum of training objectives during subsequent periods (peaking applies to sports with climax; maintenance applies to sports with extended season). *Sets: excludes warm-ups. †Intensity cycle: ratio of heavy to light training weeks. Adapted from Stone et al. (65, 66).

the limits of his or her developmental potential.

Rate of involution or decay of various training effects is a central physiological consideration in cyclic program design (81, 85, 92). Acutely, this is a function of the half-life of structures synthesized during adaptive tissue remodeling. As might be expected, their time courses vary since the half-life of glycolytic enzymes is relatively brief, ranging from ~1.5 hours to a few days, whereas oxidative enzymes turn over less rapidly, and myofibrillar proteins have a comparatively greater life span. Chronically, involution is modulated by the length of the preparation period. In general, the greater the duration of a training program, the more stable its residual training effect. This allows fitness qualities acquired during one phase to be maintained with relatively small volume loads during the next, such that emphasis can be redirected and cumulative fatigue problems can be minimized. This is the rationale for using sequential training strategies with qualified athletes, as will be discussed in the *Applied Strategies* section.

The consensus arising from the literature is to organize training programs into 4-week periods, which seem to be an optimal biological window for integrating responses: Matveyev (39) cites the existence of natural monthly biocycles as a rationale for constructing training cycles that are approximately 1 month in duration, each consisting of 3–6 subcycles of approximately 1 week duration, in order to exploit cumulative training effects (pp. 245–259). Viru (81) cites the half-time of training effect involution as the rationale for a 24–28 day cyclic training structure consisting of 4–6 subcycles, each 4–7 days in duration, in order to summate their training effects (pp. 241–299). Zatsiorsky (92) cites the need to structure training cycles around a 4 (±2) week window in order to superimpose the delayed training effects of distinct targets distributed over that time (pp. 344–421).

Even the most advanced training strategies, such as the "conjugate sequence" system discussed in the following sections (29, 55, 58, 73–81, 89, 92) generally agree with this monthly cycle guideline. As will be seen, this period can be structured in at least 2 different ways: as a mesocycle to be subdivided into multiple microcycles and objectives (for basic and intermediate applications), or as a "block" with essentially 1 objective arranged as part of a series (for advanced applications).

Classic Variants

Many practitioners still perceive Matveyev's model (38, 39)—which involves gradual, wave-like increase in workload over each phase—as the standard approach to periodization (Figure 2; also refer to Harre [27], Kukushkin [34], and Ozolin [47, 48]). From his discussions of microcyclic variations and "intermediate mesocycles" during the competition period, however, it is evident that Matveyev did not intend for this model to be applied rigidly or universally (38–41). Indeed, there have been varied interpretations throughout the international sport science community. The following are examples of different periodization schemes designed for specific applications:

- Abrupt step-like alteration in workload intensity over weekly or monthly cycles (e.g., Ermakov [12, 13]; Vorobyev [87]).
- Balanced distribution of technical skill and strength workloads during preparation as well as competition phases (e.g., Bondartchouk [3]), or with emphasis on technique during the preparatory period and strength during the competitive period (e.g., Komarova [32]; Topchiyan et al. [72]).
- An interesting strategy for elite athletes that will be addressed in more detail in the *Applied Strategies* section is the "conjugate sequence" system, where concentrated workloads with one primary emphasis are arranged in a series of blocks (e.g., Verkhoshansky [79, 80]; Werchoshanski [89]; also refer to Hartmann and Tünnemann [29], Siff [58], Satori and Tschiene [55]; Tschiene [73–77]; Viru [81]; and Zatsiorsky [92]). This approach emphasizes the role of delayed training effects in the adaptation process and rejects the idea that different abilities should be developed simultaneously.

It is instructive to compare philosophies used by coaches throughout the former Eastern Bloc. Using the sport of weightlifting as an example, the training means and methods used by Medvedev (Russia) and Abadjiev (Bulgaria) were at opposite ends of the spectrum in terms of variation (11, 19, 31, 43, 44, 91, 92), and yet their athletes achieved similar competitive success, although arguably the latter may have been more effective because Bulgaria's athlete population was smaller. Likewise, Aján and Baroga (1) offer a combined Hungarian-Romanian perspective that bears some similarities to Abadjiev's.

As is the case in any sport, there are likely as many interpre-

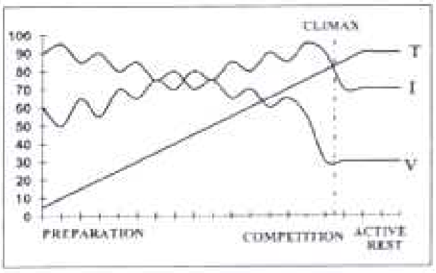

Figure 3a. *Generalized periodization model (intermediate application).* **Although the basic macrocyclic pattern of decreasing volume (V) and increasing intensity (I) is evident, both parameters are varied at meso- and microcyclic levels. Emphasis on technique training (T) increases during preparation and competition periods. Reprinted from Stone et al. (67, 68).**

tations as there are practitioners applying them, just as football coaches debate the pros and cons of different offensive systems. Each can be effective if fundamentally sound. In fact, many coaches blend elements of different systems in an effort to be as "multiple" as possible. But the basic goals are remarkably consistent: using the interior/running game to set up the perimeter/passing game, spreading the defense horizontally in order to move vertically up the field, and so on. In similar fashion, optimal training effects may be achieved by strategically blending methods (Tables 1 and 2), including those that are sport- or activity-specific, with some that are not such that the response to one amplifies another.

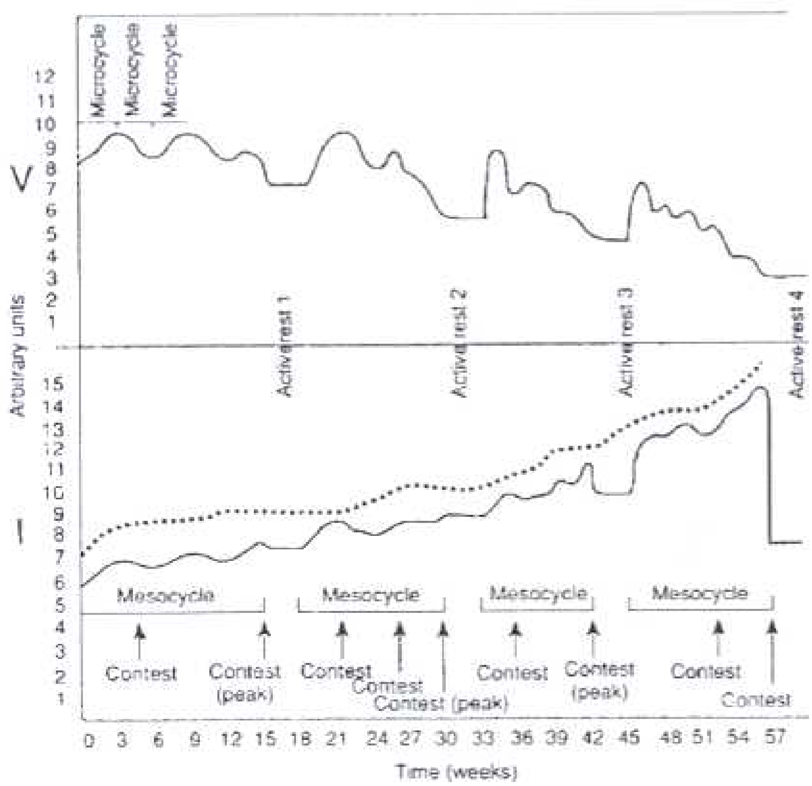

Figure 3b. *Annual macrocycle for shot put (intermediate application).* **Training peaks characterized by low volumes (V) and high intensities (I) are scheduled to coincide with important competitions at the end of each mesocycle. Reprinted from Stone et al. (67, 68).**

■ Applied Strategies

The following is an overview of some basic, intermediate, and advanced approaches to periodization. This discussion is intended to illustrate how strategic thinking can be applied to training program design, but is not an exhaustive summary of tactics. Moreover, since content variations (e.g., technique variants, assistance movements) are inherent in skill-based programs, focus is directed toward workload and recovery issues. Several other points should also be kept in mind.

First, many concepts proposed in this section originated in the former Eastern Bloc and are based on empiricism more so than scientific evidence. Although it is hoped that this information will be useful to coaches in the West, it is important to recognize the respective societies' differences in both research and training practices.

Second, the basic-intermediate-advanced scheme discussed here represents a continuum with no discrete divisions and is not intended as a rating system. All athletes should begin at a basic level and then progress through an intermediate developmental process, whereas few achieve what would be considered the "sport mastery" stage by international standards. It is a serious mistake to perceive basic and intermediate approaches as being inferior or insignificant and attempt advanced tactics too early in an athlete's long-term preparation.

Third, stressors should be applied strategically, with regard to integration rather than isolation of responses to stimuli. Although our understanding of training effect interaction may be in its infancy, there are opportunities to enhance fitness, manage fatigue, and thereby optimize an athlete's over-al preparation by exploiting certain phenomena.

Finally, a periodized plan should reflect an increasing level of "micromanagement" as the athlete's development progresses. This does not mean that all decisions should be deferred to the coach, but instead that more sophisticated variation should be applied on multiple fronts (i.e., training methods and means, within and between cycles).

Basic Strategy

In general, basic periodization strategies can be characterized by relatively limited variation in training methods and means. As mentioned above, a case can be made for such strategies being the most valuable of all because of their broad applicability. Certainly there are many more novice athletes in the early stages of development (for whom advanced tactics would be inappropriate) than elite athletes in later stages. As is the case with other stressors, the initial adaptive responses tend to be fairly general, and simple training/recovery strategies can be quite effective in these situations. With chronic application, however, adaptation becomes increasingly specific and resistant to low-level or monotonic stimuli.

The traditional periodization model attributed to Matveyev is a simple approach characterized by gradual, wave-like increases in workload (Figure 2; 38, 39). Note that this diagram was originally intended to illustrate a basic concept, but is sometimes simplistically interpreted as a "linear periodization" model (2, 4, 88). (This term has been used to describe training cycles involving gradual, progressive increases in intensity. It was originally adopted by Baker et al. [2] from Poliquin's [52] discussion of problems with linear intensification strategies. For further discussion, refer to the editorial letters by Stone and O'Bryant [64] and Stone and Wathen [71].) This is a contradiction in terms because, by definition, periodization implies nonlinear variation in training parameters. For example, Figure 2a depicts a mesocycle that would produce an undulating long-term pattern if repeated over a macrocycle. Furthermore, these intensity and volume progressions typically fluctuate at the microcyclic level. And so it would be more appropriate to refer to periodization models as traditional or nontraditional, whereas "linear" and "nonlinear" terminology is misleading.

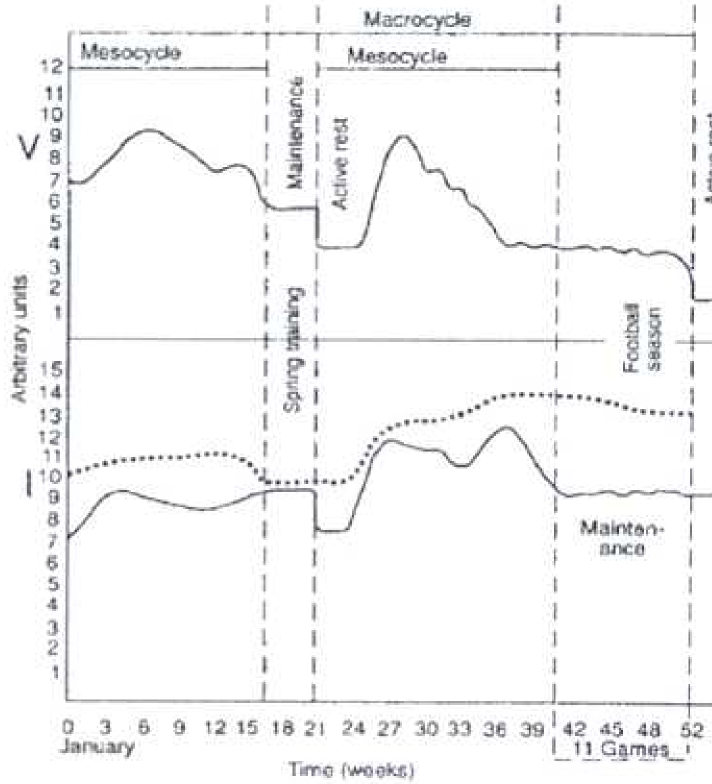

Figure 3c. *Annual macrocycle for college football (intermediate application).* **Maintenance phases characterized by low volumes (V) and moderate/high intensities (I) are scheduled to coincide with competition periods at the end of each mesocycle. Reprinted from Stone et al. (67, 68).**

A potential problem exists with steplike versions of this model where relatively flat workloads are prescribed over a period of several weeks (e.g., 3–4 week strength-endurance phase, 3–4 week maximum strength phase, 3–4 week speed-strength phase). Presumably the intent of this approach is to intensify the workloads used at each step before proceeding to the next. But consecutive weeks spent within such narrow workload ranges can effectively amount to ≤1 week of novel stimulus followed by up to 3 weeks of monotony, which may increase the likelihood of accommodation/stagnation problems. This strategy can be viable for novice athletes who are learning new

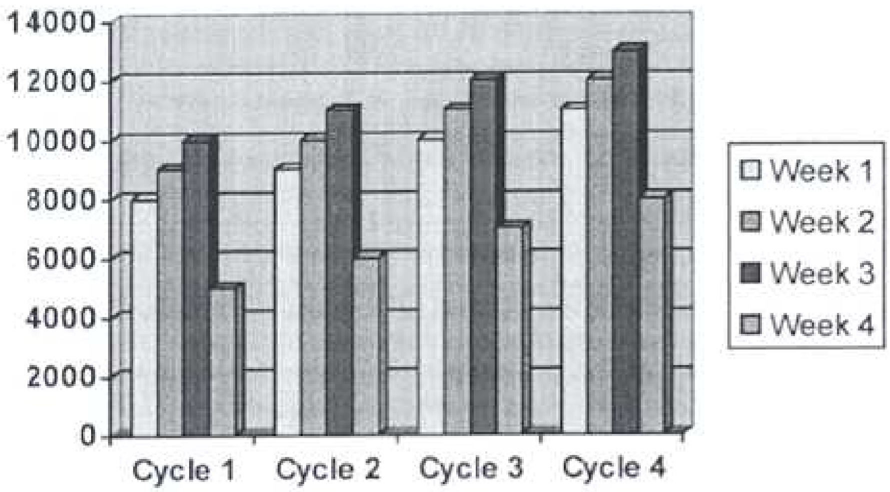

Figure 4a. *Mesocycles consisting of 3 weeks of "summated microcycles" at progressively higher workloads and 1 unloading week (intermediate application).* **Volume loads are highest in week 3, by which time cumulative fatigue may hinder certain adaptations (e.g., speed-strength); hence the need for unloading week 4 to reduce overtraining potential and promote adaptation. The same basic pattern can be used in each cycle to repeatedly introduce certain stimuli at progressively higher workloads.**

movement techniques and/or unaccustomed to high intensities. It should be possible to alleviate its shortcomings by using zig-zag progressions where volume loads are varied within reasonable ranges (e.g., a conservative "heavy/light day" system that alternates between repeated submaximal efforts and submaximal accelerative efforts; Table 1).

Intermediate Strategy

Intermediate periodization strategies can be characterized by increasing levels of variation within—as well as between—respective cycles. Whereas a beginner's program may consist of simple progression on a macrocyclic basis, tactical decisions are now directed more toward meso- and microcyclic variables (the degree of workload contrast between monthly phases, weeks, and/or individual training sessions as well as within sessions; Figure 3).

Emphasis on intensive methods can be increased (brief maximal efforts, reactive-ballistic efforts; Table 1) and a broader range of means can be applied as the athlete's repertoire of movement skills and abilities grows. Although this is limited to some extent by practical considerations such as the professional:athlete ratio and time available for instruction and supervision, it can certainly be beneficial to expand training content to include additional exercises and/or variants up to a point. In any case, the need for creative training and recovery tactics increases as athletes progress beyond the novice developmental stage.

Based on the training effect summation phenomenon discussed earlier, the concept of "summated microcycles" can be valuable as an intermediate strategy (Figure 4). It is characterized by 4-week mesocycles with an extensive to intensive workload progression and a brief restitution period. Training method distribution is the key difference from the basic approach described above. Specifically, a microcycle, rather than mesocycle, is allocated for strength-endurance, maximum strength, and speed-strength methods, respectively (Table 1). This pattern of loading, where 3 weeks of increasing volume and/or intensity is followed by an unloading week and the progression is then repeated at higher intensities, allows complementary stimuli to be reintroduced in a regular cyclic fashion such that their effects do not decay significantly. Practitioners should be careful when using this type of 3:1 approach because the greatest workloads occur in week 3, by which time cumulative fatigue may hinder speed-strength expression; hence the need for unloading week 4 to reduce overtraining potential and promote adaptation.

A summation strategy may offer dual benefits (17, 18, 38, 53): as a form of intra-mesocycle variation, it increases the probability of converging training effects while minimizing the likelihood of overstress or accommodation/involution problems. Furthermore, it adds an aspect of inter-mesocycle contrast that may stimulate adaptation over the long term. Other strategies such as planned overreaching may be more effective for advanced athletes whose training goals are to maximize strength, power, and speed, as will be discussed in the next section.

Summated microcycles can be complemented with intra-microcycle variation tactics. For example, the progression described above can be modified simply and efficiently by using a heavy/light day system where the emphasis alternates between maximum strength and speed-strength methods, respectively (Table 1). Human (14) and animal (6) data indicate that regular inclusion of submaximal days within a microcycle allows given training loads to be accomplished with greater potential for positive adaptations and results in fewer problems (note that the latter study by Bruin et al. involved 7 male race horses over 39 weeks of training, so the results should be interpreted cautiously with human athletes). Likewise, competitive-trial, interval, and repetition methods can be distributed among speed and speed-endurance sessions or modules in the field (Table 2). More research is needed to expand our understanding of this issue.

Some interesting possibilities for intrasession variation have become increasingly popular over the last decade. Many of these are based on "acute aftereffect" phenomena such as postactivation potentiation (54, 58) and include tactics like combination/hybrid exercises (e.g., clean and front squat, snatch and overhead squat); complex training (alternating between maximum strength and speed-strength methods; Table 1); and wave loading (alternating between brief maximal efforts and submaximal accelerative efforts; Table 1). The underlying strategy is to use one type of stimulus to enhance acute power output and/or rate of force development in another. Recall the modern portfolio concept mentioned earlier: just as overall return may be improved by including high-risk assets that have a low correlation with others in the portfolio, advanced athletes can strategically use movements that are not mechanically specific to their sport to augment the effects of more specialized tasks.

Collectively, these concepts should be viewed in a strategic

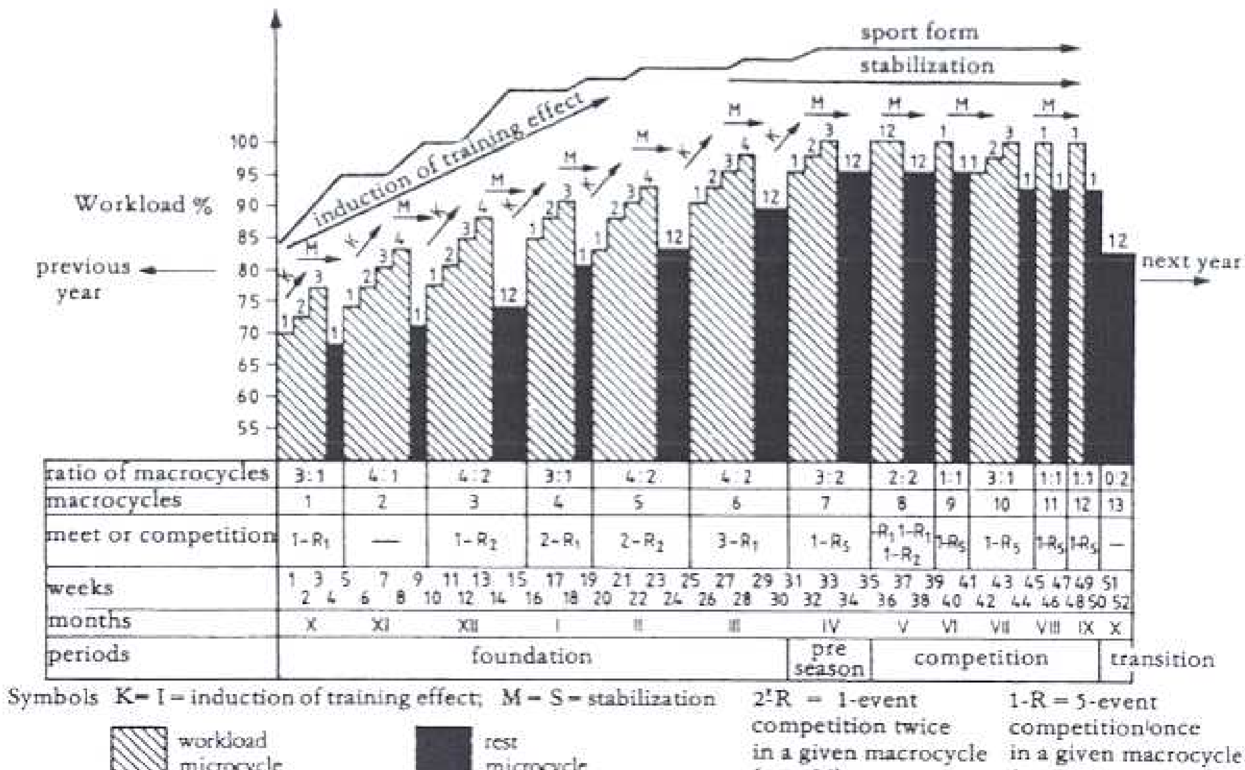

Figure 4b. *Annual macrocycle for modern pentathlon (intermediate application).* Training effects are induced during the foundation and preseason periods via a series of mesocycles—referred to as macrocycles in this diagram—consisting of 3–4 "summated (workload) microcycles" and 1–2 unloading (rest) weeks. Reprinted by permission from Nádori and Granek (45), p. 16.

Table 2
Continuum of Classic Training Methods for Speed, Agility, and Speed-endurance Development

Competitive-trial [special endurance]

Supramaximal training
Intensity: greater than competition
Duration/distance: less than competition

Maximal training
Intensity: equal to or less than competition
Duration/distance: equal to competition

Submaximal training
Intensity: less than competition
Duration/distance: greater than competition

Distance-duration [submaximal endurance]

Continuous training: 70–95% competitive speed/power
Fartlek training: unstructured changes in intensity, duration, volume, and density
Variable training: structured changes in intensity, duration, volume, and density

Interval [speed-endurance]

Extensive training
Relative intensity: low–medium (60–80% competitive speed/power)
Duration/distance: short–medium (e.g., 14–180 s over 100–1,000 m running distance for advanced athletes; 17–100 s over 100–400 m running distance for novices)
Volume: large (e.g., 8–40 reps for advanced athletes; 5–12 reps for novices)
Density: high; short incomplete relief interval allowing HR to recover to 125–130 bpm for advanced athletes or 110–120 bpm for novices (i.e. less than one third time needed for complete recovery; e.g., 45–90 s or 60–120 s for advanced or novice athletes, respectively)

Intensive training
Relative intensity: high (80–90% competitive speed/power)
Duration/distance: short (e.g., 13–180 s over 100–1,000 m running distance for advanced athletes; 14–95 s over 100–400 m running distance for novices)
Volume: small (e.g., 4–12 reps for advanced athletes; or 4–8 reps for novices)
Density: medium; longer but still incomplete relief interval allowing HR to recover to 110–120 bpm (e.g. 90–180 s for advanced athletes; 120–240 s for novices)

Repetition [speed/agility]

Relative intensity: very high (90–100% competitive speed/power)
Duration/distance: very short/medium (e.g., 2–3 s up to several min)
Volume: very small (e.g., 3–6 reps)
Density: low; long near-complete rest interval allowing HR to recover to ≤100 bpm (e.g., 3–45 min)

Note: Objectives are indicated in brackets. Source: Plisk (51, p.484). HR = heart rate; bpm = beats per minute.

context. If applied with discretion, there may be opportunities to include certain training and recovery tactics fairly early in an athlete's development. Likewise, intermediate approaches need not be abandoned when the athlete reaches an advanced stage. The key in either case is systematic application of sound means and methods in order to enhance the effects. At present, however, the summated training concept is based largely on empiricism and intuition. Further research is needed to investigate the possibilities of this and other strategies.

Advanced Strategy

Highly qualified athletes require greater stimulus variation and novelty than intermediate or novice athletes, especially at the microcyclic level. As they approach their developmental limits, higher workload intensities and volumes are necessary to trigger further adaptation and achieve peak performance. Thus they typically train with greater volume loads and may be closer to an overtraining threshold. The key is to avoid monotonous or frequent heavy loading, which can increase "training strain" and the potential for negative results (14, 17, 18, 53, 62).

Advanced periodization strategies can therefore be characterized by extensive, systematic variation in both content and workload at multiple levels of the program (i.e., between and within respective micro-, meso-, and macrocycles). Although these are extensions of the means and methods presented above for basic and intermediate approaches, such training/recovery tactics can get quite sophisticated.

The "conjugate sequence" system is an intriguing approach for advanced athletes (Figure 5; 29, 55, 58, 61, 70, 73–77, 79–81, 89, 92). This concept, also referred to as the "coupled successive" system, was pioneered by Yuri Verkhoshansky (79). Subsequent articles were published in that journal, as well as the *Soviet Sports Review* and several texts translated through Bud Charniga's Sportivny Press (79, 80). Most recently, it was discussed in Atko Viru's *Adaptation In Sports Training* text (81) and Mel Siff's *Supertraining* text (58). This method is an inter-mesocycle variation strategy that involves periods of accumulation or intentional overreaching followed by restitution during which supernormal responses can be exploited. This is achieved through a series of "concentrated blocks" that are usually 4 weeks in duration. During the first block, the athlete performs high-volume loads of work with one primary emphasis (strength/power) and minimal—presumably maintenance-type—volume loads allocated to other abilities. The objective is to saturate the system with one type of stress over a period of several weeks, during which tempo-

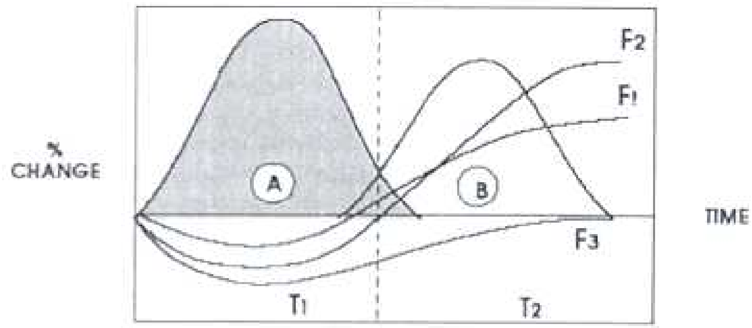

Figure 5a. *General scheme of the long-term delayed training effect (LDTE) of concentrated strength loading associated with the "conjugate sequence" system (advanced application).* **The duration of the LDTE (T2) is approximately equal to that of the concentrated strength block (T1) and is usually 4–12 weeks depending on volume load and individual recoverability. Within optimal ranges, the greater the decrement in speed-strength indices (F1, F2, and F3) during accumulation block A, the greater their recovery during restitution block B. Reprinted by permission from Siff (58; p. 362).**

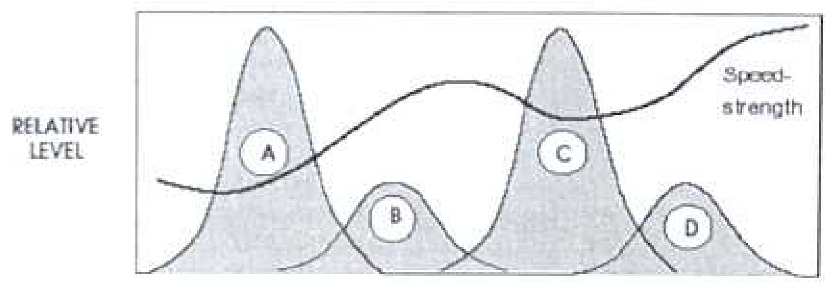

Figure 5b. *Increase in speed-strength by systematic, overlapping sequence of concentrated and moderate volume loads associated with the "conjugate sequence" system (advanced application).* **Accumulation blocks A and C represent periods of high-volume, low-intensity strength training during which the athlete intentionally overreaches (and temporary performance decrements are expected). Restitution blocks B and D represent moderate volumes of specialized, high-intensity speed-strength and technique training during which supernormal responses are exploited (and performance capabilities rebound by virtue of the LDTE phenomenon). Reprinted by permission from Siff (58; p. 386).**

rary decrements in certain performance capabilities can be expected due to residual fatigue. Emphasis is essentially reversed during the subsequent restitution block: strength-training volume load is markedly reduced, whereas the volume load of work allocated to another quality (speed/technique) is increased moderately. If implemented skillfully, the athlete's performance capabilities rebound by virtue of a delayed training effect phenomenon, allowing new levels of movement speed and technical execution to be achieved. The athlete can then proceed to the next sequence of blocks with progressively stronger stimuli.

Proponents of this strategy cite several advantages (55, 58, 61, 70, 75, 79–81, 89, 92): (a) it provides the potent training stressors needed to bring advanced athletes to a new functional state that otherwise cannot be achieved through traditional methods; (b) by emphasizing respective qualities during separate blocks, the cumulative fatigue problems associated with parallel or concurrent training can be circumvented; and (c) work volumes can be reduced over the long term. This comes with a price over the short term, however. During each accumulation block, athletes must be able to tolerate high volume loads for several consecutive weeks. This can be particularly problematic without the systematic application of restorative/regenerative measures.

One line of evidence supporting the sequenced training concept is based on longitudinal and cross-sectional studies suggesting superior gains in athletic performance variables (particularly those involving power and speed) compared with heavy resistance or speed-strength training exclusively (23, 69). More significantly, beneficial changes have been demonstrated in both a wider range and greater extent of parameters (28, 44). More research is needed to expand on these findings.

Additional supporting evidence can be found in studies of endocrine responses to planned overreaching strategies (i.e., periodic increases in volume load aimed at enhancing adaptation and performance 2–5 weeks after returning to normal training). For example, serum testosterone concentration (T) and the testosterone:cortisol ratio (T:C) are indices of anabolic/catabolic balance as well as physiological training strain (note that these can be useful markers when monitoring an athlete's response to overreaching protocols, but do not necessarily indicate an overtraining syndrome; 30, 78, 85). Resting or pre-exercise T and T:C have been shown to decrease significantly in response to severe, prolonged (≥3 week) increases in volume load (22, 24, 25, 42, 47), whereas supernormal levels and corresponding performance improvements have been documented upon returning to normal volume loads with a subsequent taper (22, 25, 47). Supernormal T:C responses have also been demonstrated after short-term (1-week) overreaching (15, 61, 63). Furthermore, prior exposure to temporary overreaching may enhance an athlete's tolerance for subsequent high volume load training and associated performance gains (15, 16). Collectively, these findings seem to explain some of the results of sequenced training and support its role as a useful periodization strategy for advanced athletes. Ongoing research is needed to enhance our understanding of sequenced training and other advanced periodization strategies.

In contrast to the concurrent approach used in many basic and intermediate programs, sequenced training is a significant departure (i.e., developing various qualities over successive mesocycles such that one potentiates another while minimizing residual fatigue and compatibility problems). Unfortunately, most advocates of this strategy describe it in theoretical terms but offer limited practical guidelines for safe and effective implementation.

In any case, several things are clear: sequenced training strategies are intended for advanced (not novice or intermediate) athletes. The duration of the off-season period must be long enough to deploy a series of blocks, which may not be the case in sports with long competitive seasons. Appropriate ordering can potentiate the effect of one block on the next, whereas inappropriate ordering may have a negative effect. The practitioner needs to understand the principle of dynamic correspondence (i.e., mechanical specificity; 58, 79, 80) as well as the nature of residual/delayed training effects (58, 79–81, 92) in order to make it work. Intensive means and methods should be used with discretion during accumulation periods due to the high work volumes being performed. Likewise, practitioners should limit the duration of these blocks so that an overtraining syndrome does not develop and be attentive to potential signs and symptoms with each passing week (14, 30, 33, 58, 62, 78, 81, 85).

The sequenced training concept arose in an environment without external constraints on training time. The following are some practical suggestions for adapting it to situations where athletes are bound by such restrictions. For example, a 14-

week preseason program can be organized into a series of blocks as follows:

- Accumulation I (3-week duration): 12 strength-power sessions distributed over this period on a 4 d/wk schedule; 6 speed-agility-conditioning sessions distributed on a 2 d/wk schedule.
- Restitution I (4-week duration): 12 strength-power sessions distributed over this period on a 3 d/wk schedule; 12 speed-agility-conditioning sessions distributed on a 3 d/wk schedule.
- Accumulation II (3-week duration): 12 strength-power sessions distributed over this period on a 4 d/wk schedule; 6 speed-agility-conditioning sessions distributed on a 2 d/wk schedule.
- Restitution II (4-week duration): 12 strength-power sessions distributed over this period on a 3 d/wk schedule; 12 speed-agility-conditioning sessions distributed on a 3 d/wk schedule.

In this way, significantly different volume loads can be allocated to respective qualities by manipulating the training density and duration of each phase without changing basic intensity/volume parameters. Even greater contrast might be achieved by further reducing density during the restitution blocks (distributing 8 strength-power sessions over these periods on a 2 d/wk schedule).

Additional tactics would be to adjust the prescribed number of sets per exercise, exercises per session, and/or sessions (modules) per day. Each of these are simple but effective ways to alter the volume loads apportioned to different abilities during particular phases. When evaluating the pros and cons of various options, it is important to consider their practical implications such as compatibility of training session duration and frequency with athletes' other scheduling commitments.

Summary

As is the case with plays comprising a game plan or assets comprising a portfolio, a periodized training program is more than the sum of its parts. Indeed, short-yardage plays can set up long-yardage plays; high-risk investments can improve overall risk/return; and nonspecific training methods can enhance the effects of specific ones. The key is to establish a playbook of fundamentally sound tactics and then skillfully combine them into appropriate strategies. Although relatively simple plans may be effective for novices, more sophisticated training and recovery methods are applicable in intermediate or advanced situations. The practical challenge is to direct adaptation toward specific targets by prescribing a bandwidth of stimuli appropriate for the athlete's sport and developmental status.

Viru (81) summarizes the issue as follows:

> The tasks of training have to be distributed rationally during the whole period of 10–12 years. Training strategy has to determine how to distribute the tasks, taking into account the organisms's development during adolescence. It means that the most favorable periods have to be found for inducing the necessary structural, metabolic, and functional changes. To training strategy also belongs the distribution of various tasks within a year by training periods, and within training periods by meso- and microcycles of training. Carrying out the induction of necessary changes is part of training tactics. Accordingly, the most rational ways for the organizing of training microcycles and training sessions have to be found. And finally the necessary training methods and exercises have to be chosen. (p. 9)

Conclusion

Siff (58) described training program design as an organizational/management problem (pp. 334–343). Stated differently, it is a problem in game theory. The value of this paradigm is that each of us regularly plays interactive games, has acquired some instinctive level of strategic thinking expertise, and can thereby infer some basic principles. Sometimes intuitive strategies are optimal, although our actions are often guided, correctly or otherwise, by emotion and impulse instead of rational decision making. By complementing the exercise/sport science competencies needed to design effective programs, game theory provides a useful conceptual framework that minimizes the problems with trial-and-error program design.

Game theory also offers a perspective beyond the "winning vs. losing" or "war and peace" views of competition. The take-home message for strength and conditioning coaches is to use cooperative program design strategies. Clearly we want to influence, but not defeat, our athletes' adaptive processes. Mix your plays and think win-win.

Finally, there are other opportunities to apply game theory in strength and conditioning practice. Consider the possibilities in skill instruction and acquisition: for example, the contextual interference effect is a well-established motor behavior/learning phenomenon (36, 56, 57, 59, 90) where random and variable practice methods result in short-term performance decrements but improved long-term retention. This is another practical application of game theory with important teaching ramifications for skill-based training programs.

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