© National Strength and Conditioning Association
Volume 26, Number 2, page 56–70

G. Gregory Haff, PhD, CSCS
Column Editor

Roundtable Discussion: Periodization of Training—Part 2

G. Gregory Haff, PhD, CSCS
Human Performance Laboratory, Midwestern State University

summary

The concept of periodization is important for strength and conditioning professionals. This roundtable covers several aspects of periodization strategies.

Question 6: Could you compare and contrast the volume, intensity, and restoration considerations for an off-season, preseason, and in-season phase of training?

Kraemer: With off-season training, you have the luxury of not having any of the major demands of practice and competition. Preseason programs are ideally a type of overreaching (OR) program with the active rest needed right before the rigors of the preseason sport practice. The in-season program depends upon the sport but is related to the need for injury prevention, recovery from the sport practice, and competition and attempts to maintain or create a slow build over the season. Some programs suffer from the drop-off of performance toward the end of a season because of a detraining effect that can be caused by a less-than-optimal off-season program with limited in-season programs as well. Obviously, too many injuries and overtraining (OT) because of mistakes by sport coaches overloading athletes' abilities to recover has a dramatic effect on the world of strength and conditioning. Thus, the strength and conditioning coach must be keenly aware of what is going on in the sport so as to act as a stabilizing force in the conduct of the macrocycle, including the competition phases.

O'Bryant: This would depend on the specifics of the sport and if the person were an individual- or multi-sport athlete. Typically, off-season training would include active rest and some general preparation (GP), usually emphasizing higher volume training to promote muscular fitness with improved short-term endurance and work capacity. A complete off-season periodized cycle may be the most important component to athletic success. Preseason may include more special preparation (SP) with exercise that is more specific to the sport with less volume and higher training intensity to promote muscular strength and power (specific to strength-power athlete). In-season training will vary a great deal depending on the demands and competitive strategy of the sport (see response to question 7). The in-season competition phase will require maintenance of physiological fitness with careful management of overall exercise volume and intensity to avoid OT and injury, greater stability of performance technique, and general emphasis on speed and power (specific to strength-power athlete).

Pendlay: The off-season encompasses the transition and preparatory phases of training. During the transition phase, the intensity and volume of work is low, and the emphasis is on rest and recuperation while maintaining general conditioning with alternate training means.

During the preparatory period, volume and intensity both rise. Volume of training is at its peak in this period. The emphasis is on raising the physical capacities of the body, for example, increasing strength and speed. The competitive period encompasses both the preseason and the in-season phases of training. At the beginning of the competitive period, the intensity of training will rise, whereas the volume will fall. The emphasis is on the specific skills needed by the athlete in competition and utilizing the increased physical abilities gained during the preparatory period to further perfect these skills. Immediately before the main competition in sports like weightlifting, or during the competitive season in sports like football and basketball, the intensity and volume both will decrease to allow for recovery before competition and between competitions.

Plisk: Generally speaking, the most aggressive periodization strategies can be implemented during the off season. The types of volume-load variations discussed in question 2 are appropriate at this time.

For sports with a preseason "camp" involving consecutive weeks of multiple daily practices, this period can be viewed as a special mesocycle where the volume load of strength training and other supplemental activities should be temporarily reduced to maintenance and restitution levels. This period also has important long-term scheduling implications, especially when using summated or sequenced training strategies during the off season. These should be planned such that athletes are not fatigued from the final preseason mesocycle.

In-season programs present a number of challenges. The length of the season varies from 3 to 4 months for some sports and up to 6 months or more for others (winter sports such as basketball and hockey tend to be at the high end of the spectrum). This creates a dual problem: It abbreviates the off-season preparation period, making it more difficult to achieve long-term gains in fitness, and creates a very long in-season period, during which the practitioner must be very creative with his or her programming strategies. Moreover, the available tactics are already somewhat limited from the standpoint that "accumulation" methods or extensive volume loads would not be appropriate in season. The practitioner should carefully plan his or her means and methods of variation to avoid monotony. And, of course, almost every athlete competing at a high level can expect to deal with injuries. In my experience, in-season injury is a matter of degree or frequency rather than whether it will happen. It is imperative to have a coordinated plan with the sports medicine team in order to ensure that the athlete returns to both competition and training progressively, without sacrificing the latter. That sounds simple enough, but usually it is not.

I am not qualified to address the issue of restoration strategies, especially regarding therapeutic and regenerative techniques. In terms of program design, however, a variety of training and recovery tactics can be implemented during all phases. Because 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 at multiple levels:

- **Macrocycle.** Active rest and transition periods after competitive periods.
- **Mesocycle.** Restitution microcycles after OR microcycles, concentrated blocks, or stressful competitions.
- **Microcycle.** Maintenance and restitution workloads or recovery days, daily training routines distributed into modules separated by recovery breaks, and additional intrasession relief breaks (e.g., rather than use 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).

Stone: This question cannot be accurately or precisely answered without knowing for what sport training is being planned, how long each phase lasts, and whether this would be for a sport requiring every game or match to be won. However, in general, the off season deals with GP and perhaps SP, preseason typically deals with SP, and the season deals with the competition phase. For many sports, a reasonable maintenance program should be developed for the competition phase. For typical high school and collegiate team sports such as American football, basketball, volleyball, etc, peaking should be avoided.

Thus, off-season programs would have a relatively high volume of training with training volume decreasing through the preseason and into the season. Restoration again depends upon proper variation at all levels but particularly from day to day. This concept is not easily applied to many high school students (and some college athletes) who are multisport athletes and have one season blending into another. In this context, multi-sport athletes in junior and senior high school may never have a chance to develop as athletes because they never really go through regular preparation phases.

Question 7: Considering question 5, what would be the cycle considerations to peak for major competitions? How do you deal with program planning with sports that require multiple competitions in the same week of training or require a high level of performance on a regular basis?

Kraemer: Here is where the science of strength and conditioning must be

Table 1
Example Nonlinear Tennis-Specific Training Program for College Women's Tennis Program with a Nonlinear 3-Day Loading Approach in Previously Nonresistance-Trained Players (17)

	Program		
Monday	**4 to 6RM training loads**		
	Set 1	**Set 2**	**Set 3**
Leg press			
Bench press			
Unilateral leg curl			
Shoulder press			
Seated cable row			
Calf raise			optional
Latissimus pull-down			optional
Dumbbell lateral raise			optional
Lumbar extension			optional
Dumbbell internal rotation			optional
Dumbbell external rotation			optional
Abdominal crunch			optional
Wednesday	**8 to 10RM training loads**		
	Set 1	**Set 2**	**Set 3**
Split squat			optional
Close-grip bench press			optional
Unilateral leg curl			
Shoulder press			
Seated cable row			
Calf raise			optional
Dumbbell Flyes			optional
Lumbar extension			optional
Dumbbell internal rotation			optional
Dumbbell external rotation			optional
Abdominal crunch			optional
Friday	**12 to 15RM training loads**		
	Set 1	**Set 2**	**Set 3**
Leg press			
Bench press			
Unilateral leg curl			
Shoulder press			
Seated cable row			
Calf raise			optional
Latissimus pull-down			optional
Dumbbell lateral raise			optional
Lumbar extension			optional
Dumbbell internal rotation			optional
Dumbbell external rotation			optional
Abdominal crunch			optional

RM = repetition maximum.

crafted into the art of strength and conditioning and working with the athletes. I am not sure anyone really knows the answer to this question, as any answers must be qualified by a host of different factors that affect an approach. With a multitude of factors affecting an athlete, you must treat each one individually to gain any sensitivity to the issue. Here is a case for optimizing individualization of training programs for each athlete in as much as this is an ultimate utopia in strength and conditioning. This is one of the reasons we have used the nonlinear format, even through a season with multiple competitions. Optimal programming needs the flexibility on a per-athlete/per-sport basis to develop a plan that works for each person. Thus, one can make recommendations as to general structures that are well known, but the key is to individualize the training program over this period of time even more so depending upon the sport, training status, injury status, and the competition schedule and its rigors, along with a keen understanding of the nutritional basis for the program. Then, one must know what are the stresses coming from the sport coach. With multiple competition schedules such as in wrestling or tennis, one can plan to "train through" the competition and actually plan for a peaking phenomenon with a multiple competition sport. However, this must be done on an individual athlete basis, as not all athletes will face the same competition demands over the course of a sport schedule. But the level of the athletes you have will determine if you can use different styles of training, add a training day, etc. How you proceed is based on each athlete and his or her capabilities during the competition schedule. Competition stress is not the same for each athlete and thus needs need to be individually examined in relationship to the strength-and-conditioning program elements programmed. There are no magic secrets or silver bullets but rather keen awareness of all the factors affecting each of your athletes and their capabilities to perform under different conditions and situations.

O'Bryant: This would tend to vary from sport to sport depending on the specific requirements and nature of the sport (length of the competitive season, importance of each competition, etc). Usually a maintenance program with low-moderate volume and moderate-high intensity is appropriate. Both training volume and intensity can be micromanaged from day to day and week to week to achieve smaller performance peaks for specific competitions that are considered more important (i.e., microcycling with higher training intensity at the beginning to middle of the week with lessened intensity immediately before an important weekend football game). However, for other sports (track, weightlifting, etc) the season will culminate with a final championship. In this case, a single performance may be more important and can be better achieved with greater emphasis on mesocycle programming and thus training through other lesser important competitions throughout the season to achieve a greater overall performance peak at seasons end.

Pendlay: The cycle considerations should be the same whether you plan on using a program that is or is not linear within the time frame you have to prepare for the competition. Sports, such as basketball, that demand an athlete compete several times across an extended timeframe do not allow a traditional peaking procedure. To ensure the athlete does not lose the influence of the off-season training by the end of the season, some preparatory training must be incorporated into the preseason. During the season, the strength coach's goal should be to preserve as much of the players' physical capacities gained during the off season as possible while not interfering with the readiness of the players to play the game with skill and without fatigue. In application, this might include such practices as doing more repetitions in some exercises during some training sessions in the preseason than would be done with a sport such as weightlifting. During the season, any stressful strength training should be weighted toward the time of the week that gives maximum recuperation before the next game, such as having the main lifting session of the week on Monday if games are played on Saturday. A coach might also plan for more stressful strength training sessions during an off week if one is available.

Plisk: It is advisable to plan one's in-season program to include taper and restitution strategies before major competitions whenever possible. This is pretty straightforward in many situations (e.g., when approaching a major tournament or playoff). As any season unfolds, however, there are usually regular-season games that can take on extra significance depending on how things shake out. And so very often the strength-and-conditioning staff and team coach may agree to modify the training program before those competitions as well. If, for some reason, no such competitions occur for several months, it is probably a good idea to stick with the ~4-week mesocycle guideline mentioned in question 2.

It is common in many sports to have multiple competitions per week. If these are on a set schedule (e.g., Wednesday and Saturday), the problem is pretty simple

Table 2
Active Rest for a High School Track Athlete (O'Bryant)

Active rest
• Duration ~ 5 weeks (from late July through August)
• Exercise (recreational level basketball, volleyball, etc)

Table 3
Off-Season Program for a High School Track Athlete (O'Bryant)

Off season	• Duration ~15 weeks (September 1 and runs through third week in December) • Exercise (weight training September 1 to second week in November) • 3 days per week (i.e., Monday, Wednesday, and Friday) • Recommend repetitions and sets are for "core exercises" only				
Phase I	**Early preparation**				
Month	**Exercises**	**Week 1**	**Week 2**	**Week 3**	**Week 4**
September	Core: PS, CPF, SBP Assistance: SS, SC, BH, RAC	3 × 10	3 × 10	4 × 10	4 × 10
October	Core: PS, CPF, SBP Assistance: SS, SC, BH, RAC	3 × 5	5 × 10RM	5 × 10RM	3 × 5RM
November	Core: PS, CPF, SBP Assistance: SS, SC, BH, RAC	1 × 10 light 1 × 5 moderate 1 × 2 heavy			
Phase II	**Specific preparation (introduction of plyometrics with CPH, LJ, and DBJ)**				
Month	**Exercises**	**Week 1**	**Week 2**	**Week 3**	**Week 4**
November	Core: PS, CPH, IBP Assistance: SS, SC, GHR, FAC, DBJ		5 × 10RM	3 × 5RM	1 × 10 light 1 × 5 moderate
	Core: PS, CPH, IBP Assistance: SS, SC, GHR, FAC, DBJ, LJ	5 × 10RM	3 × 5RM	1 × 10 light 1 × 5 moderate 1 × 2 heavy 1 × 10 (light/fast)	1 × 2 heavy
Holiday break	**Christmas through New Year's Day**				

PS = parallel squat, CPF = clean pull from floor, SBP = supine bench press, SS = shoulder shrugs, SC = sit-ups/crunches, BH = back hyperextensions, RAC = reverse arm curls, RM = repetition maximum, CPH = clean pull from hang, LJ = lunge jumps, DBJ = dumbbell jumps, IBP = incline bench press, GHR = glut-ham raise, FAC = forward arm curls.

and can be addressed with a basic "heavy/light" day system 2 days per week. If these are not on a set schedule, however (or if a previously postponed competition is being included later in the season), the practitioner may need to combine this approach with some creative scheduling adjustments or other concessions. This can usually be achieved through simple modifications in content or workload.

Stone: If the frequent multiple competitions are very important and are supposed to be won, then a maintenance program (strength and power training) is appropriate. A maintenance program depends upon the sport. Generally, a maintenance program can be carried out 2 days per week with low to moderate volumes and high to moderate intensities; the details (sets, repetitions, exercises) would depend upon the sport. However, for sports in which not every competition is crucial and a high level of performance is periodically necessary, then peaking is not out of the question and neither is training through some competitions.

Question 8: Are there basic strength and conditioning requirements before a formal periodization program is initiated?

Kraemer: If the athlete is of very low physical condition, extremely overweight, or has no background in resistance training, a "GP phase" or "base program" of about 6 to 8 weeks may be needed to provide a suitable adaptive period to resistance exercise. But because light phases or loading days can be used at the onset of any periodized training program, this may be needed only in very specific cases because periodized training theory is conducive to almost all levels of starting fitness. We have started with well-supervised training programs essentially by using untrained subjects of all ages with little or no training background and have been able to proceed in a normal fashion with the basic concepts of progression in a periodized format (1, 11, 14, 15, 17, 22, 30). The biggest mistake is too much too soon, leading to acute overuse injury or soreness.

O'Bryant: Careful assessment can provide the necessary information before beginning any exercise program. For the novice in poor condition, more GP may be required with several weeks of low-intensity, lower volume work with a strong emphasis on correct exercise technique. More gradual increases in volume and intensity may be required for those who are exceptionally weak.

Trained athletes using improper conditioning methods and who are chronically fatigued or overtrained will need a normalization period with adequate rest and recovery before beginning a formal periodized program.

Pendlay: A beginner will gain strength and skill on almost any program, but for skill acquisition, there is for almost any skill a level of effort, repetition range, and length of workout that will lead to optimal improvement and a minimum of frustration for the athlete. A periodized program for a beginner will undoubtedly force him or her to spend a good portion of training time outside these optimal ranges. A beginner's ability level and tolerance to workload are also changing so quickly as to make long-term planning at this stage almost impossible. For these reasons, I believe that when a person is introduced to a new sport or new set of skills, the coach should focus on teaching the skills with a training load based on what is appropriate to learning the skills. As the athlete's skill becomes solidified, and his or her strength and work capacity settle down to incremental increases instead of large jumps or unpredictable swings, the athlete will begin to need more variation of workload to provide the impetus for further progress. It is at this point that a coach should begin a periodized program.

Plisk: As long as the practitioner uses a sound strategy with a view toward long-term development, an athlete's training can be periodized to some degree right from its inception. The issues are (a) whether the athlete is willing to make a commitment to training and (b) how basic or sophisticated the coach's training strategies and tactics are. There is no reason why a periodized approach cannot be applied with novice athletes if the coach is teaching appropriate movement skills, prescribing workloads within reasonable bandwidths, and making prudent adjustments according to the athletes' progress.

Stone: Not sure what formal means? Obviously the athlete must know how to perform the exercises; however, this can be built into a "periodized" program. GP

Table 4
Preseason Program for a High School Track Athlete (O'Bryant)

Preseason	• Duration ~10 weeks (from second week in January to second week in March) • 3 days per week (Monday, Wednesday, and Friday) • Introduce higher level plyometrics (DJH, DJC, LS, JS, SBJ, and SLB) • Recommend repetitions and sets are for "core exercises" only				
Month	**Exercises**	**Week 1**	**Week 2**	**Week 3**	**Week 4**
January	Core: PS, CPH, IBP Assistance: SS, SC, GHR, FAC, DJC, LJ, LS, SLB		4 × 10RM	1 × 10 light 3 × 5RM	1 × 10 light 1 × 5 moderate 1 × 2 heavy 1 × 10 (light/fast)
February	Core: PS, CPH, IBP Assistance: SS, SC, GHR, FAC, DJC, LJ, LS, SLB	1 × 10 light 3 × 10RM	1 × 10 light 3 × 10RM	1 × 10 light 1 × 5 moderate 1 × 2 heavy 1 × 10 (light/fast)	
	Core: PS, CPH, IBP Assistance: SS, SC, GHR, FAC, DJC, LJ, JS, SLB, SBJ				1 × 10 light 1 × 10RM
March	Core: PS, CPH, IBP Assistance: SS, SC, GHR, FAC, DJC, LJ, JS, SLB, SBJ	1 × 10 light 3 × 5RM	1 × 10 light 1 × 5 moderate 1 × 2 heavy 1 × 10 (light/fast)		

Note: Track and field practice begins the second week in February, including general conditioning and basic high-jump skills. DJH = dumbbell jump hop, DJC = dumbbell jump complex, LS = lunge squat, JS = jump squat, SBJ = Single leg box jumps, SLB = Single leg bounds, PS = parallel squat, CPH = clean pull from hang, IBP = incline bench press, SS = shoulder shrugs, SC = sit-ups/crunches, GHR = glut-ham raise, FAC = forward arm curls, LJ = lunge jumps, RM = repetition maximum.

is designed to help the athlete prepare to train. With beginners, part of a GP phase can be used in learning the appropriate exercises. Certainly, periodized training can be tailored for the individual needs of the athlete, whether he or she is a beginner or an advanced athlete. It should be noted that the literature includes many mesocycle-length strength studies with relatively untrained subjects; most of these studies indicate that a periodized program offers advantages. Of my colleagues (working on the periodization models over the years), Kyle Pierce and Ron Byrd (U.S. Weightlifting Development Center, Louisiana State University, Shreveport) consistently work with beginning weightlifters, mostly children. Pierce introduces them to a periodized strength-training program once technique is adequate and has achieved excellent results (1).

When working with beginners through their early development, several mistakes are often made:

- The athlete does not establish good technique early on. Once a basic technique is established, it is very difficult, if not impossible, to change. If basic technique is flawed, then progress is impaired, transfer to other performance activities is reduced, and injury potential is increased. I am constantly amazed at the poor technique displayed by many athletes in the weight room. Whereas hours and hours may be spent perfecting technique in a long jump or gymnastics move, maybe 20 minutes are used to learn a squat, snatch, or clean, then the coach wonders why the strength-training program is not producing the desired result.
- The athlete is not working on basic strength levels early on which may hamper learning basic technique. If the beginner is simply not strong enough to hold key positions, then good technique will not be established. Indeed, beginners, particularly children, may demonstrate adequate technique with a broomstick or light implement, but as soon as the loading is increased (even by small amounts), movement patterns can break down and lead to the establishment of poor technique.
- The athlete continues to emphasize technique after it is too late. Once a basic technique has been established and used for several years, it is extremely difficult to change. For example, weightlifters with flawed technique can (under a coach's guid-

Table 5
In-Season Program for a High School Track Athlete (O'Bryant)

In season	• Duration ~8 weeks (from second week in March to second week in May) • 2 to 3 days per week weight training, with higher training intensities at the beginning to middle week with low intensities toward the end of the week • 1 to 2 competitions per week (more important competitions on Saturdays) • Taper plyometrics to minimal levels required only for the maintenance of the neurological benefit • Recommended repetitions and sets are for the "core" exercises only

Month	Exercises	Week 1	Week 2	Week 3	Week 4
March	Core: PS, CPH, IBP Assistance: SS, SC, GHR, FAC, LJ, SBJ			1 × 10 light 1 × 5RM	1 × 10 light 1 × 5 moderate 1× 2 heavy 1 × 10 (light/fast)
April	Core: PS, CPH, IBP Assistance: SS, SC, GHR, FAC, LJ, SBJ	1 × 10 light 1 × 5RM	1 × 10 light 1 × moderate 1 × 2 heavy 1 × 10 (light/fast)		
	Core: QS, CPH, IBP Assistance: SS, SC, GHR, FAC, LJ, SBJ			1 × 10 light 1 × 5RM	1 × 10 light 1 × 5 moderate 1× 2 heavy 1 × 10 (light/fast)
May	Core: QS, CPH, IBP Assistance: SS, SC, GHR, FAC, LJ, SBJ	1 × 10 light 1 × 5 moderate 1 × heavy 1 × 10 (light/fast)	Rest before end-of-season championships		

PS = parallel squat, CPH = clean pull from hang, IPB = incline bench press, SS = shoulder shrugs, SC = sit-ups/crunches, GHR = glut-ham raise, FAC = forward arm curls, LJ = lunge jumps, SBJ = Single leg box jumps, RM = repetition maximum, QS = quarter squat.

Table 6
Table of Abbreviations for High School Track Training Program (O'Bryant)

Core Exercise Codes			Assistance Exercise Codes		
Exercise	**Variation**	**Abbreviation**	**Exercise**	**Variation**	**Abbreviation**
Squat	Parallel	PS	Shoulder shrugs		SS
	Quarter	QS	Sit-ups/crunches		SC
	Lunge	LS	Back hyperextensions		BH
	Jump	JS	Glut-ham raise		GHR
			Arm curls	Forward	FAC
Clean pulls	From floor	CPF		Reverse	RAC
	From hang	CPH	Parallel dips		PBD
Bench press	Supine Incline	SBP IBP	Dumbbell jumps	3 × 5 regular 3 × 5 from hop 3 × 5 from hop (complex)	DBJ DJH DJC
			Lunge jumps		LJ
			Box jumps	Single leg	SBJ
			Bounds	Single leg	SLB

ance) make significant changes in technique during training with submaximal weights; however, under stress such as in a meet situation they typically revert to their older, more firmly established technique. Furthermore, no one is able to produce perfect technique every time. Thus, when dealing with advanced athletes, it may be more productive to emphasize other attributes in training (i.e., strength, power, rate of force development, etc) within a periodized context. Enhancement of these attributes will allow a greater performance within the parameters of an established technique.

Question 9: What are the basic adjustments that may need to be made to account for the age of the athlete?

Kraemer: According to the many position stands with young athletes, programs have to increase only the repetition ranges for the young athletes, with 6 repetition maximum (RM) being the starting point for heavy lifting in the prepubescent athlete. With the older athletes, it is important to cycle less frequent heavy days and guard against squeezing each repetition out or going to failure in too many sets, as this increases joint compression stress and promotes the occurrence of injuries. But here again, solid resistance-training practices and principles along with periodization progressions require little attenuation for aging if target goals, physiological status, and a comprehensive needs analysis is performed when designing a resistance-training program for younger or older athletes. The concepts are the same, but the attainable target goals, implementation, and progression may well differ.

O'Bryant: Physiological and psychological readiness should be considered as with any exercise program at any age. The young athlete usually needs more GP (as in response to previous question 8) with a greater emphasis on high-volume, low-intensity training. Advanced athletes may be physiologically ready to train at high initial volumes and intensities but will likely need more careful monitoring and greater variation (microcycling, etc) in order to avoid OT. Older populations (>40 years of age) may require more recovery time and general reductions in volume or intensity to reduce the potential for injury (4).

Pendlay: When dealing with athletes below the age of 15 or 16, the program must accommodate the mental maturity level of the athlete. Children younger than this often do not have the psychological tools to endure lengthy or monotonous workouts. Workouts should be short and include several different types of training, and psychological tools such as games or contests should be used whenever possible. As athletes pass into their 30s, recovery can be lengthened, especially after high-intensity

Table 7
Fourteen-Week Summer Program: Blocks 1 and 3 (Plisk)

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
	Strength & power 1	Strength & power 2 Speed & agility 1		Strength & power 3	Strength & power 4 Speed & agility 2	
	Strength & power 5	Strength & power 6 Speed & agility 3		Strength & power 7	Strength & power 8 Speed & agility 4	
	Strength & power 9 Speed & agility 5	Strength & power 10		Strength & power 11	Strength & power 12 Speed & agility 6	

Twelve strength-power sessions are distributed over 3 weeks on a 4-day/week schedule. Volume load progresses from low/moderate during sessions 1 to 4, moderate/high during sessions 5 to 8, high/very high during sessions 9 to 12. The first 2 sessions at each level are heavier workloads; the latter 2 are more explosive. Six speed-agility sessions are distributed over the same period on a 2-day/week schedule (these are scheduled on days when strength-power emphasis is primarily on upper-body movements).

training. Older athletes need more variability in their training to stimulate progress and avoid OT. Although these guidelines concerning chronological age have some value, the training age of the athlete is probably more important to program design. Periodization in training includes both the variation of overall training stress and the periodization of biomotor abilities (1). In general, the need for variability of both training stress and biomotor abilities increases with the time the athlete spends in a sport. A beginner needs very little variation to learn the basic skills of a sport and to raise the basic physiological variables such as strength, power, and work capacity from their untrained levels. At some point, usually well within the first year of training, increased variability is needed to stimulate further progress. The intermediate athlete will still be able to increase his or her abilities at average intensities and workloads, which will not quickly lead to OT, so the variability of overall training stress can still be less than that of a veteran athlete. The need for periodization of biomotor abilities is not as great as it will be later in the athletic career, as the workload needed to increase 1 ability is not so great that several abilities cannot be trained with sufficient intensity and volume to be improved at the same time. As the athlete matures and moves toward his or her limits, the training stress needed to improve any specific physical ability increases to the point that it is difficult to train more than 1 ability at a time sufficiently to elicit an improvement, necessitating more distinct periodization of biomotor abilities. Further, the training stress needed to improve any specific biomotor ability is quite large and likely to elicit OT if applied steadily for any length of time, necessitating a greater variation of overall training stress.

Plisk: I will expand on the analogies offered in response 2 by stating that we could probably do a better job as a profession of addressing the issue of specificity regarding age. Specificity exists on several fronts, including biomechanical, coordinative, and energetic. Each of these is a useful criterion for selecting and prioritizing training tasks. The relative emphasis placed on different means and methods should be determined in part by the athlete's developmental status, especially regarding "critical" or "sensitive" periods. The evidence seems to indicate that preadolescence is the optimal window for enhancing coordinative abilities. Although these are still trainable to an extent during and after adolescence, training should shift toward a greater emphasis on strength and power improvement upon reaching puberty. This issue has fundamental implications in all aspects of program planning but receives little attention in the West.

Stone: For young athletes, much more time needs to be spent in GP. This is a major problem in sports in most western countries, particularly the United States. For example, the beginning age in women's gymnastics is often quite young (6 to 11 years). Up until about 15 years ago, women's gymnastics in the United States did little in the way of GP or periodized programming. Most of their training consisted of performing gymnastic routines and perfecting technique; part of the reasoning behind this was the misconception that the Eastern Europeans trained this way. This type of training often led to burnout, OT, and

excessive injury rates (2). Changing the gymnasts' approach to training, largely through the efforts of Bill Sands and his colleagues (10, 11), by periodically adding a GP phase and introducing the gymnasts to the periodization concept reduced the incidence of maladaptation and injury. Since then, the United States has consistently placed higher in international competition, likely as a result of altering the training concept.

Question 10: Construct a periodization model for a specific sport of your choice.

Kraemer: This is a tough question because we have studied so many different sport-training programs, and there are so many different ways to apply the periodization concept related to variation. No single model works for everything, but periodized training of different types allowing variation in loading, volume, and rest appears to be more effective than constant programs with little variation. Much more work needs to be done, but here is an example of a simple periodization model to show how easy it can be at the base level of training variation for a sport specific application. Thus, we have recently published a very simple nonlinear training program for college women's tennis that was both effective and affected tennis performance variables. For many reasons, we used a nonlinear, 3-workout rotation random-repeating model over the entire academic year of 9 months, with great quantitative and performance success (17). We utilized different training frequencies during heavy-competition weeks (2). A 3-base workout style cycled with rest, active rest, and recovery phases during the academic year allowed for optimal improvements beyond a constant resistance protocol (2 to 3 sets of 8 to 10RM training zone only) with essentially the same volume of exercise in all the different testing variables except for speed and agility programs, which may require their own supplemental training program beyond the resistance-training program and tennis conditioning. Sets of each exercise were separated by 1.5- to 2-minute rest intervals. Heavier loads (4 to 6RM) required 3-minute rest periods for optimal recovery. An experienced personal trainer supervised all players to ensure that all essential program characteristics were strictly enforced. Most importantly, the trainers in the study were responsible for the progression of training loads. We had demonstrated that direct supervision of resistance training enhances strength performance adaptations via greater and faster training load progression. When a player was capable of performing the required number of repetitions for 3 consecutive sets of a particular exercise, the training load was increased in increments of about 2 to 13 kg, depending on the absolute load being used. Three workouts per week with 1 rest day between sessions were used unless match play allowed only 2 rest days per week. Complete (100%) attendance for all workouts was observed for this study.

Because differences in training volume between the resistance-training program

Table 8
Fourteen-Week Summer Program: Blocks 2 and 4 (Plisk)

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
	Strength & power 1 Speed & agility 1		Strength & power 2 Speed & agility 2		Strength & power 3 Speed & agility 3	
	Strength & power 4 Speed & agility 4		Strength & power 5 Speed & agility 5		Strength & power 6 Speed & agility 6	
	Strength & power 7 Speed & agility 7		Strength & power 8 Speed & agility 8		Strength & power 9 Speed & agility 9	
	Strength & power 10 Speed & agility 10		Strength & power 11 Speed & agility 11		Strength & power 12 Speed & agility 12	

Twelve strength-power sessions are distributed over 4 weeks on a 3-day/week schedule. Volume load progresses from low/moderate during sessions 1 to 4, moderate/high during sessions 5 to 8, high/very high during sessions 9 to 12. The first 2 sessions at each level are heavier workloads; the latter 2 are more explosive. Twelve speed-agility sessions are distributed over the same period on a 3-day/week schedule (shorter running distances and grater recovery times are used on days when the strength-power emphasis is primarily on lower-body movements; whereas overload/overspeed and longer distances are used on days when the emphasis is on the upper body).

designs have been proposed to influence maximal strength performance adaptations, the total number of sets multiplied by repetitions per week was equated between training groups so that this periodized training had essentially the same volume as the constant resistance-training group in this study. Thus, the major difference between the 2 programs was that the periodized group rotated loading schemes (4 to 6RM with longer rest intervals, 8 to 10RM, and 12 to 15RM) over successive workouts on Monday, Wednesday, and Friday, respectively, whereas the other nonvariation or constant resistance group utilized a traditional moderate-intensity loading scheme (8 to 10RM) where the relative intensity remained constant. Thus, this model of a nonlinear periodization is one of many we study but gives an example of using such variation in training competitive women tennis players. My laboratory is dedicated to studying all types of periodization models, and we have used both the linear and nonlinear methods to gain greater data into the training adaptations and advantages that may exist from this training theory, which appears to be very effective in strict laboratory and field study as well. The concept of variation and rest in the periodization theory appears paramount to its underlying success as a training theory in present day applications. See Table 1 for an example training program for a college women's tennis program with a nonlinear 3-day loading approach.

O'Bryant: The following is a "basic" periodized conditioning model for a "novice high school high jumper" where the competitive season begins in mid-March and continues through early May (some high school athletes will continue competition through the summer with club or junior Olympic meets). This may also be used for preparation of other types of jumping (long jump, triple jump, etc) with some slight modifications. See Tables 2 through 6 for the complete training program.

Pendlay: The following is a periodization model for an intermediate weightlifter in the third year of training. The goal of the coach and lifter is to improve the total from 280 kg to the 290- to 300-kg range. The lifter's competitive total is held back by trouble holding his snatches overhead and a maximum jerk that is about 10 kg lower than his best clean. The lifter's pulling strength and leg strength are adequate to complete heavier lifts, but his pull in the clean is especially strong, as he can pull to his shoulders a weight about 5 kg above what he can rise with. The goal of the program is to devote little time to pulling strength, devote a moderate amount of time to increasing leg strength, and focus on the jerk and holding weights overhead in the snatch. The program will be 12 weeks in length and begin after a 1-week break from lifting after a previous competition. Four training days are included in each week.

Weeks 1 to 4
Day 1: Snatch + 3 overhead squats
Clean + 3 jerks
Front-squat triples
Day 2: Hang-snatch doubles
Push-presses, 5 repetitions
Day 3: Back-squat triples
Drop-snatch triples
Push-jerk triples
Day 4: Military press, 8 repetitions
Snatch triples
Front squat, 5 repetitions
Clean doubles

During weeks 1 to 2, 5 or 6 sets with the top weight are performed in each exercise, with the top weight being approxi-

Table 9
Sixteen-Week Summer Program: Blocks 1 and 3 (Plisk)

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
	Strength & power 1	Strength & power 2 Speed & agility 1		Strength & power 3	Strength & power 4 Speed & agility 2	
	Strength & power 5	Strength & power 6 Speed & agility 3		Strength & power 7	Strength & power 8 Speed & agility 4	
	Strength & power 9	Strength & power 10 Speed & agility 5		Strength & power 11	Strength & power 12 Speed & agility 6	
	Restitution 1			Restitution 2		

Twelve strength-power sessions are distributed over 3 weeks on a 4-day/week schedule. Six speed-agility sessions are distributed over the same period on a 2-day/week schedule. Two restitution workloads are conducted during week 4, during which volume load is low.

Table 10
Sixteen-Week Summer Program: Blocks 2 and 4 (Plisk)

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
	Speed & agility 1	Strength & power 2	Speed & agility 2	Strength & power 2	Speed & agility 3	
	Speed & agility 4	Strength & power 3	Speed & agility 5	Strength & power 4	Speed & agility 6	
	Speed & agility 7	Strength & power 5	Speed & agility 8	Strength & power 6	Speed & agility 9	
	Restitution 1		Restitution 2		Restitution 3	

Six strength-power sessions are distributed over 4 weeks on a 3-day/week schedule. Nine speed-agility sessions are distributed over the same period on a 3-day/week schedule. Three restitution workloads are conducted during week 4, during which volume load is low.

mately 60 and 70% of maximum, respectively. In week 3, the athlete works up to as heavy a weight as he feels is possible for 2 top sets in each exercise. Because pressing or jerking is included in each workout, the athlete is instructed to lower the weight for the push presses or military presses if he feels overstressed in this area. During week 4, intensity is 60% and the number of top sets is 4.

Weeks 5 to 8
Day 1: Snatch + 2 overhead squats
Hang clean + 2 jerks
Front-squat doubles
Day 2: 3-position snatch
2 push presses + 1 jerk
Day 3: Snatch + 2 drop snatches
Overhead supports
Back-squat doubles
Day 4: Military press, 5 repetitions
Hang snatch + snatch
Front-squat triples
Clean doubles

During week 5, the athlete will attempt to work up to a maximum in each exercise for the repetitions listed. During week 6, 4 sets are performed with approximately 75% intensity. During week 7, the athlete will again attempt to work up to a maximum in each exercise for the repetitions listed. During week 8, the athlete will perform 4 sets with 70% intensity.

Weeks 9 and 10
Day 1: Day 1: Snatch + 2 overhead squats
Clean and jerk singles
Front-squat doubles
Day 2: Snatch doubles
Push-jerk doubles
Day 3: Hang-snatch doubles
Clean + 2 jerks
Back-squat doubles
Day 4: Snatch singles
Front-squat doubles
Military-press doubles

During week 9, all squatting exercises are performed by working up to a top set of 90 to 95%, all other exercises are performed by working up to a top set of 80 to 85%. During week 10, the athlete performs all squatting exercises up to a set of 80 to 85%, the snatch and clean and jerk singles to 100% intensity, and all other exercises to approximately 90% intensity.

Week 11
Day 1: Snatch singles
Clean and jerk singles
Front-squat singles
Day 2: Hang-snatch doubles
Push-jerk singles
Day 3: Snatch doubles
Clean and jerk doubles
Front-squat doubles
Day 4: Snatch singles
Clean and jerk singles

During week 11, day 1 is 95% intensity, day 2 is 80 to 85% intensity, day 3 is 70 to 75% intensity, and day 4 is 90% intensity. All exercises are performed by working up to 1 top set with the exception of squats, which use 2 top sets.

Week 12
Day 1: Snatch singles
Clean and jerk singles
Front-squat singles
Day 2: Snatch singles
Clean and jerk singles
Front-squat singles
Day 3: Snatch singles
Jerk singles
Day 4: Contest day

On day 1, the snatch is done to maximum, the clean and jerk is done to the athlete's estimated opening attempt, and the front squat is done to the athlete's maximal clean and jerk. On day 2, the snatch is done to the athlete's estimated opener, the clean and jerk is done to 80% of the athlete's estimated opener, and the front squat is done with the same weight as the clean and jerk. On day 3, several snatches and jerks are done with around 50% of the athlete's maximum. It is assumed that the athlete

will train Monday, Wednesday, and Thursday of this week, and the contest will be on Saturday.

Plisk: Rather than take a page out of the cookbook, I will offer a general template that combines elements of summated and sequenced training strategies (Tables 7 and 8). This model has been used successfully as a 14-week summer program for collegiate football. Specific workload assignments are not itemized, and it does not include some of the developmental adjustments that were made as athletes progressed from their first to fourth year of the program.

- Blocks 1 and 3 are each 3 weeks in duration, comprising weeks 1 to 3 and 5 to 8 of the program. Twelve strength-power sessions are distributed over 3 weeks on a 4-day/week schedule, whereas 6 speed-agility sessions are distributed over the same period on a 2-day/week schedule.
- Blocks 2 and 4 are each 4 weeks in duration, comprising weeks 4 to 7 and 11 to 14 of the program. Twelve strength-power sessions are distributed over 4 weeks on a 3-day/week schedule (effectively reducing weekly volume load by about one third compared with the previous block), and 12 speed-agility sessions are distributed over the same period on a 3-day/week 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 and volume parameters. Even greater contrast might be achieved by further reducing training density during blocks 2 and 4 (Tables 9 and 10; also note the inclusion of restitution weeks). The important point is that adjusting the prescribed number of repetitions and sets per exercise, or exercises per session, is not the only effective way to vary volume load. Scheduling variables such as number of sessions per day or week can dramatically affect training stress without necessarily changing other variables. ♦

References

Kraemer

1. Campos G.E., T.J. Luecke, H.K. Wendeln, K. Toma, F.C. Hagerman, T.F. Murray, K.E. Ragg, N.A. Ratamess, W.J. Kraemer, and R.S. Staron. Muscular adaptations in response to three different resistance-training regimens: Specificity of repetition maximum training zones. *Eur. J. Appl. Physio*. 88(1–2):50–60. 2002.
2. DeLorme, T.L., and A.L. Watkins. Techniques of progressive resistance exercise. *Arch. Phys. Med.* 29:263–273. 1948.
3. Fleck, S.J., and W.J. Kraemer. *Periodization Breakthrough.* Ronkonkoma, NY: Advanced Research Press, 1996.
4. Fleck, S.J., and W.J. Kraemer. *Designing Resistance Training Programs* (2nd ed.). Champaign, IL: Human Kinetics Publishers, 1997.
5. Fry, A.C., and W.J. Kraemer. Resistance exercise overtraining and overreaching, *Sports Med.* 23(2):106–129. 1997.
6. Fry, A.C., W.J. Kraemer, J.M. Lynch, N.T. Triplett, and L.P. Koziris. Does short-term near maximal intensity machine resistance training induce overtraining? *J. Strength Cond. Res.* 8(3):188–191. 1994.
7. Fry, A.C., W.J. Kraemer, M.H. Stone, B.J. Warren, S.J. Fleck, J.T. Kearney, and S.E. Gordon. Endocrine responses to over-reaching before and after 1 year of weightlifting training. *Can. J. Appl. Physiol.* 19(4):400–410. 1994.
8. Fry, A.C., W.J. Kraemer, F. van Borselen, J.M. Lynch, J.L. Marsit, E.P. Roy, N.T. Triplett, and H.G. Knuttgen. Performance decrements with high-intensity resistance exercise overtraining. *Med. Sci. Sports Exerc*. 26(9):1165–1173. 1994.
9. Fry, A.C, W.J. Kraemer, F. van Borselen, J.M. Lynch, J.L. Marsit, N.T. Triplett, and L.P. Koziris. Catecholamine responses to short-term, high intensity resistance exercise overtraining. *J. Appl. Physiol.* 77(2):941–946. 1994.
10. Fry, A.C., W.J. Kraemer, C.A. Weseman, B.P. Conroy, S.E. Gordon, J.R. Hoffman, and C. M. Maresh. The effects of an off-season strength and conditioning program on starters and non-starters in women's intercollegiate volleyball. *J. Appl. Sport Sci. Res.* 5(4):174–181. 1991.
11. Häkkinen, K., W.J. Kraemer, A. Pakarinen, T. Triplett-McBride, J.M. McBride, A. Häkkinen, M. Alen, M.R. McGuigan, R. Bronks, and R.U. Newton. Effects of heavy resistance/power training on maximal strength, muscle morphology, and hormonal response patterns in 60- to 75-year-old men and women. *Can. J. Appl. Physiol.* 27(3):213–231. 2002.
12. Hoffman, J.R., W.J. Kraemer, A.C. Fry, M. Deschenes, and M. Kemp. The effects of self-selection for frequency of training in a winter conditioning program for football. *J. Appl. Sport Sci. Res.* 4(3):76–82. 1990.
13. Kraemer, W.J., K. Adams, E. Cafarelli, G.A. Dudley, C. Dooly, M.S. Feigenbaum, S.J. Fleck, B. Franklin, A.C. Fry, J.R. Hoffman, R.U. Newton, J. Potteiger, M.H. Stone, N.A. Ratamess, and T. Triplett-McBride. American College of Sports Medicine. American College of Sports Medicine position stand. Progression models in resistance training for healthy adults. *Med. Sci. Sports Exerc.* 34(2):364–380. 2002.
14. Kraemer, W.J., and S.J. Fleck. *Strength Training for Young Athletes.* Champaign, IL: Human Kinetics Publishers, 1993.
15. Kraemer, W.J., A.C. Fry, P.N. Frykman, B. Conroy, and J. Hoffman. Resistance training and youth. *Pediatr. Exerc. Sci.* 1:336–350. 1989.
16. Kraemer, W.J., and K. Häkkinen. Strength training for sport. In: *International Olympic Committee Handbook in Sports Medicine.* W.J. Kraemer, K. Häkkinen, eds. Oxford, U.K.: Blackwell Scientific Publishers, 2002.

17. Kraemer, W.J., K. Häkkinen, N.T. Triplett-Mcbride, A.C. Fry, L.P. Koziris, N.A. Ratamess, J.E. Bauer, J.S. Volek, T. McConnell, R.U. Newton, S.E. Gordon, D. Cummings, J. Hauth, F. Pullo, J.M. Lynch, S.A. Mazzetti, S.J. Fleck, and H.G. Knuttgen. Physiological changes with periodized resistance training in women tennis players. *Med. Sci. Sports Exerc.*35(1):157–68. 2003.
18. Kraemer, W.J., and R.U. Newton. Training for muscular power. *Phys. Med. Rehabil. Clin. N. Am.* 11(2):341–368, vii. 2000.
19. Kraemer, W.J., and B.A. Nindl. Factors involved with overtraining for strength and power. In: *Overtraining in Athletic Conditioning.* W.J. Kraemer, B.A. Nindl, eds. Champaign, IL: Human Kinetics Publisher, 1998. pp 69–86.
20. Kraemer, W.J., N. Ratamess, A.C. Fry, T. Triplett-McBride, L.P. Koziris, J.A. Bauer, J.M. Lynch, and S.J. Fleck. Influence of resistance training volume and periodization on physiological and performance adaptations in collegiate women tennis players. *Am. J. Sports Med.* 28(5):626–633. 2000.
21. Marx, J.O., N.A. Ratamess, B.C. Nindl, L.A. Gotshalk, J.S. Volek, K. Dohi, J.A. Bush, A.L. Gómez, S.A. Mazzetti, S.J. Fleck, K. Häkkinen, R.U. Newton, and W.J. Kraemer. Low volume circuit versus high volume periodized resistance training in women. *Med. Sci. Sports Exerc.* 33(4): 635–643. 2001.
22. Mateyev, L. *Periodisierang des Sprotichen Training*. Berlin, Germany: Berles and Wernitz, 1972.
23. Medvedyev, A. Serval basics on the methodics of training. *Soviet Sports Rev.* 22(4):203–206. 1988.
24. Newton, R.U., W.J. Kraemer, and K. Häkkinen. Effects of ballistic training on preseason preparation of elite volleyball players. *Med. Sci. Sports Exerc.* 31(2):323–330. 1999.
25. Ratamess, N.A., W.J. Kraemer, J.S. Volek, M.R. Rubin, A.L. Gómez, D.N. French, M.J. Sharman, M.M. McGuigan, T. Scheet, K. Häkkinen, R.U. Newton, and F. Dioguardi. The effects of amino acid supplementation on muscular performance during resistance training overreaching. *J. Strength Cond. Res.* 17(2):250–258. 2003.
26. Selye, H. Forty years of stress research: Principal remaining problems and misconceptions. *Can. Med. Assoc. J.* 115(1):53–56. 1976.
27. Selye, H. A syndrome produced by diverse nocuous agents. 1936. *J. Neuropsychiatry Clin. Neurosci.* 10(2):230–231. 1998.
28. Stone, M.H., H. O'Bryant, and J. Garhammer. A hypothetical model for strength training. *J. Sports Med.* 21:342–351. 1981.
29. Stowers, T., J. McMillan, D. Scala, V. Davis, D. Wilson, and M. Stone. The short term effects of three different strength-power training methods. *Natl. Strength Cond. Assoc. J.* 5(3):24–27. 1983.
30. Volek, J.S., N.D. Duncan, S.A. Mazzetti, R.S. Staron, M. Putukian, A.L. Gomez, D.R. Pearson, W.J. Fink, and W.J. Kraemer. Performance and muscle fiber adaptations to creatine supplementation and heavy resistance training. *Med. Sci. Sports Exerc.* 31(8):1147–1156. 1999.
31. Willoughby, D. The effects of mesocycle-length weight training programs involving periodization and partially equated volumes on upper and lower body strength. *J. Strength Cond. Res.* 7:2–8. 1993.

O'Bryant

1. Pearson, D., A. Faigenbaum, M. Conley, and W.J. Kraemer. The National Strength and Conditioning Association's basic guidelines for the resistance training of athletes. *Strength Cond. J.* 22(4):14–27. 2000.
2. Stone, M.H., and A.C. Fry. Responses to increased resistance training volume. In: *Overtraining and Overreaching in Sport*. R. Kreider, A.L. Fry, M. O'Toole, eds. Champaign, IL: Human Kinetics, 1997.
3. Stone, M.H., R.E. Keith, J.T. Kearney, S.J. Fleck, G.D. Wilson, and N.T. Triplet. Overtraining: A review of the signs, symptoms and possible causes. *J. Appl. Sports Sci. Res.* 5(1):35–50. 1991.
4. Stone, M.H., and H.S. O'Bryant. *Weight Training: A Scientific Approach* (2nd ed.). Minneapolis, MN: Burgess International, 1987.
5. Stone, M.H., H.S. O'Bryant, B.K. Schilling, R.L. Johnson, K.C. Pierce, G.G. Haff, A.J. Koch, and M. Stone. Periodization: Effects of manipulating volume and intensity—Part 2. *Strength Cond. J.* 21(3):54–60. 1999.
6. Stone, M.H., and D. Wathen. Letter to the Editor. *Strength Cond. J.* 23(5):7–9. 2001.

Pendlay

1. Bompa, T. *Periodization: Theory and Methodology of Training.* Toronto: Human Kinetics, 1999
2. Chandler, J. T. Letter to the Editor. *Strength Cond. J.* 14(5):7–9. 2001.
3. Kramer, J.B., M. H. Stone, H. O'Bryant, M.S. Conley, R.L. Johnson, D.C. Nieman, D.R. Honeycutt, and T. P. Hoke. Effects of a single vs. multiple sets of weight training: Impact of volume, intensity, and variation. *J. Strength Cond. Res.* 11(3):143–147. 1997.
4. Poloquin, C. Five steps to increasing the effectiveness of your strength training program. *Strength Cond. J.* 10(3):34–39. 1988.
5. Selye, H. A syndrome produced by diverse nocuous agents. 1936. *J. Neuropsychiatry Clin. Neurosci.* 10(2):230–231. 1998.
6. Stone, M.H., H. O'Bryant, and J. Garhammer. A hypothetical model for strength training. *J. Sports Med.* 21:342–350. 1981.
7. Stowers, T., J. McMillan, D. Scala, V. Davis, D. Wilson, and M. Stone. The short-term effects of three different strength-power training methods. *Natl. Strength Cond. J.* 5(3):24–27. 1983.

Plisk

1. Baker, D., G. Wilson, and R. Carlyon, Periodization: The effect on strength of manipulating volume

and intensity. *J. Strength Cond. Res.* 8(4):235–242. 1994.
2. Poliquin, C. Five steps to increasing the effectiveness of your strength training program. *Natl. Strength Cond. Assoc. J.* 10(3):34–39. 1988.
3. Stone, M.H., and H.S. O'Bryant. Letter to the Editor. *J. Strength Cond. Res.* 9(2):125–127. 1995.
4. Stone, M.H., and D. Wathen. Letter to the Editor. *Natl. Strength Cond. Assoc. J.* 23(5):7–9. 2001.

Stone

1. Byrd, R., K. Pierce, L. Rielly, and J. Brady. Young weightlifters' performance across time. *Sports Biomech.* 2(1):133–140. 2003.
2. Caine, D.J., K.J. Lindner, B.R. Mandelbaum, and W.A. Sands. Gymnastics. In: *Epidemiology of Sports Injuries.* D.J. Caine, C.G. Caine, K.J. Lindner, eds. Champaign, IL: Human Kinetics, 1996. pp. 213–246.
3. Fry, A.C., W.J. Kraemer, M.H. Stone, L.P. Koziris, J.T. Thrush, and S.J. Fleck. Relationships between serum testosterone, cortisol and weightlifting performance. *J. Strength Cond. Res.* 14:338–343. 2000.
4. Fry, R.W., A.R. Morton, and D. Keast. Periodisation of training stress: A review. *Can. J. Sports Sci.* 17:234–240. 1992.
5. Garhammer, J. Periodization of strength training for athletes. *Track Technique.* 73:2398–2399, 1979.
6. Harris, G.R., M.H. Stone, H.S. O'Bryant, C.M. Proulx, and R.L. Johnson. Short-term performance effects of high speed, high force or combined weight training. *J. Strength Cond. Res.* 14: 14–20. 1999.
7. Kramer, J.B., M.H. Stone, H.S. O'Bryant, M.S. Conley, R.L. Johnson, D.C. Nieman, D.R. Honeycutt, and T.P. Hoke. Effects of single versus multiple sets of weight training exercises on body composition and maximum leg and hip strength. *J. Strength Cond. Res.* 11(3):143–147. 1997.
8. Matveyev, L. P. *Fundamentals of Sports Training*. Moscow, Russia: Progress Publishers, 1981.
9. Medvedev, A.S., V.F. Rodionov, V.N. Rogozkin, and A.E. Gulyants. Training content of weightlifters during the preparation period. Yessis, M., trans. *Teoriya I Praktika Fizicheskoi Kultury.* 12:5–7. 1981.
10. Sands, W.A. Olympic preparation camps 2000 physical abilities testing. *Technique*. 20(10):6–19. 2000.
11. Sands, W.A., R.C. Irvin, and J.A. Major. Women's gymnastics: The tie course of fitness acquisition. A 1-year study. *J. Strength Cond. Res.* 9(2): 110–115. 1995.
12. Stone, M.H., and A.C. Fry. Increased training volume in strength\power athletes. In: *Overtraining in Sport.* R.B. Kreider, A.C. Fry, M.L. O'Toole, eds. Champaign, IL: Human Kinetics, 1997. pp. 87–106.
13. Stone, M.H., H. O'Bryant, and J. Garhammer. A hypothetical model for strength training. *J. Sports Med. Phys. Fitness.* 21:342–351. 1981.
14. Stone, M.H., H.S. O'Bryant, K.C. Pierce, G.G. Haff, A.J. Kock, B.K. Schilling, and R.L. Johnson. Periodization: Effects of manipulating volume and intensity–Part 1. *Strength Cond. J.* 21(2):56–62. 1999.
15. Stone, M.H., H.S. O'Bryant, K.C. Pierce, G.G. Haff, A.J. Kock, B.K. Schilling, and R.L. Johnson. Periodization: Effects of manipulating volume and intensity—Part 2. *Strength Cond. J.* 21(3):54–60. 1999.
16. Stone, M.H., and D. Wathen. Letter to the Editor. *Strength Cond. J.* 23(5):7–9. 2001.
17. Verkhoshansky, Y. Principles of planning speed/strength training program in track athletes. *Legaya Athleticka.* 8:8–10. 1979.
18. Verkhoshansky, Y. How to set up a training program in speed-strength events. Yessis, M., trans. *Soviet Sports Rev.* 16:123–126. 1981.
19. Wilson, G., R.U. Newton, A.J. Murphy, and B.J. Humphries. The optimal training load for the development of dynamic athletic performance. *Med. Sci. Sport Exerc.* 25:1279–1286. 1993.
20. Zatsiorsky, V.M. *Science & Practice Of Strength Training.* Champaign, IL: Human Kinetics, 1995.

William J. Kraemer, PhD, is currently a full professor in the Human Performance Laboratory in Department of Kinesiology with a joint appointment as a full professor in the Department of Physiology and Neurobiology at the University of Connecticut, Storrs, CT.

Harold O'Bryant, PhD, is currently the Exercise Science Program Director and also directs the Biomechanics Laboratory at Appalachian State University, Boone, NC.

Glenn Pendlay, MS, is the head coach for the Wichita Falls Weightlifting Team based in Wichita Falls, TX. Glenn has been involved in several research projects looking at the use of hormones to model training programs.

Steven Plisk, MS, CSCS, *D, is the Sports Performance Director at Velocity Sports Performance in Norwalk, CT.

Michael H. Stone, PhD, is currently the Head of Sports Physiology for the USOC. He joined the USOC Sports Science staff in Colorado Springs in January 2002. Previously he was Chair of Sport at Edinburgh University, Edinburgh, Scotland.