Periodization and Programming for Team Sports (Supplement)

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The purpose of this supplemental chapter is to explore further the concept of periodization for team sports. This chapter will highlight advanced concepts relating to the implementation and approach to specific periodization strategies for training sport teams. Training periods and phases within the training year will be identified and discussed. For each training phase, general concerns, issues, and potential challenges will be presented. Strategies for programming mesocycles will be explored for various populations, including sequencing of programming and modifications during the season. Types of microcycle programming throughout the competitive season concludes the periodization programming concepts. Finally, this supplemental chapter will provide additional programming considerations for agility, speed, repeated sprint ability, conditioning, sport skills, and tactical populations.

Application of Periodization and the Role of Sport Science

From youth leagues to elite sport, periodization strategies have been applied by coaches in professional practice for many decades, indicating widespread cultural acceptance (126,127). Various periodization strategies (traditional, block, etc.) have been proposed over the years, ranging widely in recommended structure to meet performance demands (126). In addition, formal guidance has been available to support learning and discussion of periodization and programming for some time, through the NSCA (50) and parallel international organizations. For the sake of brevity, the reader is referred to Haff (51) and Cunanan and colleagues (23) for detailed discussion of terms and clarification surrounding critical concepts of periodization. The discussion in this supplement is focused upon information, strategies, and processes for use by sport science practitioners seeking to optimize performance (and reduce injury risk) in team sport athletes under their care, along with highlighting specific areas of research and practice that warrant further investigation by these individuals. Specific issues of interest at a variety of levels of sport are also discussed that may warrant investigation by sport scientists.

Due to methodological issues with studying athletic populations (selection bias, limited opportunities for control groups, etc.), providing an information base upon which to inform training methods requires comparative and confirmational study with team sport athletes competing at various levels (competitive youth, intermediate, advanced, professional, and elite). This cannot be done well without researcher access to team sports because of the specialized training required (typically skills taught in sport science doctoral programs) to obtain valid and reliable information, analyze it correctly, and report it responsibly. This point highlights two important elements of process and infrastructure: 1) the critical application of research programs within sport organizations, a common discussion within sport science circles, and 2) the necessity to establish formal agreements among coaches, administrators, and scientists within a framework where team problems—and even sport-wide problems—may be solved by applying scientific methods from multiple disciplines over the course of short-term and long-term investigations (4,41,109). Long-term financial support is required to nurture and sustain research programs, and, as highlighted previously in the sport science context by Stone and colleagues (125), many obstacles remain to this day. As a result, the available research base that explores athlete adaptation to training is thin, mired by practical challenges of obtaining information and the time limitations of an athlete's career (40,126).

The above issues bring to the fore the importance of convergence of research and practitioner ideas in the processes of forming training programs, and illuminate the evolution and identity of the sport scientist role as one that supports the coach-athlete relationship (40). Such infrastructure is necessary to optimize training programs and explore fruitful and rational paths that may be adjusted. This infrastructure—which may need to include a larger support staff in team sports compared to individual sports—is referred to in this supplement as the integrated support team (IST) (12,39,122). The IST is constructed and integrated specifically to support the athlete (19,122). A research and development element has also been recommended for inclusion (109) that in some ways may need to operate at a slower pace for certain projects than other operations within the sport organization (22). Coaches and administrators may rely upon this infrastructure to problem-solve, and adjust practice and policy, affecting both periodization and programming.

Periodization Strategies

To overview prior guidance for all levels of competitive sport, the training year is scheduled based upon known competitive events (scheduled games), likely competitive events (playoffs and tournaments), any physically demanding or critical events involved in the team or sport's selection process (e.g., Major League Baseball's spring training), league or governing body limitations on pre-season practice scheduling and team activities, and long-term development objectives (9,48,51). This information provides the frame for the annual plan (macrocycle) and its component phases, constructed of targeted mesocycles and their component microcycles.

Several authors have also recommended construction of multi-year training plans for high school, collegiate, and Olympic athletes (9,48,51,67,69). Though multi-year training plans are long-term in nature, they may be interrupted by the typical coaching cycle or the nature of professional sport. When coaches are replaced or management decisions are implemented, resulting changes in organizational goals may affect the individual athlete (e.g., athlete role changes, traded to another team, etc.). Nonetheless, the practice of long-term planning (periodization) over periods of at least a year remains an optimal strategy to guide programming, and has been executed with apparent success for decades in various sports (46,104,127). As such, the reader is recommended to review the well-structured planning process provided by Haff and Haff (see Table 1) for use in constructing their own plan.

Table 1. Basic Steps in the Planning Process

Step	Objective
1	a. Determine the athlete's long-term goals in order to develop a multiyear plan. Typically, this is accomplished with a quadrennial plan. b. Outline the basic structure for the multiyear plan.
2	a. Prioritize the major objectives to be targeted by the annual training plan. b. Evaluate the previous year's training plan, including competitive and performance results, and consult with the athlete or team about the training plan. c. Create a working structure for the next annual training plan based upon the competitive requirements of the team. d. Determine the number of macrocycles contained in the annual training plan. e. Establish the macrocycle lengths in the context of the structure established for the annual training plan.
3	a. Break the annual training plan into preparatory, competitive, and transitional phases based upon the schedule of the athlete or team. b. Divide the preparatory phases into general and specific subdivisions. c. Create precompetitive and main competitive phases within the competitive phase of the annual training plan. d. Insert testing days into the annual training plan at key time points.
4	a. Determine the lengths of the individual mesocycles. b. Select and sequence the various structures of the mesocycles into the annual plan. c. Prioritize the focus of the training factors for each mesocycle, considering how the factors are sequenced across each phase of training in the annual plan.

	d. Establish the loading patterns in each mesocycle and determine how loading will progress across the macrocycles in the annual plan.
5	a. Construct each microcycle. b. Divide the microcycle into training and recovery days according to the athlete's level of development and overall goals. c. Establish which factors will be trained on each training day and how many training sessions will be contained during each day. d. Create loading structures used throughout the microcycle.
6	a. Design the individual training sessions. b. Determine the loading structures for the training session. c. Select the activities for the training plan.
7	a. Implement the training plan. b. Continually monitor and evaluate the training plan and process.

(48)

As noted repeatedly by Haff (51) and others (23,61,127), the periodization framework is not rigid, but is instead informed by the monitoring program. Individual or team-wide workload adjustments may be warranted at times due to various reasons, such as athlete fatigue (23) related to training or actual playing time, or unexpected challenges, such as an upcoming match against a surprisingly high-performing opponent (74). This highlights the importance of the monitoring program, which informs the programming process (including recovery strategies) alongside careful discussion and coordination with sport coaches and other elements of the IST (11,110). Further, this process requires the involvement of individual employees who are appropriately trained to quantify and account for reliability and validity issues (measurement error, etc.) and identify meaningful change (47), and also capable of using specific tools appropriately —in that they possess sufficient knowledge and experience with similar tools or are at least able to obtain knowledge and experience within that setting while keeping testing results in the appropriate context.

One example of a common monitoring tool that can be poorly applied is countermovement jump (CMJ) testing. Use of jump height alone, for example, may be considered an incomplete practice because an athlete may be able to maintain jump height by modifying technique (e.g., increasing time to take-off and countermovement displacement). This reduces the tool's sensitivity to changes in athlete status. Another excellent example from CMJ testing is in bilateral asymmetry force comparisons. Asymmetry may vary between trials and days, and must be kept in the appropriate context. For a monitoring program to provide sufficient detail to inform the training process, selection of variables to monitor is shaped by critical discussion and informed by extant literature, training, and experience with the tool. Appropriate background work is an essential process for the IST to complete before they decide to implement any monitoring tool.

The nature of competitive team sports includes the goal of winning as many games as possible during the season to earn a place and advance in post-season play (51). In addition, practitioners may be challenged to actually bring the athletes to a physiological peak due to the brief duration (up to 2-3 weeks) of the phenomenon as it may be observed in individual sport athletes (9,126). As a result, team needs (roster-based, technical, tactical, etc.) may outweigh optimal programming for the individual athlete at times, as a balance is struck between available resources and ability to implement selected training strategies in the pursuit of achieving team performance goals across the competitive season. However, the impact of a certain amount of accumulated fatigue must be accounted for in programming activity. Sport science practitioners are thus charged with the responsibility of evaluating fatigue and its contributing variables, and helping athletes and coaches manage training over the course of the training year in order to maximize individual player availability and performance. It should be noted that fatigue—as an underpinning concept within training theory (23)—is a regular byproduct of training; sources may be complex and multiple. Therefore, fatigue should not be considered by the practitioner as unconditionally and explicitly "bad;" instead, fatigue is viewed as a phenomenon that assists in driving adaptation. As such, fatigue may accumulate at certain times as a deliberate consequence of programming included within the periodized training plan, designed to achieve team performance goals, just as fatigue is sought to be minimized at times where optimal readiness is desired.

While several authors have previously discussed periodization strategies for team sports (9,44,48,127), most of the available comparative studies involve evaluation of performance responses and adaptations to resistance training programs with minimal evaluation of the collective effects of other factors (sleep, motivation, nutrition, etc.) upon recovery-adaptation (79,87). In fairness to researchers, many variables are difficult or cumbersome to control or monitor (e.g., nutrition, energy expenditure), particularly in ecologically valid settings (in situ). Further, many variables are arguably subjective (e.g., motivation), introducing possible measurement error. Unfortunately, little long-term detailed observation has occurred in team sports for other important elements of performance such as agility and speed, for example. Part of this is due to the aforementioned access obstacles for sport scientists seeking to employ research programs, but also worthy of mention is that often ecologically valid observation of performance is context-specific and can be resource-intensive, making thorough study difficult. For the sport scientist, some amount of experience in the sport may be necessary in order to problem-solve in this manner; to identify and investigate specific performance issues efficiently may require sport-specific technical and tactical knowledge, which may, in turn, be necessary to deliver quality information for the team coaches or the coaching community at large. Further, building relationships with a coaching staff takes time, and value must both be consistently sought by the sport coach and demonstrated by the practitioner and/or researcher in order to sustain effective working relationships. This issue is typically revisited whenever a coaching staff is replaced.

Periodization concepts of preparatory, competitive, and transition periods should be applied to the training year to organize training (51,124). Each period has distinct goals that are based upon the present status of the athlete and the process the IST needs to apply in order to improve the athlete's preparedness for the competitive phase.

Because team sports typically include one competitive season in their design, a monocycle periodization framework is optimal (9,124), which is intended to prepare the athlete for the various demands of the season and (ideally) related post-season play (9,127). In several sports, physical training requires modification to include a short maintenance phase during off-season training events where sport training volume increases dramatically (e.g., collegiate American football) (127). Depending on the importance of winning and the per-athlete volume and intensity of competitive exposure, this may require modification to a two-cycle model, which has the potential of negatively impacting the effectiveness of the preparatory phase by limiting the duration and exposure to training. This issue is discussed later in further detail (see Further Issues and Additional Considerations for Preparatory Period Training). It is important to note that while they may seem independent on the surface, various biomotor abilities (agility, speed, throwing, etc.) are underpinned in part by strength due to the necessity to produce sufficient impulse to maximize performance (129); greater strength has been associated with better performance in change of direction and certain sport-specific tasks in team sport athletes (121,145). Further, an athlete's rapid force production capability (rate of force development [RFD]) within sport-relevant timeframes (i.e., ~100-300 ms, similar to ground contact time during fast locomotion) (137) may be enhanced in the short term (120). Through appropriate programming, strength may be increased and tuned to optimize impulse during athletic movement (138), making strength a critical training target for team sport athletes in order to transfer training effects to performance (128). As a result, both out-of-season and in-season programming likely to preserve or enhance strength is necessary to make a training plan comprehensive. In addition, a certain amount of training time is necessary for enhancement of muscular strength; suboptimal competition scheduling may undermine development of athletes.

Because multiple biomotor abilities (strength, agility, etc.) are critical in team sports, the periodization framework is required to be multi-factor (e.g., high ability of fast running, changing direction, and throwing, etc., as required in baseball), compared to individual sports that emphasize a single factor (e.g., running very fast, as seen in sprinters) (127). Recent modifications to periodization strategies have been made by training theorists to better fit the needs of intermediate and advanced (loosely defined) team sport athletes, providing likely more effective training structure to develop and maintain high capacities in multiple sport-relevant biomotor abilities compared to traditional strategies (68). Termed "block periodization" strategies (66), these modifications include mesocycles of 2-4 weeks emphasizing concentrated loading of multiple targeted compatible biomotor abilities that are linked across accumulation, transmutation, and realization stages (68). In context of the team sport, each ~2-month sequence of a mesocycle ends with [performance testing or] competition (68). Challenges have been noted in sports demanding conflicting biomotor abilities which are theoretically at odds in terms of likely physiological training adaptations. For example, soccer requires running endurance and high-power output events, such as top speed. To address this issue, sequencing periods of training emphasizing specific qualities, while other qualities are retained with maintenance loading may be advantageous. For example, a competitive period phase emphasizing strength-speed, followed by a phase emphasizing speed-strength may pair well with sport tactical and technical training structured to ensure sufficient duration and intensity to prevent aerobic capacity from decaying.

Evidence suggests that certain tools may be added to the programming mix to elicit specific adaptations. For example, the findings of Helgerud and colleagues (56) suggest that high-intensity interval training (HIIT) programming may be tolerated well by soccer athletes, despite substantial training demands. In this 8-week in-season study of high-level (Nardo and Strindheim clubs) junior soccer athletes, twice per week HIIT programming (4x4 minutes running at 90-95% HRmax with 3 minutes rest between sets at 50-60% HRmax) was effective in stimulating performance enhancement in a broad range of physiological variables (higher VO_2max, lactate threshold, and improved running economy) and performance metrics (greater distance covered in a match, greater number of sprints, more involvements with the ball, higher average work intensity during a match) in combination with soccer practices (4 x 1.5 hr/week) and games (1/week) (56). Within the programming decision making process, if (following testing) a theoretical IST in the above example decided that the greatest training priority should be placed upon development of aerobic capacity, then strength may be maintained to allow for greater focus upon aerobic development. This may be necessary due to the realities of in-season demands and athletes' finite (yet individual) recovery ability. In contrast with soccer, many strength-power sports have the benefit of requiring complementary biomotor abilities, with a major emphasis on power. For example, American football requires great strength, power, and acceleration, but not slower-paced running endurance (46,49) due to brief, intense demands and frequent breaks inherent in the game.

Periods Applied to the Team Sport Training Year

Preparation Period

Following adequate recovery time and activity (discussed below in Transition), progressively aggressive physical training is proposed to begin with a general physical training emphasis, with reduced time devoted to directly sport-related training (9). Drawing from traditional periodization theory, at least one mesocycle of general preparation training is necessary in order to restore and enhance fitness qualities (9). Remaining within the preparatory phase, the emphasis shifts to specific preparation, which builds upon recovered fitness qualities and works to improve the athlete's skills using more sport-relevant training, optimally inducing gains in sport-relevant biomotor abilities. Initial introduction to skill work may best occur for team sport athletes early in the preparation period, where the athlete may have more time to explore intricacies of basic movements to set the foundations for more complex ones—or in order to maintain fundamental skills by applying a retaining load. The phases of the preparatory period are detailed below.

General Preparation Phase

Physical training objectives for the general preparation (GP) phase begin with building tolerance to training volume via physiological adaptations and the restoration or improvement of strength (Table 2). In a simplistic view, team sport training ideally begins using less complex modes of training during GP, with primary emphasis upon physiological adaptations and lesser emphasis on sport-specific skills. As training progresses, stressors are increased, particularly in terms of intensity. A minimum of 25% of the time allocated to the preparatory phase is suggested to be allocated to GP, with no more than 40% of training considered intensive (high intensity) (9). The foundation for additional biomotor abilities such as agility and speed (discussed later) may be introduced during this phase progressively. Theoretically, activities involving less stressful changes of direction and speed are advisable until a general fitness base has been re-established (46,111). Because of the likelihood of substantial fatigue resulting from GP training sessions, any skill-intensive programming should occur early in the training session. Due to available time in the preparation period, as opposed to the competitive phase, additional programming to ensure holistic athlete development (e.g., knowledge of practical nutrition strategies, citizenship training, etc.) is ideally scheduled here, beginning in the GP phase (Table 2).

Table 2. Objectives of the Preparatory Period

Overarching Preparatory Period Objectives	
• Improve physical capacity • Improve sport-relevant biomotor abilities • Cultivate desirable physiological traits • Develop individualized and sport-specific nutrition plan • Optimize body mass	• Develop, improve, or perfect technique • Familiarize athletes with strategic maneuvers to be mastered in the following phase • Teach sport-specific theory and methodology of training
General Preparation Phase(s) Objectives	**Specific Preparation Phase(s) Objectives**
• Enhance basic technical skills • Improve knowledge of individual and team tactics • Gradually expose athlete to high-intensity exercise • Improve strength • Improve knowledge of applicable mental skills • Improve nutrition knowledge • Increase/reduce body mass • Integrate sleep education, drug and alcohol education, character education, citizenship and social awareness programs	• Apply technical elements in game situations • Practice team tactics • Improve tactical awareness • Improve biomotor abilities: power, strength, agility, speed, repeat sprint ability, and specific endurance • Refine in-game mental skills routines and habits • Refine nutritional strategies • Make small changes to body mass (if applicable) • Refine recovery strategies

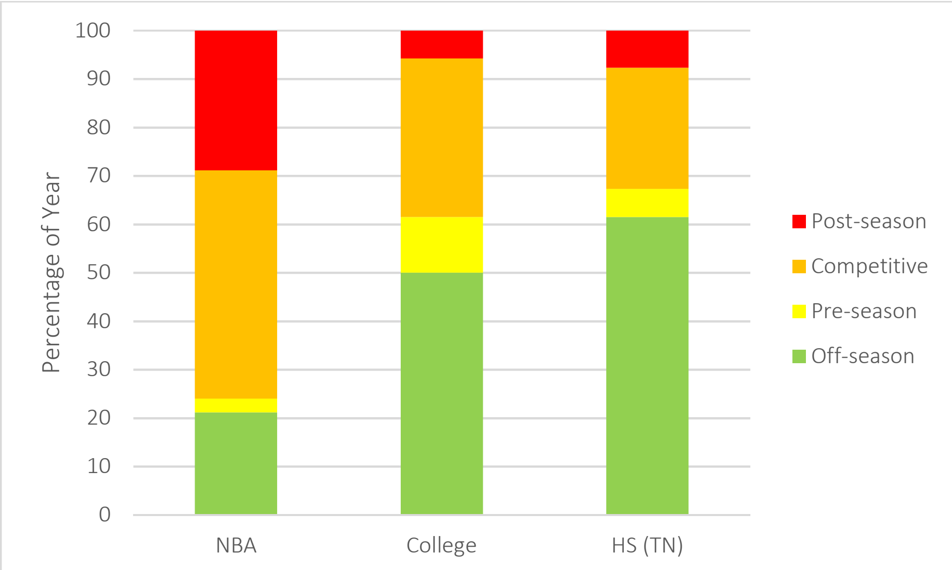
Adapted from (10,47,97)

For younger athletes (assessed by biological/developmental age, training age, or training history), training theorists have long recommended that a greater proportion of the training year be allocated to general preparation compared to the seasoned advanced or professional athlete in order to develop physical capacity and skills (9). Because of accumulated fatigue as a result of aggressive training, Bompa and Buzzichelli (9) firmly recommended that coaches specifically avoid competition during this phase. Of note, this presents a direct conflict with policies of many competitive travel team leagues operating in youth sport (e.g., in baseball this is an issue yet unresolved in the United States [U.S.]) (3). Many studies have observed injury rates resulting from year-round single-sport competition (75); instead, parents are advised to prioritize preparatory training and competition in several sports to present diversity in stress through the early teen years (17,99).

Issues and Challenges Specific to General Preparation

In some contrast with training theory developed from practical experience with individual sports, holistic development of the team sport athlete may be challenging to achieve if multiple components of sport skill work are substantially limited during any part of the training year. This issue may be worsened if a long season is typical. Indeed, concurrent development of multiple biomotor abilities (e.g., strength, agility, speed, etc.) is necessary, in light of the short preparatory period available for many professional team sports (e.g., Premier League, National Basketball Association), the National Collegiate Athletic Association (NCAA) Division I revenue sports, or even some scholastic-level sports (particularly for multi-sport athletes) (Figure 1). Considering the extent of skills and physical development required for many high-level sports, off-season training has become a practice of great importance that is readily acknowledged by most sport coaches, but in many sports it is not truly prioritized over competition at any time of the year.

Figure 1. Percentage of the Training Year for U.S. Men's Basketball

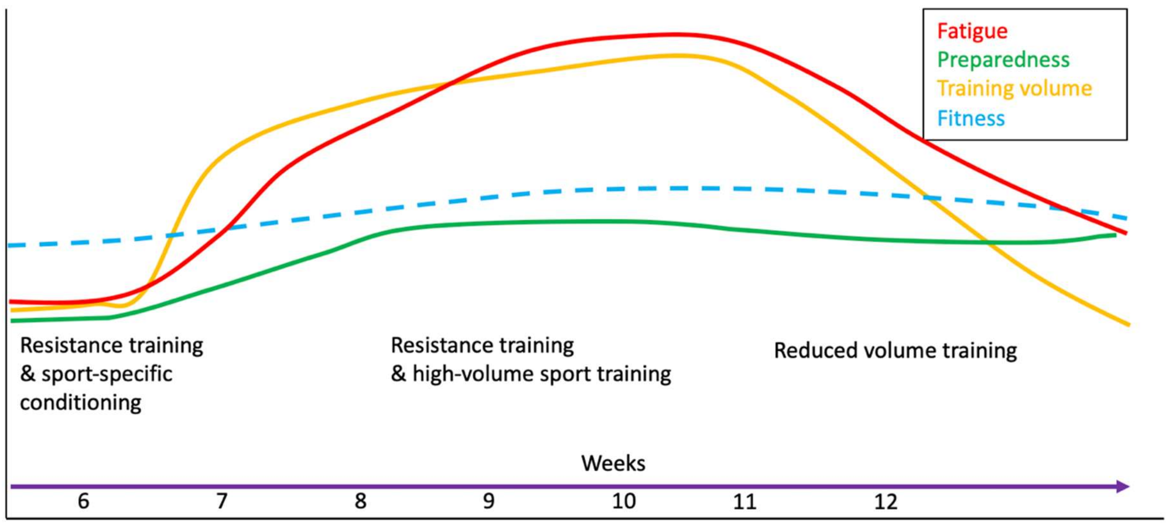


While the practice is rare overseas, some U.S. sport associations forbid coaches to be involved in sport-relevant skills practice in certain sports (but not others) during the preparation phase. For example, NCAA policy allows for college basketball players to scrimmage year-round, and even with un-signed athletes during recruiting visits, but the practice is not allowed in most other sports (100). One of the most restrictive sports, American football, forbids coach contact with athletes for technical and tactical instructional purposes for most of the off-season, and limits coach contact hours during training periods (100). Instead, in order to help develop athletes, low volumes of modified intensity, modified contact, position-specific skill-intensive drills (e.g., hawk tackle drills, ball catching and handling, grappling, etc.) may be applied during the GP phase, in addition to holistic development programming in order to reduce involution (decay) of important skills, and enhance retention and development later in the specific preparation phase. The optimal ranges of drills, volumes, and intensities of skill work have yet to be explored formally. Of course, caution must be taken to minimize chances of acute and overuse injuries that may affect the athlete's progress; however, helping sport coaches and strength and conditioning coaches to integrate training tools smoothly is arguably well within the job description of the sport scientist. In addition, this example also highlights areas where the work of sport scientists may influence positive changes upon sport policy and positively influence athlete performance outcomes.

Specific Preparation Phase

After targeting important physical adaptations during the GP phase, the specific preparation (SP) phase is designed to tailor the athlete's training gains toward the various needs of the upcoming competitive season. Objectives for SP are listed in Table 2. In contrast to the GP phase, higher volumes of sport-specific training are applied in the SP phase (9) with progressively greater intensity, while lesser amounts of general training occur compared to GP. Competition-related training assumes the major emphasis during this phase, accounting for 70-80% of the total physical programming, with a secondary emphasis upon maintenance of broad athlete development (roughly 20% of programming) (9). Programming includes technical and tactical work in order to improve on-field/court performance. Because of increased intensity over the course of this phase, practitioners should monitor volume when programming activities to simultaneously improve multiple biomotor abilities; accumulated fatigue may negatively affect training gains if volume is not kept in check (Figure 2). Balancing increased sport-specific training time with fatigue management may prove challenging. Excessive volume may outpace adaptive biological resources and require a microcycle or two of unloading before the competitive season begins to permit the dissipation of fatigue and allow for sufficient preparedness to perform optimally; doing so may be difficult to accomplish without reducing fitness and sharpness of skills, however.

Figure 2. Theoretical Effects of Excessive Training Volume from Late Specific Preparation Phase to Pre-Season Phase



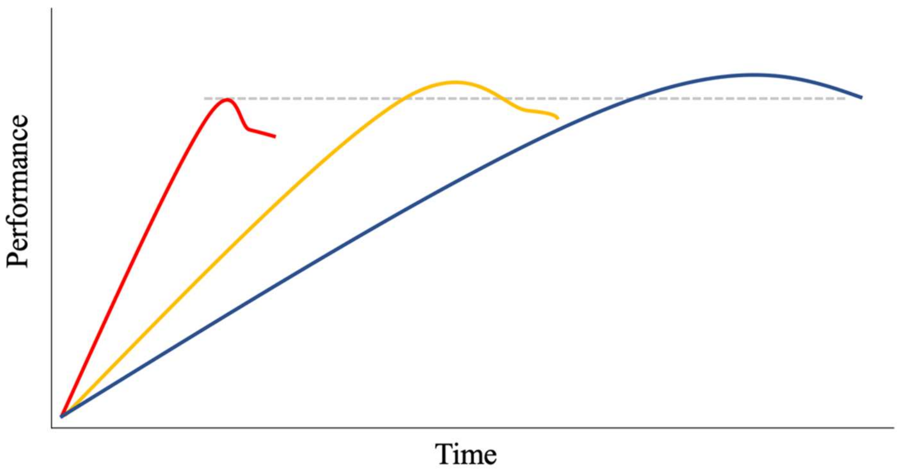
Bompa and Buzzichelli (9) noted that a coach should expect to see improvement in testing toward the end of this phase, and suggested that some form of competition toward the end of the phase would be appropriate to evaluate the athlete as the competitive season approaches. As a result, strength and conditioning coaches and sport scientist practitioners are advised to coordinate testing batteries and monitoring programs to collect data at strategic points in order to optimize availability of important information that may influence programming and guide process development.

Issues and Additional Considerations for Preparatory Period Training

Performance-enhancement goals for the developing athlete may require more time to reach than those of the elite athlete, due to expected timeframes for physical gains to mature; therefore, a longer preparatory period is consistently recommended for younger athletes (9) with specific emphases likely necessary at certain times of development (80), including year-round resistance training (37). Whatever the athlete's level of play, a sufficient duration of training time is necessary to achieve performance goals, the duration of which is likely to depend on the athlete's training history, work habits, and talent level.

The rate of performance adaptation is important to consider. Stone and colleagues (126) observed that: 1) the average intensity of a training program is inversely related to the duration of a performance peak, and 2) the average intensity of a training program is also inversely related to the height of the peak (Figure 3) (33,53). Restated, "slow cooking," or patiently developing an athlete, may provide sufficient time for a variety of qualities to mature better and stabilize for a longer period. In contrast, if an athlete is rushed to regain or develop fitness, then the duration of retention may be shorter and they may not perform as well. Further research is necessary to confirm this for various biomotor abilities.

Figure 3. Theoretical Rates of Performance Adaptation



Theoretical rates of performance adaptation. Observational differences in training programs based upon average intensity (red = highest, blue = lowest).
Note: 1) height of peak is inversely related to intensity, and 2) the higher the intensity, the earlier the peak.

Adapted from (126)

Similar to the practice of scheduling "friendly" games in European soccer during Preparation and General Preparation, several U.S. collegiate sports (i.e., baseball, soccer, American football) have adopted the practice of playing exhibition games or scrimmages in-house or against other teams during the preparatory period. At this time, games do not count against the team's season record, so these games (in theory) serve as a chance to provide developmental players additional competitive opportunities to promote skill development and for coaches to evaluate their progress. This situation presents an opportunity for sport scientists to work with athletes to design and refine a variety of athlete strategies (warm-up, nutritional, psychological, etc.) in order to enhance performance outcomes during later countable games, or refine internal processes of the IST (e.g., global positioning system [GPS] data collection). It should be noted that due to the non-countable nature of off-season games, playing time could theoretically be spread across the roster more than usual, which may allow off-season training volumes and intensities to require minor alteration, in essence "training through" the events. Provided training loads do not exceed moderate levels, a single periodization model may still be most appropriate for application unless 1) winning these developmental games becomes a priority or 2) the volume of technical-tactical development demands warrants adjustment of training loads, and therefore alters periodization structure. Practical experience with sports at this level suggests modification is typically necessary, which may reduce the effectiveness of the preparatory period. The effect upon athlete skills development, however, is unclear.

Indeed, an important value a sport scientist provides is to help coaches quantify sport-specific demands and outcomes of specific types and mixes of programming to a greater extent so that the particular programming may be applied more effectively in the future. This idea extends to sport skill and beyond (38). Of great value in the sport management area, investigation of the timing of scrimmages and high-volume sport skill developmental work is necessary. If several weeks of heavy sport technical-tactical development would be better placed in a longer pre-season phase, then scheduling adjustment would appear appropriate in this example. At this time, no investigation appears to have occurred, and the policies allowing “fall ball” in baseball and spring soccer scrimmages in NCAA sports appear to be arbitrary.

Competitive Period

The competitive phase is separated by three subphases: precompetitive, main, and taper (9). Objectives for the competitive phase are listed in Table 3 (9). Duration of the competitive phase (also termed “in-season” in coaching circles) may extend from about three months in many youth sports to 10 months in some professional sports (84). In addition, opportunities may exist for representative play at a higher level (Tri-Nations, World Cup, etc.). During the competitive phase, priority is placed upon activities that directly enhance performance, with secondary and tertiary emphases upon maintenance of supportive elements of fitness, fatigue management, and psychological strategies. Around 90% of activity during this phase is recommended to be sport-specific activity (skill-based conditioning, tactical drills, etc.), and roughly 10% of activity dedicated to active rest or indirectly related activities (9), both of which may induce psychological as well as physiological benefits. Coaches and IST members are advised to be mindful about the volume and intensity of restorative activities during this phase, as what constitutes a recovery emphasis in another phase may supply additional fatigue due to the accumulative nature of fatigue during a sport season.

Table 3. Objectives of the Competitive Period

Competitive Period Objectives	
• Improve or maintain sport-specific biomotor abilities • Maintain sport-specific fitness • Dissipate fatigue and elevate readiness • Perfect and consolidate technique • Perfect technical and tactical maneuvers	• Optimize team synergy • Gain competitive experience • Enhance sport-relevant psychological traits • Optimize nutrition habits & refine nutrition plan • Maintain body mass

Adapted from (9,10)

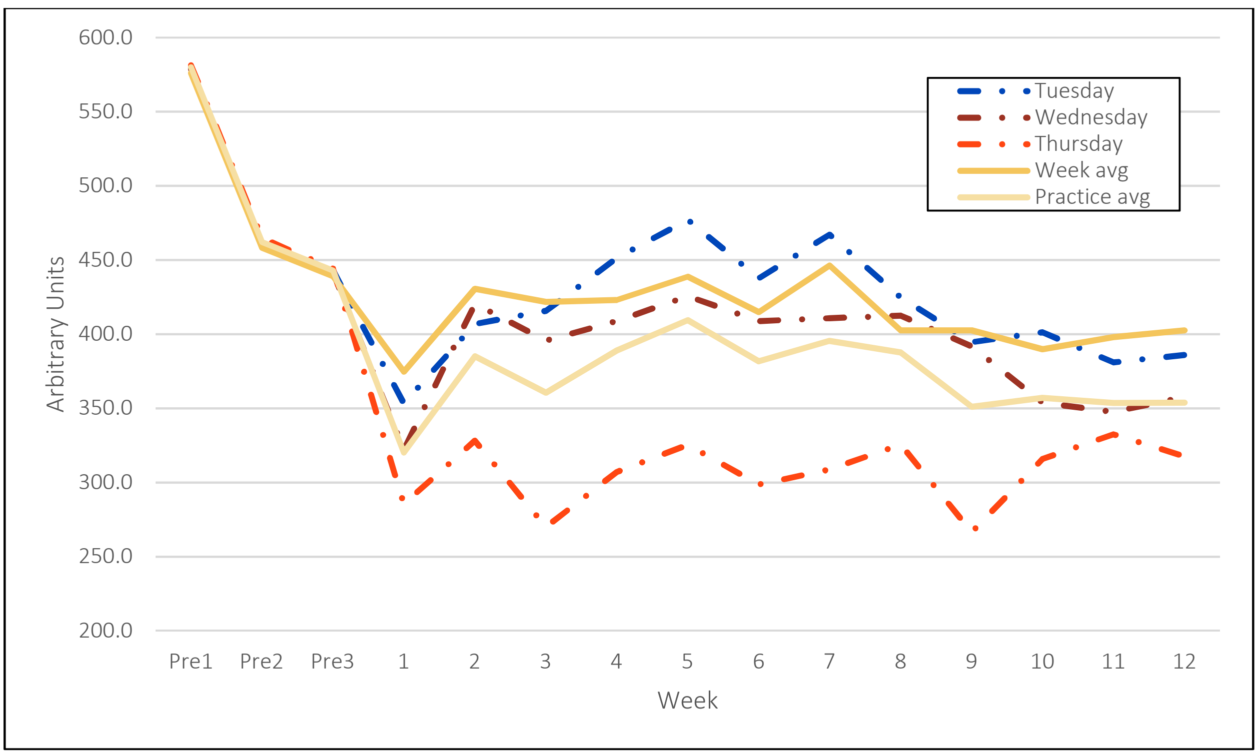
Precompetition Phase

Commonly referred to as “training camp” and the “pre-season,” the precompetition phase begins with focused on-field/court sport training practices to prepare the team for scheduled competition. Proposed durations for this phase vary among training theorists, from vague recommendations of inclusion (9) to nine weeks in duration (84,107). The critical concept is that the phase should be of sufficient duration to prepare athletes for adequate performance in games. A sufficient volume of competitive events such as scrimmages and unofficial games are theoretically proposed that provide coaches with ample athlete evaluation opportunities and do not interfere with the progress of training; however, sport practices may contribute substantial fatigue, and physical training volumes must be modified accordingly by practitioners. Additional brief application of mental skills and strategic nutritional interventions are very important during this timeframe, as the athlete is challenged to manage stress, and maintain physical mass and biomotor abilities due to an abrupt increase in practice time (in many sports). In the precompetition phase, training volume is high, and can be some of the highest in the year, depending on the sport. Optimally, the architecture of training during the precompetition phase involves a progressive transition of biomotor abilities developed in the GP and SP phases, which ready the athlete to excel in the competitive phase.

Issues in the Precompetitive Phase

Challenges presently may be seen in many high-level sports in application of optimal strategies with respect to awkwardly-aligned training architecture and the effect upon training loads. For example, in high-level collegiate American football, Wellman and colleagues (142) observed an enormous early spike in sport practice training load during the precompetitive phase (Figure 4). This presents an example of what constitutes two consecutive “shock” microcycles (weeks Pre1 and Pre2) of sport training that may induce great risk of injury for athletes unprepared to withstand the stressors (note: this strategy was proposed by Verkhoshansky for use by advanced athletes following sufficient preparation). While associations between training load and injury are still developing (32,42,63,64,70,119), rapid increases in training load have been associated with injuries in various sports (31), suggesting patience for adaptation may be warranted at times, following initiation of a set of stimuli. In the U.S. college football context, the initial week of “pre-season” is when athletes are first allowed to wear equipment (helmets and pads), and as such, are adapting to equipment in what is typically the hottest weather of the year. From a safety perspective alone, this is not an ideal time to program the highest training loads of the year. This example would also be ill-advised from a skill development perspective, due to substantial environmental stress as a confounding factor (131).

Figure 4. Training Loads in High-Level Division I Collegiate American Football



Adapted from (142)

A better strategy to introduce semi-novel tasks (sport practice in pads) may be to program an adaptation microcycle during the initial week of training camp, and follow a progressive increase in volume, achieving normal loads in competitive week 1. Practical experience in American football indicates enormous challenges in managing recovery—let alone adaptation—due to current schedule restrictions by many leagues. In addition, for most programs, intravenous fluid infusions are frequent interventions necessary for some athletes due to aggressive training in harsh environmental conditions with little time allocated between sport practices. To this point, no research has investigated the effects of changing practice strategies and scheduling upon injuries or skill development or retention. As such, the common structure of sport practices in American football remains primarily based upon coaching knowledge, fertile ground for exploration by qualified research teams.

Of similar concern to the issues above in American football, Ishida and colleagues (65) observed a rapid and brief pre-season increase to a high external training load in female collegiate soccer players following an uncontrolled summer training period. The precompetition phase for these athletes was two weeks long, and it also included some of the highest GPS training (and match) loads of the year. The authors noted a longer precompetitive phase and better controlled preparation period (particularly regarding summer training between semesters) would be of great benefit to athletes, from an injury prevention perspective.

Main Competitive Phase

The main competitive phase is when scheduled, competitive games are played. As team sports must win as many games as possible, a balance between recovery-adaptation and technical and tactical development and refinement must be struck by coaches, with the assistance of the IST. As the research base grows for each sport and reports of training loads (TL) and game loads using passive tracking tools (GPS, etc.) are published, sport training sessions may be constructed based upon a well-informed range of typical training and game loads during a sport season. It is important to note that the movement profile of each level of play has been shown to differ within and across different sports (132); therefore, research exploring every level is important in order to inform practice.

Due to recent technological advances (GPS, heart rate monitors, etc.) and low-tech subjective tools (sRPE, etc.) and their applications in many sports, training loads can be deliberately set jointly by sport coaches and other members of the IST to cover substantial detail. For example, the characteristics of specific drills may be evaluated (velocity ranges, etc.) over time so that the sport scientist can advise coaches on matching training content with training load targets (acceleration and velocity profile, percentage of time in heart rate ranges, etc.). The sport scientist in charge of monitoring provides information quickly using visual representations to coaches and athletes in order to ensure goals are met; in addition, the practitioner may identify any acute variable of concern, such as an atypical acute high volume in a high velocity range (10,135). A recently-developed practice from professional soccer and rugby is to manage training loads of bench players and nonstarters by applying a tailored amount and type of extra physical training in an attempt to balance out the time the individual athlete did not spend playing the game, including evaluation of specific intensities, so as to maintain fitness throughout the season (15,143). Because HIIT training and small-sided games (SSG) may be applied very efficiently, such programming tools appear optimal for this purpose (15,76).

Taper Phase

In the late competition period, training is narrowly focused upon maximizing sport performance, with specific programming intended to bring about the athlete's peak performances of the year. Due to the nature of team sport playoffs and tournaments, the most difficult competition of the season is often encountered in this timeframe. Psychological stress is expected to be high. In addition, accumulated fatigue is expected due to the effects of the competitive season, in which variation in training loads may need to be minor in order to maintain fitness. Overuse injuries and lingering issues may also be observed, requiring further management and creative modifications from the IST in order to keep players available.

For many sports, the practice of tapering has been proposed as a best-practice to dissipate accumulated fatigue and bring about peak performance before critical competition (97). Tapering may be executed by reducing intensity, volume, and/or frequency of training in some fashion as the important competitive event draws near (95,96). Recommendations for optimal taper structure and duration vary, and may indeed be complicated by travel, equipment access, and other variables that introduce complexity to the team sport context. A tapering strategy for team sport athletes is conceptually applied in order to: 1) (ideally) induce a supercompensation effect bringing about improved performance capacity, or a “peak” (96), or 2) (at a minimum) reduce accumulated fatigue in order to restore performance capacity (95). Exploration of tapering in individual sports indicates functional overreaching (FOR), which typically involves an increased training load for a microcycle, and is necessary to bring about a supercompensation effect in the short term (96). Due to accumulated fatigue in team sport athletes, the realities of a long season, and likely existence of overuse injuries, practitioners may be challenged to safely implement deliberate FOR in some team sports late in the season, limiting available programming options to volume (by reduced duration of certain activities and strategic exercise deletion) and/or intensity reductions. However, evidence of improved physical performances have been observed following pre-season tapering in team sports. For example, Coutts and colleagues (21) reported six weeks of progressive overload training depressed performance during testing (as part of FOR), but performance improvements were observed following a 7-day stepwise taper. This demonstrates that fatigue is not always an issue if planned and managed appropriately. Additionally, tapering strategies have been used successfully by teams before international tournaments (i.e., World Cup) that follow club seasons (95), though little research is available to specifically demonstrate their effects.

More recently, Vachon and colleagues (139) observed that team sport athletes have responded favorably to tapering programs of 7-21 days, with favorable changes reported in repeat sprint ability (RSA), maximal power, change of direction speed, and maximal oxygen uptake. The authors endorsed the practice of tapering; however, they noted that coaches tend to use previously validated tapering methods, which leads to “circular thinking” with regard to strategies that may hamper innovation (139).

Coaches should note, certain physiological changes have been observed from a taper that do not coincide with reduced performance. For example, Bazyler and colleagues (5) observed slight reduction in muscle thickness, but not jumping performance after a 4-week taper in collegiate volleyball players. The authors also suggested a FOR phase may be necessary to preserve muscle thickness; however, further research is necessary to confirm this idea, and if it is necessary—both from a performance and injury prevention standpoint.

Additional Concerns for a Taper

Bompa and Buzzichelli (9) recommend additional time (3-7 days) and refer to it as a “special preparation period,” which is time allocated to tactical refinement prior to a championship. Because some of this time may be spent in sedentary activity such as watching film or minimally-fatiguing activity such as strategic tactical walk-throughs intended to enhance athlete awareness and application of tactics, this programming strategy may fill practice time typically allocated to demanding physical activity (e.g., scrimmaging, SSG).

Stone and colleagues suggested that peak performance may only be obtained for a 2-3 week timeframe (126); therefore, questions remain as to the appropriate timing, sequencing, and length of playoffs and tournaments from a sport management perspective.

Issues in the Competitive Phase

Duration of competition tends to last most of the year in high-level sport. In Australian professional rugby union, for example, a Super Rugby player that is selected for an international squad would play relatively consistently from February to October, or until November in a World Cup year. This is indeed an extensive season, similar in length to the National Basketball Association season (including finals). Much of the rationale for such long seasons is fueled by financial opportunities for leagues, teams, and athletes alike; however, human physiological and psychological limitations must still be accounted for when establishing the season length and density in order to responsibly manage athlete health. Of concern to all stakeholders, a very long, congested season may foster higher rates of overuse injuries and present challenges for athletes to maintain physical and mental capacities that support high-performance outcomes, particularly when combined with regular travel and impaired sleep (117,141).

Bompa and Buzzichelli (9) observed the number of games required to achieve optimal performance (in-season form) may be 7-10; while an interesting idea, this figure appears arbitrary and is likely to vary according to sport, training age, and the training and competitive history of the individual athletes involved. At this time, research and debate regarding the optimal duration and nature of the competitive phase is warranted. The question at hand for high-level sport coaches, athletes, and administrators alike is the balance between league revenue, athlete salaries, and viewership, and the physiological and psychological limits of team sport athletes. Optimal competitive phase duration and density may vary due to the physical demands of the particular sport; major considerations include collisions (rugby, American football), high-intensity contacts (e.g., repetitive jumping and landing in basketball or volleyball), and typical time available between games.

Few researchers have evaluated schedule density, with studies taking solely epidemiological lens (105,123), or based upon GPS data (98). Time available between games has been demonstrated to influence in-game position-specific movement profile (98), but qualitative nature of the game (competition quality, tactical situations, etc.) must also be accounted for by embedded researchers familiar with typical athlete evaluation processes. Therefore, both determining performance effects and the rate of injuries is a complex interdisciplinary issue requiring holistic research. Though it may appear obvious from coaches' and athletes' perspectives, excessive congestion may limit time available for tactical preparation and prevent many athletes from recovering performance capacity to prior levels before the next competition. In addition, excessive season length can potentially compromise the time dedicated to the very-necessary preparatory training period. With an insufficient preparatory period, athletes may not be able to recover from the prior season and return to sporting form by the next competitive phase.

As a result of condensed schedules and long seasons, athletes may feel pressured to use performance-enhancing drugs (PED) in order to recover and sustain performance capacity throughout the competitive phase and beyond (91). Indirect survey methods have revealed concerning rates of PED use among high-level athletes, extending up to 48% in some samples (35). In contrast, World Anti-Doping Association testing results consistently return about 2% positive tests, the majority of which are anabolic agents (8,35). Ample examples exist of successful athletes who have succumbed to restorative drug use. One of the most public in recent years is Major League Baseball (MLB) all-star Mark McGwire's public admission of steroid use to sustain his career, as he admitted steroids had become a necessary tool to overcome injuries (36). From an ethical standpoint, league administrators and coaches must provide an environment that allows for sufficient athlete restoration and training time, in balance with competitive opportunities. This requires long-term researcher access to the sport and a strong context-specific, evidence-based sport performance sport medical influence upon policy. Due to obstacles in studying the acute and long-term health effects of performance enhancing drugs, little is known about the long-term health implications (physiological or psychological) of PED use in support of athletic careers (7,8,60). Ultimately, prevalence of doping remains an uncomfortable topic with unclear implications for high-level sport, particularly in light of the many challenges that reduce the effectiveness of drug testing programs (i.e., funding, information).

Scheduling restorative breaks in a long season may provide some advantage to foster high performance levels. Professional athletes competing in international sport competitions such as a World Cup may benefit from a restoration mesocycle in order to improve recovery for the international competition. Mujika (95) discussed scheduling challenges in elite soccer, when time was provided between the professional club season and the World Cup. Recommendations included initial team training several weeks prior to the first game, beginning with a recovery microcycle, an accommodation microcycle, then a taper microcycle with low training volume and high intensity (95).

Transition

Aligned with periodization theory, what most coaches, athletes, and media refer to as the "off-season" encompasses the transition and preparatory phases (51); typical objectives of these phases are listed in Table 4. As Bompa and Buzzichelli cautioned (9), the term "off-season" may be one to avoid, in that it implies minimal activity; for the serious athlete there is never an off-season, only training, competition, and deliberate recovery. Sport scientists and coaches are advised to consider the transition phase not as the last and least important section in sequence of a linear training year, but as one critical sequential part of the whole training cycle. The preparatory phase should follow some form of programmed rest and activity intended to promote recovery from the accumulated physiological, psychological, and social stress imposed upon an athlete by a sport season (9,127), preparing the athlete to embark upon aggressive training. The transition phase continues the momentum of the annual plan in a circular (not linear) nature, as a part of the multi-year plan; therefore, the deliberate emphasis on recovery paired with training aligns with the perpetual nature of planning training, not restarting a repetitive annual process. Practitioners must take care to prevent omission of time allocated to restoration as they plan the ebb and flow of year-round training due to the likely decay of biomotor abilities.

Table 4. Objectives of Transition Period

Transition Period Objectives	
• Rehabilitate injuries	• Recover psychological status
• Maintain basic fitness	• Maintain body mass
• Dissipate accumulated fatigue	• Explore social interests

HOW CAN A SPORT SCIENTIST AFFECT SPORT POLICY?

Some sport association policies, such as the NCAA, restrict training for several weeks following an American football season (100). While the exact origins of this rule are unclear, it was likely arranged to allow athletes to return home during the Christmas break and minimize housing costs to athletic departments. Timing of this cessation of directed training is questionable, as substantial detraining of many biomotor abilities may be seen over a three-week period (92), particularly in consideration that many biomotor abilities may also decay some during a long season (93) and decay rate of biomotor abilities may differ based upon task (136). Because acute overtraining injuries (e.g., rhabdomyolysis) are commonly reported when teams resume training by American football programs participating in Division I NCAA athletics (118), in the interest of athlete welfare a modification to policy may be warranted, allowing strength and conditioning coaches to help athletes maintain a certain level of fitness year-round. This point demonstrates how a sport science perspective may be integrated to optimize sport policy in order to reduce preventable training injuries.

After conclusion of the competitive season, generally two options are available for coaches to choose from—stop training temporarily or change training. While some coaches opt for a several weeks of uncontrolled (likely sedentary) time away from the team environment, an approach aligned with certain league rules (e.g., NCAA), several weeks of active rest is recommended by many sport physiologists and coaches (26,53,108,126) before starting aggressive training within the preparatory period. Because necessary recovery typically includes rehabilitation of injuries (acute and/or overuse) and overcoming psychological impacts of a long season, such as under-recovery, burnout, impaired motivation, or the impact of the prior season's competitive outcome (78), programming deliberately designed to address those issues may provide substantial value to the athlete.

For team sports, the transition phase spans a brief 2-6 weeks, in which team physical activity may remain planned and organized or individual. "Active rest" (synonymous with active recovery) is a broad equivalent term for submaximal activities thought to enhance return to homeostasis or a prior performance level (77). Recovery strategies may be applied during the training session (e.g., intra-set, such as walking between running intervals), immediately after (e.g., cool-down), or include weeks of time off from typical training while strategies are applied over days or weeks to counteract fatigue-related consequences of aggressive training (126). Additional passive recovery techniques may also be of benefit during this timeframe, depending on the training goals (97). Programming during the transition phase is general in nature, deliberately lower impact, lower volume, and different in nature to typical training that the athlete is exposed to (26,53,62,126). In addition, active rest may include leisure activities for the athlete during transition.

Though direct research support is lacking at this time for team sport athletes to remain in team training environments during transition, the practice may provide opportunities for the athlete to stay engaged, nurture social connections with teammates, and improve compliance, thereby preventing substantial physiological loss of fitness qualities (intramuscular enzyme concentrations, mitochondrial concentration, etc.) that have been shown to result from short-term sedentary rest (92). Indeed, many authors have cautioned coaches to avoid allowing sedentary rest for their athletes (53), as hard-earned training gains decay within weeks of training cessation (92,93,94), likely due to their biological expense for the athlete to maintain.

Complete recovery indicates readiness to resume typical training effectively in the next preparation macrocycle (26). Recovery may be indicated by several internal and external tools: survey, force plate data from common tasks such as countermovement jumps, or submaximal set-intensity tasks; practitioners are discouraged from using maximal-effort, sport-specific tasks due to fatigue implications (73). Practitioners are recommended to explore how much active rest—and what modes, intensities, and volumes of activities within it—appears to be of value for each sport and level of athlete, along with the effectiveness and proper application of recovery indices.

Demonstrating some acute physiological effects of a transition phase, one study is available with weightlifters (n=7 regional and national-level) who completed a 1-week overreaching microcycle, 3-week peaking phase, and 2-week transition phase between testing sessions (62). Females' isometric mid-thigh pull testing results showed temporary decreases in peak force (PF) (5.23%, Cohen's d effect size [d]=0.29) and RFD (10.14%, d=0.70), while males' testing results showed decreases of PF (10.53%, d=2.89) and RFD (16.43%, d=1.28). Contrasting these results to those of team sport athletes, physiological detraining due to uncontrolled time off may be variable between athletes due to individual athlete compliance with an away training program.

Further research is necessary to explore what constitutes between-phase meaningful changes and thresholds of concern in sport-relevant biomotor abilities, in addition to exploring between-athlete and between-sport differences. To clarify, some range of performance of biomotor abilities is to be expected throughout the training year; the observation of a reduction may not constitute a concerning event, while a reduction beyond a certain threshold, according to a published industry-wide or internal team precedent, would indicate a problem for the sport scientist to investigate (47).

Coaches should exercise caution in programming activities during the transition phase, as athletes are naturally competitive. As such, selecting a different activity to what they compete in is important. For example, it would be naive to assume that a soccer team would play soccer at a reduced intensity—play will naturally become a full-go scrimmage. Instead, for example, the team might play 20-30 minutes of water polo in the shallow end of a pool. This provides an environment that may allow for restoration of affected joints and musculature in an intensity and impact-restricted manner, and the duration of activity is controlled to minimize fatigue. A theoretical sample week of transition programming is provided in Table 5.

Table 5. Sample Active Rest Week Programming for Collegiate Soccer

Monday	Tuesday	Wednesday	Thursday	Friday
AM: Rehabilitation with sport medicine; 20-30 min of cycling at 64-76% age-predicted max HR followed by 3 rounds of: asymmetrically-loaded overhead squat x6 (light), kettlebell hang clean and press (6/side), superset with 1-arm staggered-stance cable mid-row at light-moderate intensity; 30 seconds between rounds	AM: Rehabilitation with sport medicine; 20-30 min of water polo in shallow end of pool	Rehabilitation with sport medicine or off	AM: Rehabilitation with sport medicine 20-30 min of cycling at 64-76% age-predicted max HR followed by 4 rounds of: asymmetrically-loaded overhead squat x6 (light), kettlebell hang clean, squat and press (6/side), superset with 1-arm staggered-stance cable high-row; moderate intensity; 30 seconds between rounds	AM: Rehabilitation with sport medicine 20-30 min of water polo in shallow end of pool PM: team mini-golf

Mesocycle-level Programming Strategies

Mesocycles (4±2 week phases) are classified based upon their purpose, which guides their content emphases (primary, secondary, tertiary). Several authors have presented a variety of around nine mesocycle purposes (48,126), which may be adapted to suit the goals of novice and intermediate team sport athletes. For example, “build up” enhances general conditioning, while “stabilization” is intended to establish sport-specific fitness and skills, and “competitive build-up” is intended as a brief increase in TL to improve sport-specific fitness during a long season (48). Recently, as a modification to block periodization strategies, these strategies were reduced to three types: accumulation, transmutation, and realization (67) for use with advanced athletes.

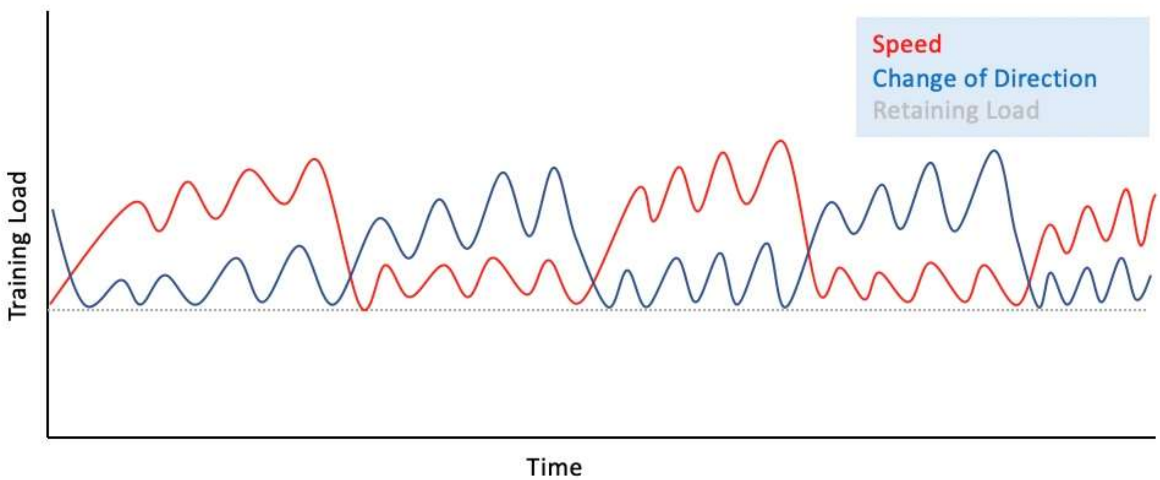
Sequencing Programming for Novice Athletes

As Haff and Haff observed (48), early work exploring the effectiveness of traditional periodization included beginner athletes. In this model, a wide array of biomotor abilities can be developed concurrently in a progressive manner (126). An inverse relationship between intensity and volume is observed in traditional periodization; volume is higher during the GP phase, and gradually reduced as intensity increases during the SP phase (126). Parallel development of targeted training variables in simple progression (51) has been identified as a potential strategy for novice athletes, and may particularly suit younger athletes due to necessity of training a variety of skills. One basic premise of this concept is that athletes demonstrate sufficient mastery of skills over a period of time before progressing to more advanced stressors with greater complexity.

Sequencing Programming for Intermediate Athletes

As the team sport athlete progresses toward intermediate and advanced level (loosely-defined), transitioning to an emphasis training model may be ideal due to greater time allocation for development of specific skills and biomotor abilities (126,148). The emphasis training model (51) increases variation via emphasis and de-emphasis of biomotor abilities and sport skills over time. Suiting the needs of a team sport athlete, this strategy allows for training multiple targeted abilities in parallel. For example (Figure 5), one 4-week training block in the GP phase may primarily emphasize strength development (80-95% 1RM), while change of direction training (short and hard; 5-10 m, 45-180° turns) and acceleration (short; 5-20 m) are placed in secondary emphasis, and retaining loads are applied for power exercises, basic sport skills, repeat sprint ability (RSA), and mental skills. To guide practitioners, the majority of in-session training time is devoted to the primary emphasis, which occurs earlier in the session.

Figure 5. Theoretical Emphasis Training Model: Speed and Change of Direction Programming



Modified from (148)

Across the mesocycle, Stone and colleagues (126) recommended implementing summated microcycles of resistance training, increasing the degree of workload contrast within and between cycles. In this method, emphasis of the mesocycle remains consistent for about four weeks, while average loading of each successive microcycle is gradually increased, then decreased (three up, one down) to accommodate fatigue. On a cautionary note, as intensity of workloads increases through the third week of the 4-week training block, coaches and practitioners should be cautious about fatigue accumulation that could negatively affect other activities with high-neurological demands (i.e., top speed programming). Because of their equivalent reliance on the neuromuscular system, other modes of training may also be implemented either progressively or in sequential manner during this stage of development, depending on the athlete’s level of mastery and training goals.

A second strategy to begin exposing the intermediate athlete to is concentrated loading, which (again at the mesocycle level) is characterized by an initial aggressive concentrated load (typically 1 microcycle) intended to saturate the athlete with the primary targeted ability (48). Following the concentrated loading microcycle (FOR), TL returns to a normal level (2 up), and finally TL is reduced in the last microcycle (1 down). Here performance is briefly depressed as a result of the FOR microcycle, and a long-term delayed (improved) training effect is observed later in the mesocycle (126). The intermediate athlete is also recommended to begin exposure to additional strategies such as exercise deletion and representation strategies, cluster loading, and post-activation potentiation complexes, in order to present further variation (126). Certainly exercise deletion and representation strategies may be used in progression of various sport skills.

Sequencing Programming for Advanced Athletes

At the mesocycle level, programming of activity for the advanced athlete has been recommended to include use of the above strategies of summated microcycles and concentrated loading, along with a conjugated sequencing model (48) to elicit adaptations. In the conjugated sequencing model, delayed physiological adaptations are anticipated to occur following strategic sequential application of particular training stressors (48). Stressors are organized into three mesocycles: accumulation, transmutation (each 2-4 weeks), and realization (1-2 weeks), intended to be applied in order (67). As discussed at the mesocycle level below, modification of the concept has been recommended for application to team sport athletes as a multi-targeted block periodization strategy (68). Compatible biomotor abilities are developed concurrently (e.g., short sprints and power), while non-compatible biomotor abilities (e.g., strength endurance and max speed) are recommended to be separated into different blocks according to compatibility (67,68).

Accumulation

The accumulation mesocycle is 2-4 weeks in length, and it includes a concentrated load of a particular biomotor ability, with secondary and tertiary emphases upon other complementary biomotor abilities to prevent decay (68). In order to force adaptation, the volume targeted within the concentrated loading period is particularly stressful and challenges recovery mechanisms, which depresses performance capability. From a practical coaching perspective, fatigue induced by this strategy may negatively influence technique in complex motor tasks (i.e., strength-endurance training inappropriately paired with top speed running), therefore all programming options may not be available to the coach during this mesocycle in light of temporary performance decrement induced by accumulated fatigue. It is implied that the workloads applied during training sessions within the accumulation mesocycle can be expected to impair complex skill acquisition due to late session fatigue.

Transmutation

The transmutation mesocycle is also 2-4 weeks in length. Here the athlete resumes a normal training load and shifts priority of the mesocycle to a sport-specific biomotor ability, with adjustment of secondary and tertiary priorities (48). The athlete is still unlikely to demonstrate major improvement in the targeted biomotor ability during this timeframe, as it is likely to require several weeks of reduced training loads to observe due to the delayed training effect and impact of the stressful sport-specific training loads occurring in this phase (67).

Realization

The realization mesocycle is shorter in duration (1-2 weeks) and consists of a reduced training load (also referred to as deload and taper) compared to prior mesocycles in order to allow for recovery-adaptation (68). Primary emphases of prior mesocycles are now allocated to secondary or tertiary emphases during this mesocycle in order to retain developing technical skills and important biomotor abilities (48). Because of sport specificity, power is a likely primary emphasis for this mesocycle at some point throughout the training year. Reduction of training load allows fatigue to dissipate and expression of training gains emphasized in the accumulation phase to be observed (measured).

Modification of Block Periodization Strategies for the Competitive Period

Because of the importance of winning games, performance cannot be depressed frequently due to training loads, as seen in FOR. As a result, Issurin (67) recommended mini-cycles of specific qualities to retain certain physiological adaptations during the transmutation mesocycle. Targeted brief microcycles are recommended to span several days (67); this concept may also be applied at strategic points if gaps in team sports competition schedule are observed (bye weeks, etc.). For example, in collegiate basketball during the holiday break, many teams do not compete for over a week. During this time, coaches may briefly emphasize maximal strength, for example, a quality difficult to maintain in the face of a dense competitive season.

Summary of Mesocycle-level Strategies

To overview the above concepts, more gradual exposure to intensity is recommended for the beginner athlete, and more severe stimuli are applied as the athlete achieves advanced status. Due to the increasing severity of stimuli required to drive adaptation, restorative strategies (e.g., realization phase and intra-microcycle TL modifications) become more important for inclusion in programming. Additionally, monitoring strategies are key to ensure the athlete progresses properly. Intra-athlete and situational differences in recovery ability are important to consider—as is adaptive potential—in application of programming. Of note, Issurin (67) suggested modifications for experienced (older) athletes, including a longer transition period and less training volume (10-30% less) than their younger peers; presumptively, this is due to greater training stress applied to force adaptation with accommodations made for a reduced rate of recovery-adaptation seen in older athletes.

Microcycle-level Programming Strategies

Several authors have proposed a diverse range of microcycles (~1 week in duration) intended for specific purposes across the training year (9,51,126). For application to team sports here, Issurin's terminology is used (67): adjustment, loading, impact, pre-competitive, competitive, and restoration microcycles. This set of strategies may be applied across the training year as the IST adjusts the programming puzzle to drive adaptation and foster recovery-adaptation.

Adjustment Microcycle

The adjustment microcycle is intended to foster initial adaptation or adjustment to training (67) so that soon-to-be-applied higher training loads are tolerated well. Here TLs are proposed to be "medium," often with a gradual increase of TL from one microcycle to the next (126). These are typically arranged in a series of progressively intense adjustment microcycles (as in summated microcycles), followed by a restoration microcycle (see below) that in order to provide time for recovery-adaptation (126).

Loading Microcycle

The loading microcycle is intended to improve a certain set of biomotor abilities using a range of workloads from substantial to high (67). Particularly necessary for advanced athletes is the connection of restoration microcycles following a series of loading microcycles, as accumulated fatigue is expected to be high.

Impact Microcyle

Fitness improvements are intended to result from the impact microcycle, with extreme stimuli applied to the training athlete (67). Also referred to as a "stress," "impact," or "shock" microcycle (126,148), this strategy is recommended to be limited to advanced and elite athletes, as younger athletes are unlikely to tolerate such increases of intensity and/or volume without undue risk of injury (140). Further guidance suggests use of the strategy no more than 3-4 times per year; two sequential stress microcycles may be considered for elite athletes, but no more than once per year (148). Of interest, Verkoshansky noted the initial "shock regime" method of training was not exclusively used for plyometrics (e.g., depth jumps), but also included a variety of loading methods involving a rapid stretch of tissues followed by a vigorous muscle action (140). Siff (116) suggested a broad menu of special strength training that may be used to provide major training stress for advanced athletes, including: plyometrics, supramaximal methods (e.g., accentuated eccentric loading), repeated single 1RM training, contrast methods, forced repetitions, electrical stimulation, and maximal eccentric methods. Notably, not all of these methods have been explored formally in athletic populations, and further research is required to substantiate efficacy. Because of higher fitness in advanced athletes, a stress microcycle may be applied in an abrupt manner, and performance will be expected to be depressed temporarily (weeks) as a result of the severity of the training stress. This demonstrates the concept of the long-term delayed training effect (126) and highlights the necessity for more complex programming for advanced athletes in comparison to beginners.

Pre-Competitive Microcycle

Specifically intended to improve performance in sport-specific tasks, the pre-competitive microcycle is intended to include a medium training load and be scheduled prior to beginning of the competitive subphase (67). This microcycle may include a wide array of content from multiple specialties in order to help prepare the athlete for improved performance.

Competitive Microcycle

Training loads in the competitive microcycle are high or very high and focused upon activities that prepare the athlete for improved performance (67) and maintain fitness (126). Programming may narrow in focus over the course of the season; an early season microcycle may vary substantially from programming in a late season microcycle, as training is modified to optimize physiological and psychological outcomes by reduction of monotony. Less priority may be placed upon retention of certain biomotor abilities due to accumulated fatigue. Depending on the goals of the IST, and the level of sport, a particular consistent training load range may be observed throughout much of a competitive period. Studies have reported little between-week TL variation (83) in reserve La Liga soccer players, and some between-week TL variation in Premier League soccer players (85). It should be noted that creativity is important to avoid monotony.

Restoration Microcycle

Consisting of active recovery, the recovery microcycle contains intentionally lower training loads in order to allow for recovery-adaptation (67). Programming may be sport-specific and of reduced intensity/volume, or sport non-specific, depending on the placement within the training year and the developmental needs of the athlete. Duration of this microcycle may be shorter late in the competitive season, with a smaller reduction in selected training variables (i.e., intensity, volume, etc.) in order to avoid loss of fitness. Targeted recovery methods (e.g., muscle temperature manipulation) may vary throughout the year; for instance, cold application strategies may be used during the season, but not used during the preparatory phase due to primary emphasis upon the influence of recovery upon on-field performance versus driving long-term physiological adaptation (73,97,110,130).

Setting Loads Within the Microcycle

Due to the fatigue aftereffects of loading, most resources suggest a wave-like approach to resistance training loading across the microcycle, with reductions of 10-20% intensity recommended later in the microcycle for resistance training (115). Though other loading strategies have been proposed, such as intensity-predominant loading featuring chronic high intensities with volume manipulation (126), few of those strategies appear to have been explored in team sport athletes. Sport-specific conditioning modes and sport training also require regular loading modification to optimize the stimuli, manage fatigue, and prevent staleness (24,25,38). Therefore, the microcycle is recommended to include a particular range of TL targeted for each training session (67). For the sport scientist, this provides an opportunity to 1) help set TL and 2) confirm the strength and conditioning coach, or sport coach, and the athlete are able to achieve the targeted load in accordance with the training plan (143). To foster quality of stimuli, modifications may be necessary if regular deviation from prescribed loads occurs.

Programming Workloads and Variation

Practitioners involved in planning programming and managing training loads are advised to consider the short-term (where are we now?), medium-term (where are we going soon?) and long-term (where are we ideally going in the next few months or so?) realities when planning and adjusting programming (108). In addition, recent and long-term training history of the individual athlete are important to evaluate in order to optimize transition between phases. Within the process of constructing programming designed to improve and maintain performance, coaches and sport scientists will deliberately select modes of training (activity, exercise, or drill) and plan training variables, such as frequency, target intensity range, target volume range, and complexity of the activity (9,16); further considerations include nuanced changes to small-sided games, for example, in order to modify the range of stressors (15), density, and order of exercises or drills. The above programming decisions are optimally linked with appropriate nutritional, psychological, and recovery strategies (97,110), and appropriate adjustment of modifiable variables is performed according to goals of the period. At any level of sport, challenges are introduced to the training process that warrant adjustment for the individual athlete, such as accommodations for new players obtained by free agency, and acute stressors such as educational demands of the athlete (82); therefore, some modification is to be expected.

A range of intensity variation is also necessary for other activities. For example, sprint tempo work has been proposed for speed athletes at a range of 60-85% of maximum sprinting speed (24). It is important to note that popular guidance such as the "10% rule," where training increases of any variable should not exceed 10% per week is purely anecdotal (43), and clearly not considered in programming at intermediate or advanced levels due to long-held strategies of training theorists that reflect more aggressive training load changes. Further, such conservative increases may be difficult to apply to the limited time available for preparatory training with high-level athletes.

Loading variation has become a contemporary concept in resistance training, included in most coaching resources (50). Additionally important, recommendations for employing restorative microcycles and loading variation is not exclusive to resistance training, and may be applied in programming the training of various biomotor abilities in order to improve the chances of progress as athletes develop. Stone and colleagues (127) noted one benefit of loading variation is that the athlete is exposed to a broader range of velocities (and stressors), which may enhance power adaptations. The same may be true for other modes of training. For example, in change of direction training, skill retention may be enhanced by exposing the athlete briefly to retaining loads of less demanding movements, in addition to targeted drills.

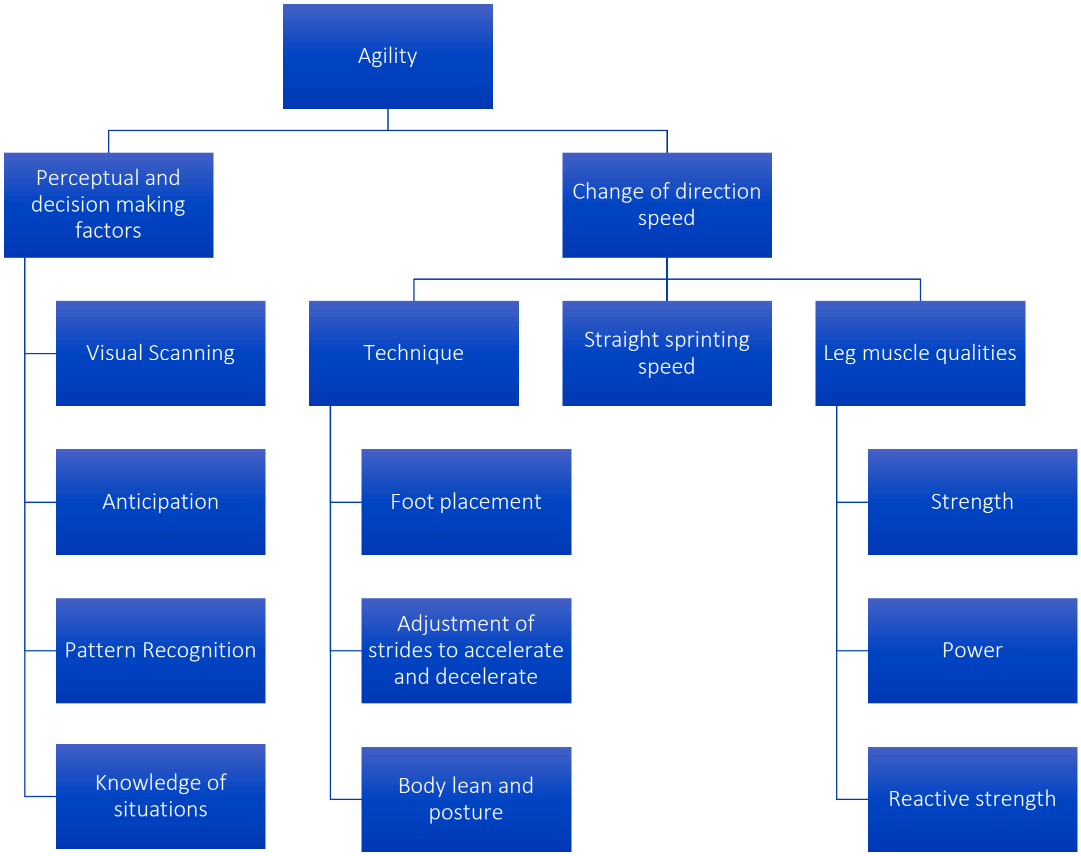
Another element to consider in programming TL is exercise variation. Indeed, prior discussion of the idea (108) suggested optimal program design involves "multilevel diversification" analogous to investing. Applied to sport training, this analogy holds that as an investor deliberately selects a fruitful market that is likely to produce financial yield, so does the coach or sport scientist select activities in order to expose the athlete to training modalities that are likely to improve performance. For team sport athletes, a wide array of activities may provide benefit, and many variables must be considered in order to improve a wide array of performance variables that the team sport athlete must command. Each new idea should be vetted for effectiveness, however, before application.

Variation in programming is important to consider as coaches select processes for exercise inclusion, replacement, and deletion. In theory, an athlete's skill development in any area may become stagnant without some amount of novelty, leading to monotony and a lesser neurological adaptation as the nervous system faces little challenge with non-novel activities (126). To complicate this idea, specificity to the athlete's performance requirements is important, particularly with respect to the cognitive-perceptual elements of agility that appear to separate athletes at the highest levels (147).

Considerations for Agility

Agility is defined as a "rapid whole-body movement with change of velocity or direction in response to a stimulus" (113). Clearly implicated as a quality of great importance in higher caliber performance during invasion games (147), multiple considerations in the development of agility are important for team sport athletes, both physical and cognitive-perceptual in nature. Evaluation of integral components of agility demonstrates multiple interlinked programming targets (Figure 6) (146). Further work in this genre indicates that sport-specific cues are important for athletes to recognize and adjust to during training in order to prepare them for better performances in competition (147). As such, in development of multi-year performance curricula and thorough testing methods, practitioners must consider performance of both closed skills (i.e., change of direction speed demonstrated by an athlete navigating a cone drill) and open skills (i.e., recognizing and responding to a variable stimulus during movement) (114). Recent developments in agility involve reactive tests using sport-specific visual cues in sport-relevant situations (144). It is important to note that the integration of reactive stimuli change many qualities of a change of direction (COD) technique, and ideally are accounted for in a training curriculum and annual plan.

Figure 6. Components of Agility



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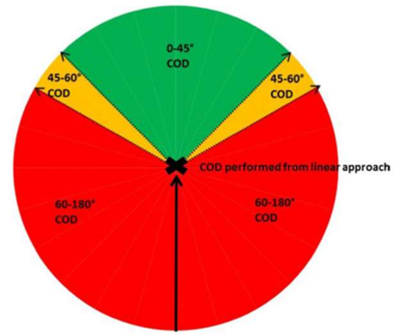
Athletes may choose between split-step (straddle), side-step, and crossover cutting techniques in order to optimize situational performance (29). Indeed, faster athletes demonstrate shorter ground contact time and greater force application during the critical steps of the COD (27), indicating the importance of technical and physical development of COD skills. Of note, different COD angles present specific biomechanical demands, providing more to consider in programming training (30). Coaches should be mindful for skill preparation, as angle and velocity have been identified to impact skill application—both variables are modifiable by the coach (28). Recent recommendations offer guidance on how to best construct programming. A "traffic light system" (Figure 7) provided by Dos'Santos and colleagues (28) seeks to optimize technique application for CODs of specific angle ranges, indicating that technique is likely to affect the performance outcome of a COD.

Figure 7. Change of Direction Traffic Light System

Red ***"Slam on the brakes!"***	**Directional changes 60-180°** • Substantial braking over PFC and potentially steps prior to push-off • Side-step or pivot strategy recommended
Amber ***"Slowdown"***	**Directional changes 45-60°** • Moderate braking prior to push-off • Possible role of PFC • Side-step strategy recommended
Green ***"Go!"***	**Directional changes 0-45°** • Velocity maintenance key • Limited braking requirements, thus PFC not required for braking prior to push-off • XOC strategy faster than sidestep

Key: PFC = Penultimate foot contact; XOC = Crossover cut



From (29)

Nimphius classified agility/change-of-direction (ACOD) drills and offered a progression strategy, suggesting that drills are considered in terms of movement pattern, velocity, and cognitive demands (101). Beginners are advised to focus on skill mastery in basic drills with lower entry velocity, bends and less-demanding cuts, and progress toward greater entry velocities and more diverse and demanding cuts, as appropriate. Further recommendations involved adjusting programming based upon diverse testing procedures, with a greater percentage of programming devoted to skill development in areas that testing identified as requiring improvement (i.e., below normative average) (101).

Dos'Santos and colleagues (29) provided coaching points and proposed a process or how to best program (off-season) activities for three mesocycles within a periodized plan (Table 6). Further development of sport-specific ACOD curricula is recommended by practitioners; of great relevance to development is exactly how much general skill is important in comparison with specific skill development.

Table 6. Cutting Development Framework

	Phase 1	Phase 2	Phase 3
	Technique acquisition	Technique retention and integrity	Movement solutions
Aims	Introduce and teach different cutting techniques and reinforce and modify mechanics using closed, preplanned drills of low intensity (low approach velocity and COD angle).	Cutting drills performed maximally, with increased intensity, to maintain and reinforce optimal mechanics under high mechanical loading.	Increased complexity and sports specificity to provide random environment for athletes to retrieve, select, and perform the different cutting maneuvers. Performed under high cognitive load and constraints to improve decision-making.
Intensity	Progressive increases in intensity through increases in approach velocity, angle, incorporating sports-specific implements, and stimuli.		
	Progressive increases in cognitive load through changes in skill practice and increased contextual interference.		
Example Drills	Closed, preplanned drills, performed sub-maximally. 1. 20-45° XOC: 5m entry and exit 2. 2. 30-90° side-step: 5m entry and exit 30-90° split-step: 2.5m entry and exit	Closed, preplanned drills performed maximally. 1. 20-45° XOC: 5-10m entry and exit 2. 30° XOC to 60° side-step: 5m entry and exit between cuts 3. 30-90° split-step: 2.5m entry and exit Increased complexity with the addition of several CODs and combinations of different cuts. Introduction of sports-specific drills that incorporate an implement/object and open drills performed sub-maximally. 1. Y-agility drill past an opponent/response to ball 2. Mirror drill versus an opponent 3. Cut in response to a pass from a teammate	Evasive open drills, and simulated sports-specific scenarios such as small-sided games, conditioned games, etc. Example: Conditioned evasive SSDs, that is, pitch dimensions and rules: 1. Touch rugby 3 versus 3—limit number of passes to encourage evasive cutting actions 2. Y-agility drill past an opponent from various approach distances and environmental constraints Note: drills will be dependent on the task and sporting demands, and should be designed accordingly
Practice Structure	Block-serial	Serial and random	Random, differential, variance
COD = change of direction; XOC = crossover cut			

From (30)

Considerations for Periodization and Programming of Speed and Repeated Sprint Ability

Similar to agility, speed is an essential biomotor ability for athletes in most team sports. RSA is another biomotor ability with clear speed underpinnings. Like agility training, speed training and RSA are ubiquitous in off-season training sessions across team sports. Because of the common roots in linear acceleration, speed training is often applied in some combination with agility training. Little formal guidance is available for applying periodization strategies to many sports. Hansen (52) recommended a short-to-long approach for speed development in team sport athletes, due to greater opportunities for technical improvement supporting later expression of speed and better synergy with resistance training strategies used in block periodization. In this model, the athlete begins the GP phase with [a secondary emphasis upon] short acceleration (≤15 m), and progresses in distance over sequential training phases toward sprints up to 40 m (52) (as a secondary or tertiary emphasis for most team sport athletes). Applying this concept to team sports may require following top speed emphasis with RSA emphasis, matured from a tertiary emphasis, then a secondary emphasis in prior phases. In a practical sense, this approach pairs well with secondary or tertiary emphasis of acceleration and retaining loads of technical drills during high-volume resistance training of the early GP phase. Acute and residual fatigue has been demonstrated to negatively affect sprinting technique by increasing ground contact time due to reduced force production, particularly in repeat sprinting (34,45). While neurological fatigue has been proposed (but not directly confirmed), clear evidence implicates muscle damage as one variable associated with changes in repeat sprint performance capacity (89). Muscle damage is certainly expected to occur with high-volume resistance training (112), but has also been observed following repeated sprint activity (72), and team sport game play (90,120). As a result, anything greater than retaining loads of speed training may be best placed outside the competitive season, with RSA training cautiously applied at times in the season when recovery is feasible (retaining load or during FOR microcycle). Research is necessary to validate this notion; studies with well controlled methods and multi-dimensional, monitored training programs are rare in high-level athletes.

Considerations for Traditional Aerobic Conditioning Methods, SSGs, and Conditioned Games

For team sports that require endurance and strength, concurrent training (resistance training and aerobic development), may be a necessary reality (18). Concurrent training has long been observed to impair strength gains, beginning with the early work of Hickson (59). Muted strength adaptations are thought to result from conflicting intracellular messaging, however training history may play a role in exactly how much the athlete is affected, as does training volume and structure (88). For example, performing continuous aerobic training for over 20 minutes at moderate intensity (<85% maximal heart rate) has been proposed to elicit the most substantial effect upon strength training effects (88). In their review, Petre and colleagues (106) observed that the concurrent training effects were focused upon lower body and were greater in well-trained subjects; they also noted some moderately-trained subjects appeared to have been affected more. This was proposed to result from unfavorable cell signaling for strength development or higher fatigue that accompanies a more well-trained status.

Separating resistance training from aerobically-targeted training may aid in minimizing intracellular conflict (106). These two methods of training may be separated by as much time as possible (alternating days) or by a number of hours in the day, with resistance training occurring before endurance training (102). Further, due to the importance of strength and power for team sport athletes, greater reliance upon sprint interval training and HIIT may be advantageous for endurance development, as opposed to steady-state aerobic training (88). O'Sullivan (102) provides further recommendations for concurrent training across the training year.

In professional soccer, a variety of HIIT and SSG are common as part of the "tactical periodization" approach (14) (discussed further below). Of note, it is likely that little traditional resistance training occurs within this paradigm due to current cultural norms in European soccer. The reader is referred to Laursen and Buchheit (76) for a survey of HIIT-related programming strategies from practitioners working in a variety of high-level sports settings and Buchheit and Laursen (16) for further discussion of application.

Considerations for Periodization and Programming of Sport Skills

Recent attention has been placed upon updating skill acquisition knowledge for application in high performance sport. In their seminal work, Farrow and Robertson (38) proposed the Skill Acquisition Periodization framework. Similar to resistance training, sport skills may be programmed progressively (easier to harder), varied, and monitored throughout the training year. Effectiveness of sport skills sessions may be improved—just like in resistance training—by quality observation during execution of specific skills. For example, following a practice session, a soccer coach or sport scientist may review video of a passing drill with variables (e.g., rating of pass complexity, successful and unsuccessful attempts, number of passes), which may be graphically represented and tracked over time. This process allows for the coach to modify future practice activities to address specific needs, thereby refining the training process based upon data. This model provides the coach and sport scientist the ability to account for specificity, progression, overload, reversibility, and tedium, and identify issues and provide specific recommendations to improve each area of sport practice sessions. Farrow and Robertson (38) recommended researchers explore intensity, volume, and density effects, reversibility of skills (by level of athlete), if wearable technology may be used to improve efficiency of data collection, and if monotony and strain may be included effectively into the model.

Various monitoring tools have recently been developed to quantify skill challenge, which may be used to guide coaches and sport scientists in programming sport skills as part of the annual plan. For example, Hendricks and colleagues proposed the rating of perceived challenge (RPC) for athletes to subjectively assess the difficulty of a technical skill and produce a marker of internal load using a 0-10 scale, similar to rate of perceived exertion (57). This was applied to a framework Hendricks and colleagues (58) designed to recommend an age- and skill-dependent structure to coaching rugby tackling skills.

Additional developments in structuring training sessions have been made in the area of specialist coaching (defined as coaches who typically work independently with smaller groups). Otte and colleagues (103) used the example of training soccer goalkeepers to illustrate how a specialist coach could structure skills training in a progressive way, with game-representativeness of the task, level of perceived task complexity, and the athlete's level of skill development major areas of consideration, along with planned focus of the individual training session, and the mesocycle emphasis. In addition, the number of athletes involved in the session may influence possible programming. Through the training year, and similar to a theme of traditional periodization, programming can be ordered from easier to harder over time, through the coordination training, skill adaptability training, and performance training phases. Certainly applicable in other areas of team sport, elements of the model are designed for adaptation to the skill development efforts required by those serving in assistant coach roles.

Literature has emerged within the last several decades from European team sport exploring the effects of SSG for conditioning (76). A great benefit of this type of training includes greater exposure to technical and tactical scenarios, which may lead to improved (or maintained) ball handling skills and decision making, in addition to enhancing in-session training motivation. Of note, both evasion games and SSG have been recommended to help sport athletes develop cognitive-perceptual skill (147).

Taking physical development and merging it with technical and tactical performance remains a frontier with little academic exploration. One broader skill development strategy was developed by soccer coach and academic, Vitor Frade, which he termed “tactical periodization.” Detailed analysis suggests “tactical periodization” is more correctly defined as a pedagogical technical-tactical programming strategy involving deliberate sequential manipulation of tactical and technical scenarios, rather than targeting a broad range of physiological variables and skills in a holistic and sequential manner, as seen in periodization strategies; however, the skill development strategies developed in soccer (by Frade and others) and adapted to other football codes (86,133,134) are eloquent ideas whose effectiveness has been minimally evaluated thus far. The strategies of what is referred to as “strength,” “endurance,” “speed,” and recovery programming employed in this approach (14) do appear to provide differing stimuli between sessions (13,71,81). Karlsson (71) observed training and match loads across a season of a high-level (Toppserien) Norwegian women’s team, and noted that most TL values (total distance covered, high speed running, etc.) were much higher in games compared to practice. While results should be interpreted cautiously due to pre- and early season schedule interruptions, negligible or unclear changes were observed across the season, with some significant changes observed between pre-season and in-season or between in-season and post-season testing sessions. The authors observed a reduction in training loads across the second part of the season, with a moderate effect size (d=0.3-0.5) observed for most variables. Only one training load variable (number of accelerations and decelerations) was greater in the second part of the season, on match day (MD)-3. In the tactical periodization philosophy, the hardest training days of a standard week are MD-4 and MD-3; a key programming point is that a reduced training load during these days in particular may elicit an insufficient physiological response to sustain fitness, which in turn may explain any undesirable changes in fitness over a season, if they occur. Initial evidence suggests that further investigation is warranted to explore the capability of Frade’s strategy to maintain fitness compared to other programming methods, particularly in relation to performance testing and training load. Of concern, as the approach is purportedly used in soccer, is the limited ability to offer progressive overload, and limitations upon strength and power development.

Recently, Frade’s concept was applied in principle to rugby union; researchers suggested a game phase-based multi-disciplinary model of applying of tactical/technical training strategies that is more pertinent to gameplay, and applied during the competitive period (133). As Tee and colleagues (133) suggested, efficacy of this strategy requires great planning and communication between the sport coach and the strength and conditioning coach (or perhaps as described more likely a sport scientist with strength and conditioning skills), and offers quality control for team drills and practices, which represents a promising intra-organizational alliance ripe for future exploration in high level sport. Tee and colleagues (133) posed several excellent questions yet to be resolved: optimal level of play (youth through adult professional/international) for the model’s application, optimal timeline of installation of this approach, effectiveness of related physiological adaptations compared to traditional means, and is decision-making actually improved compared to other pedagogical strategies? Each of these answers may be provided by specialists within the field of sport science.

Considerations for Periodization and Programming in Tactical Populations

Because many tactical units resemble sport teams in some ways at the operational level (e.g., a 12-person Special Forces Operational Detachment Alpha that trains and deploys together), periodization and programming of training for tactical populations may also be constructed in a similar manner to team sports. In the absence of a standalone chapter, this genre is discussed briefly here, as tactical performance is another promising frontier for sport science. Particularly as a result of the establishment of human performance and rehabilitation programs within military units

(THOR3, POTFF, H2F, etc.), performance and rehabilitation program infrastructure has recently grown in what has been arguably the most rapid growth in the strength and conditioning and rehabilitation fields to date.

While service-based programs have been previously described in the literature (6), the industry has been challenged to provide consistent service and demonstrate value to military populations due to training-related and other unpredictable occupational demands. Early evidence in military populations shows some value in using short-term programming strategies consistent with existing periodization models (2,54,55). In military personnel, limited research is available to evaluate the long-term effects of contemporary programming thought to enhance performance in sporting populations, nor is there yet substantial evidence to highlight any particular periodization strategy that appears to be most effective. Similar to athletic populations, skill development progression, common injury sources, and fatigue are all factors to be accounted for, along with limited access to equipment and longstanding popularity of cultural training methodologies. Due to the above issues, optimizing performance in military populations remains a frontier for training theorists and practitioners alike. At this time, practitioners are bound to working around military obligations in most organizations, often with isolated responsibilities (e.g., strength and conditioning coach, not IST). Further development in the tactical sector requires more holistic considerations such as long-term development of military personnel (including skills). Like in sports, organizations with sufficient resources are encouraged to evaluate long-term processes and match resources accordingly.

Summary

Best-practices in training for all levels of athletes involve periodization and deliberate programming to enhance elements of sport performance; however, many frontiers remain for researchers and practitioners alike. Block periodization strategies appear valuable for team sport athletes; resistance training can be integrated with other training modes within this paradigm. Because biomotor abilities and skills are interdependent, coaches and sport science practitioners are charged to choose training methods deliberately and monitor athletes carefully. The team sport setting provides many opportunities and challenges to planning training. Guided by a monitoring program, structured training may be modified according to need by coaches, and refined over time to elicit greater effectiveness. Further, sport organizations are encouraged to look through a sport science lens at their competitive schedule in the interest of athlete safety and to foster an environment favorable for high performance.

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