University of Science and Technology Mohammed Boudiaf ORAN

Institute of Science and Techniques of Physical and Sports Activities

COURSE PLAN

Planning and Programming in Physical Preparation

DERBAL FETHI

Djaballah Khaled

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Field: Sports training

Specialty: physical and sports preparation

Table of Contents:

I. Course Information

II. Course Presentation

III. Content

IV. Prerequisites

V. Learning Objectives and Aims

VI. Learning Assessment Methods

VII. Teaching-Learning Activities

VIII. Operational Modalities

IX. Support Resources

I- Course Information:

Institute: Sciences and Techniques of Physical and Sports Activities
Department: Sports Training
Target Audience: 1st Year Master in Physical and Sports Preparation
Course Title: Planning and Programming in Physical Preparation
UEF: Fundamental
Semester No. = 02
VHS: 45 H (Weeks 14–16)
VHH Lecture: 1:30
VHH Personal Work: 1:30
Coefficient: 03
Credit: 05
Schedule: Saturday and Tuesday from 8:00 AM to 12:00 PM
Room: 02
Instructor: Conference: **Dr/ Fethi DERBAL**, Dw: **Dr/ Djaballah Khaled**
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Laboratory Availability: Saturday, Tuesday from 8:00 AM to 12:00 PM
Email: All correspondence via email will be answered through the same channel.

II. Course Presentation:

This course is intended for 1st-year Master's students in Sports Training and Physical Preparation, in accordance with the new LMD system program.
It focuses primarily on the **basic concepts of sports planning and programming**.

The course is structured as follows:
Conference No. 01 Introduction to Planning and Programming and Needs Analysis in Sports Training
Conference No. 02 Monitoring and Control of Training Load
Conference No. 03 Fundamental Principles of Periodization and Types of Sports Planning
Conference No. 04 Organization of Sports Training and the Role of the Coach in Designing Plans
Conference No. 05 Periodization, Programming, and Tactical Strategies in Sports Training
Conference No. 06 Traditional Linear Planning Model and Block Periodization in Sports Training
Conference No. 07 Long-Term Planning and Annual Planning in Sports Training
Conference No. 08 Design of Macrocycle, Mesocycle, Microcycle, and Training Session in Sports Planning
Conference No. 09 Sports Planning for Individual vs. Team Sports and Individual Differences
Conference No. 10 Sports Planning for Youth Athletes and Elite Athletes
Conference No. 11 Planning and Competition Management
Conference No. 12 Recovery, Regeneration, and Nutrition in Sports Planning
Conference No. 13 Reathletization in the Context of Sports Planning
Conference No. 14 Adaptation of Planning to Environmental Constraints
Conference No. 15 Future Perspectives: Artificial Intelligence and Sports Planning
Conference No. 16 Integration of Psychological and Ethical Dimensions in Sports Planning

III - Content:

Conference No. 01 Introduction to Planning and Programming and Needs Analysis in Sports Training. **P : 01- 09**
Planning
Programming
Periodization
Organization
Conceptual Foundations of Needs Analysis

Conference No. 02 Monitoring and Control of Training Load . **P : 10-16**
Importance of Continuous Monitoring
Biomarkers of Fatigue and Adaptation
Quantification of Training Load
Control of Training Load

Conference No. 03 Fundamental Principles of Periodization and Types of Sports Planning . **P :17- 25**
Theoretical and Historical Foundations of Periodization
Structural Components of Periodization
Fundamental Principles of Periodization Application

Conference No. 04 Organization of Sports Training and the Role of the Coach in Designing Plans . **P : 26 -33**
Progressivity in the Development of Physical Components
Organization of Training Units and Cycles
Key Responsibilities of the Coach in Planning

Conference No. 05 Periodization, Programming, and Tactical Strategies in Sports Training . **P :34 - 44**
Concepts of Periodization
Periodization Models
Programming of Training Loads

Conference No. 06 Traditional Linear Planning Model and Block Periodization in Sports Training . **P: 45 -53**
Fundamental Principles of the Traditional Linear Model
Fundamental Principles of Block Periodization

Conference No. 07 Long-Term Planning and Annual Planning in Sports Training . **P: 54 -65**
Fundamental Principles of Long-Term Planning
The LTAD Model (Long-Term Athlete Development)
Sustainable Development Strategy

Conference No. 08 Design of Macrocycle, Mesocycle, Microcycle, and Training Session in Sports Planning . **P : 66 - 80**

Macrocycle
Mesocycle
Microcycle

Conference No. 09 Sports Planning for Individual vs. Team Sports and Individual Differences . **P :81- 89**
Theoretical Foundations of Sports Planning
Planning for Individual Sports
Planning for Team Sports

Conference No. 10 Sports Planning for Youth Athletes and Elite Athletes . **P : 90 -99**
Specificities of Youth Athlete Development
Principles of Adapted Planning for Youth Athletes

Conference No. 11 Planning and Competition Management . **P : 100 - 105**
Pre-Competition Loading
Post-Competition Transition Loading
Temporal Programming and Management of Multiple Competitions

Conference No. 12 Recovery, Regeneration, and Nutrition in Sports Planning . **P : 106 – 114**
Importance of Recovery in Sports Training
Foundations of Regeneration and Nutrition
Athlete Nutritional Needs

Conference No. 13 Reathletization in the Context of Sports Planning . **P : 115 - 123**
Definition and Distinction: Reathletization vs. Medical Rehabilitation
Role of the Coach and Physical Trainer
Functional Phases of Reathletization and Key Principles

Conference No. 14 Adaptation of Planning to Environmental Constraints . **P : 124 - 127**
Altitude
Heat and Humidity
Cold
Air Pollution
Adaptation Strategies

Conference No. 15 Future Perspectives: Artificial Intelligence and Sports Planning.**P:128 -133**
Technological Foundations of Modern Planning
Current and Emerging AI Applications
Sports Planning Platforms and Software

Conference No. 16 Integration of Psychological and Ethical Dimensions in Sports Planning. **P : 134 - 140**
Theoretical Foundations of Sports Psychology
Periodization of Psychological Skills
Psychological Intervention Methodologies

IV- Prerequisites:

To get the most out of this course, you must:
• Understand the basics of sports training science.
• Be familiar with biological and physiological concepts related to training (load, adaptation, recovery).
• Have a basic understanding of training load components and types.
• Be able to analyze the structure of a training session.

V - Learning Objectives and Aims:

-General Course Objectives :

• Enable students to understand the principles and theoretical foundations of planning and programming in sports training and physical preparation.
• Develop their ability to design annual and seasonal training plans based on individual and athletic characteristics.
• Empower students to use modern performance planning methodologies.
• Enable them to understand the relationship between training load, recovery, and adaptation at different stages of the sports season.
• Prepare students to engage with new advances in planning, such as the use of modern technologies and interactive programming.

- Learning objectives: (Procedural – Measurable):

By the end of this course, the student must be able to:

1. Precisely define the concepts of planning and programming, as well as their types.
2. Distinguish the stages of sports planning and interpret the objectives of each.
3. Analyze training load and design an effective monitoring plan.
4. Develop annual training plans aligned with performance and competition goals.
5. Design training sessions (macro, meso, micro) adapted to a specific category or level.
6. Integrate recovery and regeneration principles into the training plan.
7. Use software or digital tools to plan and analyze sports performance.
8. Evaluate a training plan based on performance indicators and physical preparation.
9. Adapt the training plan in case of injury using sports development strategies.

10. Propose a personalized training plan that addresses individual differences between athletes.

VI. Learning Assessment Methods:

The final evaluation is conducted through:
a- Continuous and regular assessment, representing **25% of the final grade**, allowing you to earn points throughout the semester. This evaluation is carried out in various forms:

- Presence
- Participation
- Homework assignments

b- Written quiz covering all material studied in the course chapters. The quiz grade represents **25% of the final grade**.
c- Final exam covering all content taught during the semester. This exam counts for **50% of the final grade**.

VII. Teaching-learning activities:

Understanding and mastering evaluation tools and methods is crucial for your success. To support your learning, we have designed a comprehensive program combining **in-person** and **distance** activities.

In-Person:

• **Participatory debates**: Stimulate critical thinking and exchange ideas with peers during lively discussions on key questions.
• **Directed works (TD)**: Apply your knowledge to real-world cases and deepen your understanding of concepts covered in each chapter.
• **Practical laboratory work**: Implement various evaluation techniques in a controlled environment with personalized guidance.

At a distance:

• **Interactive quizzes**: Test your knowledge and identify strengths and weaknesses using varied formats (MCQ, true/false, etc.).
• **Educational writing**: Strengthen your understanding by reformulating and synthesizing key course concepts.

By combining these approaches, you maximize your chances of success and develop a solid understanding of **planning and programming methods in training and physical preparation**.

VIII- Operational Modalities:

The course is organized into:

- **Theoretical session** to transmit all knowledge (basic definitions and various methods of planning and programming in training and physical preparation).
- **Directed works session (TD)** for each learning unit to help you mobilize acquired knowledge.
- **Practical work session** to implement all content related to the topics taught.

In addition to in-person sessions in the classroom and pedagogical laboratory, **distance learning** is conducted via the teaching platform to deepen concepts covered in person.

IX -Support resources :

Resources are made available to you on the platform:

- **Pedagogical support**: This resource is essential for preparing the theoretical session (in-person).
- **TD sheets**: This resource compiles all methods and tools needed during TD sessions.

Conference No. 01 Introduction to Planning and Programming and Needs Analysis in Sports Training

Introduction :

Planning and needs analysis form the fundamental pillars of modern sports training, enabling a scientific structuring of the training process to optimize performance, prevent injuries, and avoid overtraining. Planning establishes a strategic roadmap, translated into precise programs through programming and periodization, to achieve performance peaks at key competitions. At the same time, needs analysis is an essential diagnostic step, assessing the specific demands of the discipline, the individual characteristics of the athlete, and the overall context, in order to design individualized and adapted programs. Together, these processes transform a generic approach into a scientific, dynamic, and personalized approach, promoting sustainable progression and maximizing efficiency while preserving the health and motivation of athletes.

1. Definitions and Key Concepts of Planning :

1.1. Planning :

Planning is a strategic process defining short, medium, and long-term objectives and establishing the means to achieve them. According to Bompa & Buzzichelli (2019), it constitutes a "roadmap" organizing training and recovery loads to achieve a performance peak at specific times.

• Objectives: Improve performance (e.g., +10% running speed), win competitions, prevent overtraining.

• Resource Analysis: Evaluation of time slots, equipment, staff, and athlete profile (age, sex, level).

• Strategies: Structuring into cycles (macro-, meso-, micro-cycles) with SMART objectives (Specific, Measurable, Achievable, Realistic, Time-bound).

• Practical Example: A 400 m runner plans a season to achieve a time of 46 s at the national championships, with a macrocycle integrating strength and speed blocks.

1.2. Programming :

Programming translates planning into precise training content, specifying the "how" and "when" of sessions. It includes:

• Volume: Amount of work (e.g., 10 km run, 20 repetitions).

• Intensity: Effort level (e.g., 80% VMA, 70% 1RM).

• Frequency: Number of sessions per week.

• Type: Nature of exercises (HIIT, strength, technique).

• Recovery: Time between repetitions/sets (e.g., 2 min between sprints).

• Practical Example: A footballer programs 4 sessions/week: 2 HIIT (90% FCmax, 30 min), 1 strength (60% 1RM, 45 min), 1 technique (90 min).

1.3. Periodization :

Periodization organizes training loads into time cycles to achieve performance peaks, alternating overload and recovery (Matveiev, 1964). It is divided into:
• **Preparatory Phase**: Development of base capacities (endurance, general strength).
• **Competitive Phase**: Refinement of specific qualities, reduced volume, increased intensity.
• **Transition Phase**: Active recovery to avoid burnout.
• **Models:**
o Linear (Matveiev): Progression from volume to intensity.
o Block (Issurin, 2008): Focus on one quality (strength, endurance) for 2–6 weeks.
o Non-Linear: Daily/weekly variations in volume/intensity.
o Double Peak: Two annual peaks (e.g., football, basketball).
• **Practical Example**: A swimmer follows linear periodization with 12 weeks of preparation (aerobic endurance, 30 km/week), 8 competitive weeks (speed, 20 km/week), and 4 transition weeks (light swimming, yoga).

1.4. Organization :

Organization links planning, programming, and periodization by coordinating resources (schedules, staff, equipment) and ensuring continuous monitoring.
• Timing: Precise session schedules (e.g., 6–8 PM).
• Monitoring/Evaluation: Regular tests (VMA, CMJ, HRV) and adjustments.
• Flexibility: Adaptation to unforeseen events (injuries, calendar changes).
• Practical Example: A rugby team organizes a macrocycle with fixed time slots, a multidisciplinary staff (coach, physical trainer, nutritionist), and biweekly tests (GPS, RPE).

2. Structure of Planning :

2.1. Time Units :

Unit	Duration	Objective	Example
Career Plan	4–8 years	Long-term development (LTAD)	A tennis player's path to ATP top 100
Annual Plan (Macrocycle)	6–12 months	Seasonal performance	Football season
Mesocycle	3–6 weeks	Specific quality	Maximal strength block
Microcycle	3–10 days	Weekly loads	General preparation week
Session	60–180 min	Punctual stimulus	HIIT + strength session

2.2. Training Loads :

• External Load: Objective measures (distance, repetitions, speed).
• Internal Load: Physiological responses (HR, lactate, HRV).
• Types:
o Physical: Bioenergetic/biomechanical demand (e.g., 10 km at 70% VMA).

o Cognitive: Information processing (tactical analysis).
o Affective: Emotional management (resilience, motivation).

3. Fundamental Principles :

• Specificity: Adapt training to sport demands (e.g., endurance for marathon, power for weightlifting).
• Progressivity: Gradually increase volume/intensity (e.g., +5% volume/week).
• Individualization: Consider athlete profile (age, sex, level, injuries).
• Reversibility: Maintain minimal stimulus to preserve adaptations.
• Load-Recovery Alternation: Integrate active rest periods for supercompensation (Matveiev, 1983).

4. Periodization: Models and Applications :

4.1. Linear Model (Matveiev) :

• Preparatory: High volume, moderate intensity (e.g., 30 km/week swimming).
• Competitive: Reduced volume, high intensity (e.g., sprints at 95% VMA).
• Transition: Active rest (yoga, light cycling).
• Application: Suitable for single-calendar sports (athletics, swimming).

4.2. Block Periodization (Issurin, 2008) :

• Focus on one quality (strength, endurance) for 2–6 weeks.
• Example: A weightlifter dedicates 4 weeks to maximal strength (80–90% 1RM), followed by 4 weeks of explosive power.

4.3. Non-Linear Periodization :

• Daily/weekly variations in volume/intensity.
• Example: A basketball player alternates heavy sessions (HIIT, 90% FCmax) and light sessions (technique, 60% FCmax) in a microcycle.

4.4. Double Peak :

• Two annual peaks for team sports (e.g., football: mid-season, finals).
• Example: A footballer plans a peak in December (Cup) and May (Championship).

5. Programming: Variables and Tools

5.1. FITT-RA Variables :

• Frequency: Number of sessions (e.g., 5/week).
• Intensity: Effort level (e.g., 80% VMA, RPE 7/10).
• Time: Duration (e.g., 60 min/session).
• Type: Exercise nature (HIIT, strength, tactics).

• Recovery: Time between sets/sessions (e.g., 2 min between sprints).
• Adaptation: Progression via overload (e.g., +5% volume/week).

5.2. Progression Model :

• Load-Fatigue-Supercompensation:

1. Load > usual tolerance.
2. Acute fatigue (24–72 h).
3. Supercompensation (48–96 h) with adequate recovery.
4. New stimulus before return to baseline.
   • Example: A runner increases volume from 40 to 48 km/week, followed by 3 days of active recovery (cycling, 30 min).

5.3. Quantification Tools :

• GPS/HR: Distance, speed, TRIMP (e.g., Catapult, Polar).
• Physiological Tests: VMA, lactate, HRV (e.g., WHOOP).
• Psychometric Monitoring: POMS, stress questionnaires (RESTQ-Sport).
• Example: A tennis player uses Catapult GPS to measure 8 km per match and adjusts intensity via HRV (baseline > 60 ms).

6. Logistical Organization :

6.1. Annual Mapping :

• Competitions: A goals (championships), B (tournaments), C (friendlies).
• School/Professional Periods: Integration of external constraints.
• Camps/Stages: Intensive sessions (e.g., 10 days at altitude).
• Recovery: Active rest periods (yoga, light swimming).

6.2. Multidisciplinary Staff :

• Head coach, physical trainer, physiotherapist, nutritionist, psychologist, video analyst.
• Example: A football team integrates a video analyst to adjust tactics and a psychologist to manage pre-match stress.

6.3. Infrastructure Management :

• Optimized time slots, equipment maintenance, safety standards.
• Example: A weight room is reserved from 4–6 PM for strength sessions, with regular equipment checks.

7. Monitoring, Evaluation, and Adjustments :

• Continuous Monitoring: Inter-mesocycle tests (VMA, CMJ, isometric strength).
• Dashboard: Software like TrainingPeaks or Smartabase to track RPE, HRV, PlayerLoad.
• Staff Meetings: Weekly/biweekly adjustments based on data.
• Reverse Planning: Shift peaks in case of injury (e.g., 2 weeks rest for a sprain).
• Example: A sprinter adjusts their microcycle after a VMA test showing a 5% drop, incorporating more active recovery.

8. Dimensions of Planning :

• Temporal: Long-term (LTAD, 4–8 years), medium-term (season), short-term (session).
• Physiological: Supercompensation, residual effects (Issurin, 2010).
• Physical: Strength, speed, endurance, coordination.
• Technical: Refinement of specific gestures.
• Tactical: Game analysis, decision-making.
• Psychological: Resilience, confidence (Deci & Ryan, 2000).
• Nutritional: Phase-adapted diets (e.g., +500 kcal in preparation).
• Social/Educational: Sport-study balance, educational values.
• Technological: GPS, HRV, digital platforms.
• Administrative: Budget, facilities, staff.

9. Contemporary Challenges :

• Competition Density: Packed calendars (e.g., 50 matches/year in football) complicate cycles.
• Interdisciplinarity: Coordination between coaches, nutritionists, psychologists.
• Monitoring: Integration of data (Smartabase, TrainingPeaks) for real-time adjustments.
• Individualization: Variable responses between athletes (Kiely, 2018).

10. Case Study: Professional Footballer :

A 20-year-old footballer follows an annual plan:
• Macrocycle: 10-month season (August–May), with peaks in December (Cup) and May (Championship).
• Mesocycles:
o Preparation (July–August): Aerobic endurance (10 km/week), strength (60% 1RM).
o Competition (September–April): Explosive power, tactics, reduced volume (6 km/week).
o Transition (June): Active rest (yoga, light swimming).
• Microcycle: 5 sessions/week (2 HIIT, 1 strength, 1 tactics, 1 recovery).
• Monitoring: Catapult GPS (PlayerLoad 700/match), WHOOP HRV (> 60 ms), monthly VMA tests.
• Result: Maximal speed improvement (+5%) and qualification for the final.

11. Conceptual Foundations of Needs Analysis :

Needs analysis is a systematic process of identifying and evaluating the demands of a sports discipline and the individual characteristics of the athlete, aimed at designing an optimal

program (Turner & Stewart, 2021). It fits into a multidimensional framework (Jeffreys & Moody, 2016), integrating:
• Discipline analysis: Specific demands and performance factors.
• Athlete analysis: Strengths, weaknesses, history.
• Context analysis: Environmental, material, and organizational constraints.
Neglecting this step leads to standardized, inadequate programs (Joyce & Lewindon, 2014). It targets limiting factors, prioritizes actions, and ensures a rational approach, using tools like SWOT analysis (Strengths, Weaknesses, Opportunities, Threats).

11.1. Analysis of Sports Discipline Demands :

Demand analysis is structured in a hierarchical model (Bourdon & Cardinale, 2017), distinguishing:
• Primary Demands: Energy systems (aerobic, anaerobic) and physical qualities (strength, speed, endurance, power). For example, identification of limiting mechanisms via time-motion analysis and physiological response measurement (Buchheit & Laursen, 2013).
• Secondary Demands: Motor and technical skills, including movement patterns, coordination, and timing. Use of technologies like video analysis to quantify joint angles and execution speeds (Verkhoshansky & Siff, 2009).
• Tertiary Demands: Tactical and decision-making components, such as decision-making under pressure and adaptability (Davids et al., 2013).
Psychological demands are also essential, covering concentration, stress management, motivation, and communication (Weinberg & Gould, 2019).

11.2. Analysis of Individual Athlete Characteristics :

Individual assessment covers multiple dimensions to build a complete profile and identify priority areas.
• Physical Profile Assessment: Standardized tests measure body composition, strength (1RM, strength endurance), speed, endurance (VO_2max), mobility, and stability (Turner et al., 2022). For example, Wingate test for anaerobic power or Cooper test for endurance.
• Technical and Tactical Assessment: Skill analysis via video, observation grids, and simulations to evaluate technical efficiency, stability under fatigue, and tactical intelligence (Davids et al., 2013).
• Psychological and Behavioral Profile: Assessment of traits (resilience, confidence) and skills (visualization, self-talk) via questionnaires like POMS or RESTQ-Sport (MacNamara & Collins, 2015).
• Personal History and Context: Consideration of training history, injuries, life constraints (professional, social), and motivational factors (Coutts et al., 2018).

11.3. Context and Constraint Analysis :

• Material and Human Resources: Identification of facilities, equipment, available expertise, and monitoring tools (Bishop, 2008).
• Temporal and Organizational Constraints: Analysis of competitive calendar, availability,

academic/professional constraints, and travel (Mujika et al., 2018).
• Environmental and Climatic Factors: Assessment of climatic conditions (temperature, altitude) and acclimatization strategies (Racinais et al., 2015).

12. Methodologies and Tools for Analysis :

• Quantitative Approaches: Physical tests (strength, endurance), time-motion analyses, physiological monitoring (HRV, lactatemia), and biomechanical (inertial sensors).
• Qualitative Approaches: Interviews, structured observations, video analyses, and psychological questionnaires (O'Sullivan et al., 2021).
• Emerging Technologies: GPS, accelerometers, monitoring apps, and artificial intelligence for continuous and predictive analysis (Cardinale & Varley, 2017).

13. Integration of Analysis into the Planning Process :

• Goal Setting: SMART objectives stem from identified gaps, prioritized by impact and timing (Weinberg & Gould, 2019).
• Training Content Prioritization: Criteria include performance impact, adaptation timelines, quality interactions, and motivation (Zatsiorsky & Kraemer, 2006).
• Continuous Evaluation Process: Regular reassessment adjusts goals and priorities, integrating new data for adaptive planning (Robertson & Joyce, 2018).

14. Practical Example: Preliminary Analysis Sheet (Road Cycling)

Variable	**Value**	**Elite Reference**	**Gap**
VO_2max (ml·kg⁻¹·min⁻¹)	62	72–78	–12%
5″ Power (W·kg⁻¹)	11.8	14–16	–20%
HRV ln rMSSD	3.68	4.0–4.3	–8%

For a cyclist, this identifies limiting factors (anaerobic power), leading to goals like +8% VO_2max in 12 weeks, with means such as HIIT and explosive strength.

Conclusion :

Planning and needs analysis form an integrated system that transforms sports training into a scientific, individualized, and dynamic process. Planning, through programming, periodization, and organization, structures training loads to achieve performance peaks while preserving health and avoiding overtraining. Needs analysis, as the initial compass, ensures a personalized approach by identifying discipline demands, athlete characteristics, and contextual constraints. By combining quantitative, qualitative, and technological methods, these processes optimize performance, minimize risks, and strengthen motivation. Modern technologies (GPS, HRV, platforms like TrainingPeaks) and a multidisciplinary approach enable continuous adaptation, while flexibility remains essential to respond to unforeseen events, ensuring lasting success and excellence in sports training.

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Conference No. 02 Monitoring and Control of Training Load

Introduction :

Monitoring and controlling training load are essential to optimize sports performance while preventing overtraining and injuries. We will explore the importance of continuous monitoring, biomarkers of fatigue and adaptation, the relationship between load and recovery, as well as modern tracking tools (WHOOP, Polar, Garmin). A scientific and individualized approach, integrating digital platforms and response indicators, enables dynamic load management, ensuring an optimal balance between effort and recovery.

1. Importance of Continuous Monitoring :

1.1. Monitoring Objectives :

Continuous monitoring aims to (Soligard et al., 2016):
• Performance Optimization: Adjust loads to maximize physiological adaptations (e.g., VO_2max, strength).
• Overtraining Prevention: Detect early signs of fatigue to avoid overtraining syndrome (Meeusen et al., 2013).
• Individualization: Adapt plans to athletes' specific responses, considering their physical condition, age, and experience.

1.2. Advantages :

• Precision: Objective data (GPS, HRV) and subjective data (RPE) allow targeted adjustments.
• Injury Prevention: Regular monitoring reduces risks associated with excessive load (Halson, 2014).
• Immediate Feedback: Modern tools provide real-time data, facilitating quick decisions.

1.3. Practical Example :

A cyclist monitored via a Polar device shows an elevated heart rate at low intensity (e.g., 140 bpm at 60% VO_2max), signaling accumulated fatigue. The coach reduces the microcycle volume by 20%, incorporating an active recovery session (light cycling, 30 min at 50% FCmax).

2. Biomarkers of Fatigue and Adaptation :

2.1. Main Biomarkers :

Biomarkers provide objective indicators of physiological state (Plews et al., 2013; Meeusen et al., 2013):
• Heart Rate Variability (HRV): Reflects autonomic nervous system balance. Low HRV (e.g., ln rMSSD ↓ > 10%) indicates fatigue or high stress.
• Creatine Kinase (CK): Marker of muscle damage, with an alert threshold at 800 $UI \cdot L^{-1}$

(football).
• Cortisol and Testosterone: A T/C ratio < 0.35 signals overtraining risk.
• Blood Lactate: Measures anaerobic intensity and recovery capacity (e.g., lactate threshold at 4 mmol·L⁻¹).
• Salivary Markers: Salivary cortisol or α-amylase, measured 30 minutes after waking, indicate acute stress.

2.2. Practical Application :

For a marathon runner, low HRV measured via WHOOP (e.g., 50 ms) after an intensive week (ACWR > 1.5) leads to a 30% volume reduction (from 60 to 40 km/week) and lactate analysis to confirm the anaerobic threshold (4 mmol·L⁻¹). Elevated CK post-intensive training (> 800 UI·L⁻¹) indicates a need for 48 hours of active recovery (yoga, 30 min).

2.3. Limitations :

• Accessibility: Blood tests (CK, cortisol) require a laboratory, increasing costs.
• Context: Biomarkers must be interpreted considering sleep, stress, or nutrition.

3. Relationship Between Load and Recovery :

3.1. Basic Principles :

• Progressive Overload: Gradual load increase to stimulate adaptation without excess (Zatsiorsky & Kraemer, 2006).
• Adequate Recovery: Active/passive rest periods to allow physiological regeneration.
• Load/Recovery Ratio: A balanced ratio promotes supercompensation, while imbalance leads to overtraining (Gabbett, 2016).

3.2. Imbalance Indicators :

• Fatigue: Performance decline, insomnia, low HRV, or high RPE for moderate loads.
• Adaptation: Performance improvement, stable HRV, or rapid post-effort HR recovery.
• Example: A basketball player with low HRV (↓ 15%, 50 ms) and RPE of 8/10 after three intensive weeks requires an active recovery week (yoga, light swimming, 20–30 min).

3.3. ACWR Model :

The acute:chronic workload ratio (Acute:Chronic Workload Ratio) guides management (Gabbett, 2016):
• Safe Zone: 0.8–1.3.
• Gray Zone: 1.3–1.5 (caution).
• Red Zone: > 1.5 (injury risk × 2.5).
• Monotony: Weekly load / standard deviation, threshold < 2.0 (Foster, 2001).

4. Daily Monitoring Tools :

4.1. Digital Platforms :

• WHOOP: Measures HRV, sleep, and daily load, with a recovery score (0–100).
• Polar: HR monitors with intensity zone analysis and sleep tracking.
• Garmin: Watches measuring distance, speed, HR, and estimated VO_2max.
• Smartabase: Integrates GPS, HRV, and RPE for comprehensive analysis.

4.2. Other Tools :

• RPE Scale: sRPE = RPE × duration (min), with an alert threshold > 400 a.u. for intensive microcycles (Foster, 2001).
• GPS (Catapult, STATSports): Measures distance, speed, and accelerations (e.g., PlayerLoad™).
• Questionnaires: RESTQ-Sport (fatigue score > 3.2) or POMS (gap > 5 points) to assess psychological state.

4.3. Practical Example :

A footballer uses a Catapult sensor (10 km covered, 20 accelerations > 5 $m \cdot s^{-2}$, PlayerLoad 750) and WHOOP (HRV 50 ms, recovery score 30%). The coach programs a light session (RPE < 3, 30 min of technical drills) to promote recovery.

5. Response and Overload Indicators :

5.1. Positive Response :

• Performance: Improvement in 400 m time (e.g., ↓ 1 s), 1RM (↑ 5%), or maximal speed.
• Recovery: Rapid return of HR to rest (< 100 bpm in 2 min), stable/increasing HRV (> 60 ms).
• Example: A weightlifter increases 1RM by 5% (from 100 to 105 kg) after a strength mesocycle, with stable HRV (65 ms).

5.2. Overload :

• Persistent Fatigue: Performance decline, low HRV (< 50 ms), or high RPE (> 8/10) for moderate loads.
• Physiological Markers: CK > 800 $UI \cdot L^{-1}$, elevated cortisol (T/C < 0.35).
• Psychological Signs: Lack of motivation, sleep disturbances (HADS score > 8).
• Management: Immediate load reduction (10–30%) or addition of active rest (yoga, light cycling).
• Example: In a rugby program, low HRV (50 ms) and average RPE of 8/10 after closely spaced matches lead to a 20% volume reduction (from 6 to 4.8 km/session) and cryotherapy integration (-110 °C, 3 min).

6. Integration into Planning :

6.1. Decision Loop :

• Acquisition: Daily data collection (HRV, RPE, GPS).
• Analysis: Calculation of indicators (ACWR, monotony, strain).
• Action: Load adjustment via platforms like TrainingPeaks.

6.2. Practical Example :

A footballer shows an ACWR of 1.55 and a 15% HRV drop (from 65 to 55 ms). The coach reduces the session to 35 minutes of light technical work, followed by cryotherapy (-110 °C, 3 min). A re-test HRV the next day shows normalization (+8%, 60 ms).

6.3. Integration into Planning Cycles :

• Microcycle: Daily adjustment based on real-time feedback (RPE, HRV). Example: A runner's microcycle includes 3 intense sessions, but low HRV (50 ms) on day 3 leads to adding a rest day (light cycling, 20 min).
• Mesocycle: Weekly or biweekly adjustment based on trends (e.g., progressive volume increase over 4 weeks). Example: A triathlete's general preparation mesocycle increases swimming volume from 20 to 30 km over 6 weeks, with adjustments based on GPS and RPE data.
• Macrocycle: Long-term planning integrating recovery periods to avoid fatigue accumulation (Mujika & Padilla, 2003). Example: An annual macrocycle for a track athlete includes load peaks before championships, with adjustments based on biomarkers (CK < 400 UI·L^{-1}, T/C > 0.45).

7. Quantification of Training Load :

7.1. Definition :

Training load quantification evaluates the total physical work performed by an athlete over a given period, combining volume, intensity, and frequency, to optimize progression and prevent overtraining.

7.2. Load Components :

• Volume: Total work amount (e.g., 40 min of aerobic endurance, 10 km covered).
• Duration: Effort time without rest (e.g., 15 min at 80% FCmax).
• Intensity: Effort level (e.g., 80% 1RM, 90% maximal speed).
• Repetition: Number of times an exercise is performed (e.g., 5x30 m sprints, 20x abdominals).
• Set: Group of repetitions at the same pace (e.g., 5x30 m sprints, 3 sets, 450 m total).
• Recovery: Time between repetitions/sets, often active, depending on intensity and volume.

7.3. Quantification Methods :

7.3.1. Calvert Model (1976) :

• Formula: UA = duration (min) × intensity (W/kg).
• Example: A 70 kg athlete runs 60 min at 150 W. Load = 60 × 150 = 9000 UA.
• Advantages: Simple, accurate for endurance sports (swimming, running, cycling).
• Limitations: Ignores specificity and training variability.

7.3.2. Lucia Model (2003) :

• Formula: UE = duration (min) × k × IFC × S × V.
o k: Intensity factor (0.6 low, 1.0 moderate, 1.4 high).
o IFC: Individual factor (sex, fitness).
o S: Specificity (1.0 for specific activity, < 1.0 otherwise).
o V: Variability (> 1.0 for variable load, < 1.0 for stable).
• Example: A runner (male, good fitness) runs 60 min at 150 bpm, specific, variable. Load = 60 × 1.0 × 1.0 × 1.0 × 1.2 = 72 UE.
• Advantages: Accounts for specificity and variability, suitable for endurance sports.

7.3.3. Foster Model (1996) :

• Formula: Load = RPE × duration (min).
• Example: An athlete rates effort at RPE 15 for 60 min. Load = 15 × 60 = 900 a.u.
• Advantages: Simple, subjective, useful without physiological tools.
• Limitations: Depends on individual perception, inter-athlete variability.

7.3.4. Banister TRIMP Model :

• Formula: TRIMP = duration (min) × k × IFC.
o k: Intensity factor (0.6 low, 1.0 moderate, 1.4 high).
o IFC: Individual factor (sex, fitness).
• Example: A runner (male, good fitness) runs 60 min at 150 bpm. Load = 60 × 1.0 × 1.0 = 60 TRIMP.
• Advantages: Objective, integrates HR, suitable for endurance sports.
• Limitations: Requires HR monitor, less accurate for explosive sports.

7.3.5. Monotony and Strain :

• Monotony: Weekly average load / standard deviation. Example: Average load 532 a.u., standard deviation 367 a.u., monotony = 532 / 367 = 1.44. Threshold < 2.0 (Foster, 2001).
• Strain: Weekly load × monotony. Example: Load 3724 a.u., monotony 1.44, strain = 3724 × 1.44 = 5363 a.u.
• Application: High monotony (> 2.0) or strain increases overtraining risk. The coach varies sessions (intensity, volume, themes) to reduce monotony.

7.4. Training Dosage Keys :

• Specific Objectives: Adapt the program to strength, endurance, speed, or flexibility.
• Progressive Overload: Gradually increase volume, intensity, or complexity.

• Variety and Specificity: Combine varied and sport-specific exercises.
• Recovery: Integrate active (yoga, light swimming) and complete rest.
• Individualization: Consider level, age, injury history.
• Quantification: Use RPE, GPS, or biomarkers to monitor load.
• Progression/Adaptation: Adjust the program according to evolving needs.

8. Control of Training Load :

8.1. Control Methods :

• Quantification: Measure volume, intensity, and frequency (e.g., sRPE, TRIMP).
• Fatigue Signs: Observe performance, sleep, appetite, mood, motivation.
• Tools: GPS, HRV, questionnaires (RESTQ-Sport, POMS).

8.2. Practical Advice :

• Quantify First: Establish a data baseline (e.g., 900 a.u./session via Foster).
• Monitor Signs: Remove the athlete if persistent fatigue (RPE > 8, HRV < 50 ms).
• Flexibility: Adjust the plan according to fitness state (e.g., reduce volume by 20% if ACWR > 1.5).
• Listen to the Athlete: Integrate their subjective feedback (RPE, feelings).

9. Challenges and Perspectives :

9.1. Challenges :

• Data Complexity: Integrating GPS, HRV, and RPE requires analytical expertise.
• Cost: Tools like WHOOP or Catapult are expensive for limited-budget teams.
• Privacy: Compliance with GDPR for biometric data (EU 2016/679).

9.2. Perspectives :

• Predictive AI: Algorithms (e.g., Kitman Labs, AUC 0.87) to anticipate injury risks.
• Advanced Sensors: Epidermal patches (BioSticker) or textiles (Hexoskin) for continuous monitoring.

10. Conclusion :

Monitoring and controlling training load rely on a multi-indicator approach combining biomarkers (HRV, CK, cortisol), digital tools (WHOOP, Polar, Garmin, Catapult), and subjective analyses (RPE, questionnaires). Quantification methods (Calvert, Lucia, Foster, TRIMP) enable precise and individualized management, optimizing performance while preventing overtraining. Emerging technologies, such as AI and advanced sensors, enhance precision and accessibility, paving the way for increasingly effective planning.

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Conference No. 03 Fundamental Principles of Periodization and Types of Sports Planning

Introduction :

Periodization and sports planning are methodical and scientific approaches essential for structuring training, optimizing performance, and ensuring sustainable athlete development while minimizing the risks of overtraining and injuries. Emerging in the 1950s–1960s with the work of Lev Matveiev, periodization organizes training loads into temporal cycles to ensure performance peaks during key competitions. Complementarily, sports planning is structured around three temporal scales—short, medium, and long term—each addressing specific objectives, from immediate adaptation to building sustainable careers.

1. Theoretical and Historical Foundations of Periodization:

1.1. Origins and Evolution:

Periodization has its roots in the work of Matveiev (1960), who proposed a cyclical model based on observations of Soviet Olympic athletes (Matveiev, 1981). Unlike earlier constant-intensity methods, this model introduces planned load variation to maximize adaptations and avoid overtraining (Issurin, 2016). Tudor Bompa popularized the concept in the West during the 1980s–1990s, while Verkhoshansky and Issurin developed approaches tailored to modern sports (Bompa & Buzzichelli, 2019).

1.2. Physiological Bases:

Periodization is based on several physiological principles:
• Supercompensation: After training stress, the body recovers and exceeds its initial level (Selye, 1956).
• Specificity: Adaptations depend on the type of stimulus, requiring progression from general to specific (Hawley, 2008).
• Variability: Planned variation of stimuli avoids performance plateaus and maintains adaptation (Kiely, 2012).
• Individuality: Responses vary according to athlete characteristics (genetics, history, age), requiring personalized planning (Mann et al., 2014).

2. Structural Components of Periodization:

2.1. Temporal Hierarchy:

Periodization is organized into a hierarchical structure:
• Macrocycle: Covers a season or Olympic cycle (1–4 years), targeting a major objective (Plisk & Stone, 2003).
• Mesocycle: Lasts 3–6 weeks, targeting a specific quality (accumulation, transmutation, realization).

• Microcycle: Lasts one week, structuring sessions according to mesocycle objectives.
• Session: Basic unit, adapted to targeted qualities and recovery needs.

2.2. Macrocycle Phases:

Matveiev's classic model divides the macrocycle into:
• **Preparatory Phase:**
o General: High volume, moderate intensity, development of physical and technical bases.
o Specific: Transition to discipline-specific exercises, increasing intensity.
• **Competitive Phase:** Performance optimization, low volume, high intensity, with tapering before competitions (Mujika & Padilla, 2003).
• **Transition Phase:** Active recovery for physical and mental regeneration, essential to avoid overtraining (Stone et al., 2007).

3. Fundamental Principles of Periodization Application:

3.1. Progression:

Training load (volume, intensity) increases progressively to induce adaptations:
• Linear: Constant increase, suitable for beginners.
• Undulating: Alternation of light, medium, and heavy loads to manage fatigue.
• Stepwise: Maintenance of a load before a significant increase (Fleck & Kraemer, 2014).

3.2. Systematic Variation:

Planned variation of variables (volume, intensity, exercises, methods) maximizes adaptations, reduces overtraining, prevents plateaus, and maintains motivation (Rhea & Alderman, 2004).

3.3. Progressive Specificity:

Training progresses from general (physical bases) to specific (competitive demands), particularly crucial for technical and tactical sports (Young, 2006).

3.4. Individualization:

Planning adapts to individual needs (genetics, history, fitness level, external constraints) through regular monitoring (Mann et al., 2014).

3.5. Recovery and Supercompensation:

Active and passive rest periods are integrated to allow regeneration and improvement of capacities beyond the initial level (Banister, 1975).

4. Periodization Models:

4.1. Linear Periodization:

Characterized by progression from high volume/low intensity to low volume/high intensity. Suitable for sports with concentrated calendars and beginners (Rhea et al., 2003).

4.2. Non-Linear (Undulating) Periodization:

Frequently varies volume and intensity (daily/weekly), offering flexibility and fatigue management, ideal for extended competitive calendars (Fleck & Kraemer, 2014).

4.3. Block Periodization:

Concentrates specific qualities in short blocks (2–4 weeks: accumulation, transmutation, realization), minimizing interference between qualities. Suitable for complex sports and advanced athletes (Issurin, 2016).

5. Contemporary Challenges of Periodization:

5.1. Extended Competitive Calendars:

Prolonged seasons complicate single peaks, requiring multiple-peak, undulating, or form-maintenance models (Mujika et al., 2018).

5.2. Individualization and Monitoring:

Inter-individual variability requires precise monitoring via technologies (HRV, GPS, blood analyses) for real-time plan adjustments (Kiely, 2018; Bourdon et al., 2017).

5.3. Multidisciplinary Approach:

Integrates technical, tactical, psychological, nutritional preparation, and injury prevention, requiring coordination among specialists (Robertson & Joyce, 2018).

6. Conceptual Foundations of Sports Planning:

6.1. Definition of Temporal Scales:

Sports planning is organized into three main horizons (Balyi et al., 2013; Bompa & Buzzichelli, 2019; Issurin, 2016):

• **Short term:** Covers periods of a few days to a few weeks (microcycles and mesocycles), targeting immediate adaptations or preparation for a specific competition.

• **Medium term:** Encompasses a season or year (macrocycle), aiming to structure training to achieve performance peaks during major competitions.

• **Long term:** Extends over several years (2–8 years, often an Olympic cycle), focused on overall and sustainable athlete development.

These scales form a hierarchical system where short-term objectives align with medium- and long-term ones, ensuring coherent progression.

7. Integration of Temporalities:

The effectiveness of planning relies on harmonious integration of temporal scales (Mujika et al., 2018):

• Continuity: Short-term objectives contribute to medium- and long-term goals.

• Logical Progression: Content evolves from general to specific, respecting adaptation principles.
• Flexibility: Adjustments based on individual responses without compromising the overall vision.
• Hierarchization: Clear prioritization of objectives at each level to avoid conflicts.

8. Long-Term Planning:

8.1. Objectives and Characteristics:

Long-term planning aims for sustainable athlete development, optimizing potential over several years (Ford et al., 2011). Its characteristics include:
• A developmental vision focused on physical, technical, and psychological bases.
• Stepwise progression adapted to biological and psychological age.
• A holistic approach integrating performance and well-being.
• Flexibility to adapt to individual trajectories.

8.2. Long-Term Development Models:

The Long-Term Athlete Development (LTAD) model by Balyi et al. (2013) structures planning into stages:

1. Initiation (6–9 years): Development of fundamental motor skills, emphasis on fun.
2. Learning (9–12 years): Acquisition of general sports skills.
3. Development (12–16 years): Progressive specialization, base reinforcement.
4. Perfection (16–23 years): Optimization of specific qualities.
5. High Performance (18+ years): Maximization of competitive performance.
6. Retirement: Transition to post-career.

8.3. Olympic Cycles and Multi-Year Structures:

In elite sport, long-term planning revolves around Olympic cycles (4 years) or world championships (Issurin, 2016):
• Linear Progression: Gradual load increase each year.
• Stepwise Progression: Alternation of intensive and consolidation years.
• Concentrated Progression: Maximal loads concentrated toward the end of the cycle.

8.4. Considerations for Young Athletes:

For youth, the YPD (Youth Physical Development) model by Lloyd and Oliver (2012) emphasizes:
• Development of fundamental physical qualities.
• Stimulus diversity to avoid monotony.

• Prevention of risks related to early specialization.
• Integration of psychosocial aspects.

9. Medium-Term Planning:

9.1. Macrocycles and Annual Periodization:

Medium-term planning corresponds to a macrocycle, generally a season (Stone et al., 2007). It is divided into:

1. **Preparatory Phase:**
   o General: High volume, moderate intensity, base development.
   o Specific: Discipline-specific content, increasing intensity.

2. **Competitive Phase:**
   o Pre-competitive: Refinement of specific qualities.
   o Main Competitive: Maintenance of optimal performance.

3. **Transition Phase:** Active recovery for regeneration.

9.2. Annual Periodization Models:

Models vary by discipline (Kiely, 2018):
• Traditional Periodization (Matveiev): 1–2 form peaks, for concentrated calendars.
• Block Periodization (Issurin): Sequential quality concentration, for complex sports.
• Undulating Periodization (Kraemer & Fleck): Frequent stimulus variation, for extended calendars.
• ATR Model: Accumulation, transformation, realization, for individual sports.

9.3. Adaptation to Competitive Calendars:

Planning adapts to calendars (Mujika et al., 2018):
• Concentrated: Single peak, classic periodization.
• Extended: Form maintenance or multiple peaks.
• Hierarchical: Progression between preparatory and major competitions.

9.4. Annual Load Management:

Load management is based on (Gabbett, 2016):
• Strategic distribution of volumes and intensities.
• Alternation between overload and recovery.
• Modulation according to individual responses.

10. Short-Term Planning:

10.1. Mesocycles and Training Blocks:

Mesocycles (2–6 weeks) target specific objectives (Plisk & Stone, 2003):
• Accumulation: Base development (strength, endurance).
• Transmutation: Transformation into specific qualities.
• Realization: Peaking for competition.
• Recovery: Regeneration after intense efforts.

10.2. Microcycles and Weekly Organization:

Microcycles (1 week) structure sessions according to (Bompa & Buzzichelli, 2019):
• Mesocycle objectives.
• Recovery between similar stimuli.
• Alternation of high/moderate loads.
• Types: ordinary, shock, approach, competition, recovery.

10.3. Session Planning:

Sessions follow (Haff & Triplett, 2016):
• Priority: Key exercises at the start of the session.
• Sequential Specificity: Technical and physiological logic.
• Interference Management: Minimization of conflicts between exercises.
• Individualization: Adaptation to athlete needs.

10.4. Tapering and Terminal Preparation:

Tapering (1–3 weeks) reduces volume (40–60%), maintains intensity, and minimizes fatigue to optimize performance (Mujika & Padilla, 2003).

11. Coherence and Hierarchization:

Short-term objectives derive from medium- and long-term ones, with clear hierarchization and regular evaluation (Kiely, 2018).

11.1. Adaptability:

Agile planning integrates (Coutts et al., 2018):
• Continuous monitoring (HRV, RPE).
• Adjustments based on objective/subjective data.
• Balance between structure and flexibility.

11.2. Transitions Between Cycles:

Transitions involve (Mujika et al., 2018):
• Evaluation of achievements.
• Redefinition of objectives.
• Physiological and psychological adaptation.

12. Practical Applications:

12.1. Individual vs. Team Sports:

• Individual: Classic periodization, precise peaks, advanced individualization.
• Team: Form maintenance, simultaneous collective/individual management (Robertson & Joyce, 2018).

12.2. Developing vs. Elite Athletes:

• Developing: Long-term development, stimulus variation.
• Elite: Specialization, fine optimization (Bompa & Buzzichelli, 2019).

12.3. Calendar Constraints

Adaptation according to (Mujika et al., 2018):
• Short Season: Single peak.
• Extended Season: Maintenance or multiple peaks.
• Continuous Circuit: Blocks with strategic recovery.

12.4. Contemporary Trends:

• Agile Planning: Flexible approach challenging rigid models and valuing continuous monitoring (Kiely, 2018).
• Monitoring Technologies: GPS, sensors, and AI enable precise tracking and increased personalization (Cardinale & Varley, 2017).
• Interdisciplinary Approaches: Coordination between physical, technical, mental, and nutritional preparation for a holistic vision (Mujika et al., 2018).

Conclusion:

Periodization and sports planning form an integrated and strategic framework that balances immediate performance, seasonal optimization, and long-term sustainable development. Periodization, by structuring training into hierarchical cycles (macrocycles, mesocycles, microcycles), combines progression, variation, specificity, and individualization to maximize adaptations while preventing injuries and overtraining. Planning, through its temporal scales (short, medium, and long term), articulates coherent progression, integrating specific competition objectives and overall career aspirations. Supported by modern technologies (GPS, HRV, AI) and an interdisciplinary approach, these methodologies promote adaptive and personalized planning, guiding athletes toward excellence while respecting their uniqueness and ensuring their well-being.

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Conference No. 04 Organization of Sports Training and the Role of the Coach in Designing Plans

Introduction:

The structured organization of sports training is a methodical process aimed at optimizing athletes' performance through a coherent progression of physical, technical, and psychological components. This approach is based on scientific principles such as progressivity, load-adaptation balance, and interdisciplinary integration. By using modern tools and visual planning strategies (chronomapping), coaches can maximize results while respecting the individual needs of athletes (Bompa & Haff, 2009). Moreover, the coach plays a central and multifaceted role, far beyond simply transmitting technical knowledge. He is both a guide, a motivator, a strategist, and above all an architect of planning, responsible for designing training programs that allow athletes to reach their full potential, prevent injuries, and maintain constant progression. Planning is not limited to creating a schedule of exercises; it requires rigorous analysis, strategic decision-making, effective communication, and continuous performance evaluation. To accomplish these tasks, the coach must possess in-depth knowledge of exercise physiology, biomechanics, sports psychology, and be able to adapt this knowledge to the individual needs of each athlete as well as the specifics of the discipline practiced.

1- Progressivity in the Development of Physical Components:

- Principles of Progressivity:

Progressivity ensures safe and effective development of physical qualities (strength, endurance, speed, flexibility, coordination) by avoiding excessive fatigue (Zatsiorsky & Kraemer, 2006).
• Gradual Increase: Loads (volume, intensity, frequency) increase by 5–10% per week to stimulate adaptation (Gellish, 2007).
• Specificity: Exercises are aligned with the demands of the discipline (e.g., aerobic endurance for a cyclist, power for a weightlifter).
• Individualization: Adaptation to the athlete's capacities, age, and experience.

- Practical Application:

• Strength: Start with light loads (50–60% 1RM) for technique, then progress to 80–90% for maximal strength over 4–6 weeks.
• Endurance: Transition from continuous running (60–70% VO_2max) to intervals (90–95% VO_2max) over a mesocycle.
• Speed: Short sprints (10–20 m) evolving to longer sprints (40–60 m) with extended recovery.
• Example: A footballer begins with squats at 60% 1RM (3x10 reps), then incorporates plyometric exercises (explosive jumps) after 4 weeks.

- Monitoring Progression:

• Periodic Tests: Vertical jump (CMJ) for power, Cooper test for endurance.
• Technological Tools: GPS sensors (Catapult) for external load, HRV monitors (WHOOP) for physiological response.

2- Organization of Training Units and Cycles:

- Training Units:

• Structure: Warm-up (10–15 min, neuromuscular activation), main block (40–70 min, targeted exercises), cool-down (10 min, active recovery).
• Duration: 60–120 min depending on the discipline and objective.
• Example: A swimming session includes 15 min warm-up (light swimming), 60 min of technical drills and intervals (8x100 m at 90% effort), and 10 min recovery (stretching).

- Training Cycles:

• Microcycle (3–14 days): Weekly plan balancing load and recovery (e.g., 2 intensive days, 2 moderate days, 2 active recovery days, 1 rest day).
• Mesocycle (3–6 weeks): Focus on a specific objective (strength, endurance, power) with a deload every 3–4 weeks (-40% volume).
• Macrocycle (6–12 months): Quadriphasic structure (general preparation, specific, competitive, transition).
• Example: A track athlete plans a macrocycle with a strength mesocycle (6 weeks, 3x10 reps at 70% 1RM), followed by a power mesocycle (4 weeks, sprints + plyometrics).

3- Balance Between Load and Adaptation:

- Principles of Balance:

• Controlled Overload: Sufficient loads to stimulate adaptation, followed by recovery to allow supercompensation.
• Supercompensation: Increased performance after optimal recovery post-load (Zatsiorsky & Kraemer, 2006).
• Individualization: Adjustment based on physiological and psychological responses (Banister, 1975).

- Balance Indicators:

• Load: Measured via RPE (1–10 scale), GPS (PlayerLoad™), or heart rate (Polar).
• Adaptation: Evaluated by tests (VO_2max, 1RM) and biomarkers (HRV, creatine kinase).

- Management of Imbalances:

• Load Reduction: Decrease of 15–20% volume if RPE >8 or HRV ↓ >8%.
• Recovery Microcycles: Every 3–4 weeks (volume -40%, intensity maintained).

• Example: A swimmer with high RPE (9/10) switches to an active recovery session (light swimming, 30 min) to avoid overtraining.

4- Temporal Logic of Sessions and Cycles:

- Session Organization:

• Sequence: Alternation between intense sessions (e.g., HIIT at 90% VO_2max) and light sessions (active recovery, yoga) to optimize recovery.
• Frequency: 5–6 sessions/week in general preparation, 3–4 in competitive phase.

- Cycle Organization:

• Macrocycle Phases: General preparation (strength, endurance), specific (techniques, tactics), competitive (peak form), transition (recovery).
• Transitions: Deload mesocycles (1–2 weeks, -40% volume) to transition between phases.
• Example: A footballer plans 8 weeks of general preparation (aerobic endurance, 12 km/week), 6 specific weeks (tactics, small-sided games), and 2 weeks of tapering before a key match.

5- Integration of Physical, Technical, and Psychological Objectives:

- "3-2-1" Model:

• 3 Physical Objectives: E.g., VO_2max, explosive strength, lactate tolerance.
• 2 Technical Objectives: E.g., improved serve, pass accuracy.
• 1 Psychological Objective: E.g., competitive stress management via visualization.
• Example: A cyclist works on endurance (3x20 min at 70% FTP), power (4x5 min at 90% FTP), pedaling technique, and confidence via 10 min daily visualization.

- "Blending" Strategy:

• Intra-Session: Combination of 20 min technique (e.g., dribbling), 15 min physical quality (sprints), and 10 min mental (meditation).
• Temporal Priority: Priority discipline (e.g., technique) receives 60% of weekly load, physical 25%, psychological 15%.

- Case Study: Volleyball Team:

A weekly microcycle:
• Monday: Strength (squat, 3x8 at 70% 1RM) + serving drills.
• Tuesday: Aerobic endurance (jogging, 30 min) + defensive tactics.
• Wednesday: Active recovery (yoga, 45 min) + visualization (team cohesion).
• Thursday: Power (plyometrics, jumps) + fast attacks.
• Friday: Simulated match + video analysis (Hudl).
• Saturday: Active rest (light swimming, 30 min).
• Sunday: Complete rest.

Monitoring: GPS data (Catapult, 400 a.u./week) and HRV (WHOOP, score 60–80) adjust loads, while RESTQ-Sport (fatigue score <3.0) reinforces cohesion.

6- Visual Planning Tools (Chronomapping):

- Reverse Gantt:

• Method: Backward planning from the major competition (e.g., Olympics) to define load and tapering phases.
• Example: A swimmer plans 12 weeks before a championship, with 6 weeks volume, 4 weeks intensity, and 2 weeks tapering.

- Load Heat-Map:

• Method: Cross-table (week × component) with color coding (red: high load, green: low).
• Example: 100 m swimming, 8 weeks: strength (3 red weeks), technique (2 orange weeks), endurance (3 green weeks).

- Critical Path Method (CPM):

• Method: Identification of critical sessions (tests, competitions) and flexible sessions to optimize the calendar.
• Example: A cyclist prioritizes VO_2max tests (week 4) and A competitions (week 12), with flexible recovery sessions.

- Challenges and Perspectives:

- Challenges:

• Complexity: Coordinating multiple objectives requires an interdisciplinary team.
• Individual Variability: Different athlete responses to loads.
• Cost: Limited access to tools like Catapult or Smartabase for amateur clubs.

- Perspectives:

• Technologies: Platforms like Training Peaks integrate physical, technical, and psychological data.
• AI: Prediction of adjustment needs via algorithms (e.g., HRV drop → load reduction).
• Accessibility: Development of affordable tools for amateurs.

- Case Study: Road Cyclist:

An accumulation mesocycle (4 weeks):
• Week 1: 12 h (volume), 55% FTP, 1 HIIT session (4x4 min at 85% FTP).
• Week 2: 14 h (+15%), 58% FTP, 2 HIIT sessions.
• Week 3: 16 h, 60% FTP, strength work (4x8 min at 90% FTP).
• Week 4: Deload (-40% volume), intensity maintained, HRV ↑ 12%.

Monitoring: Garmin data (power, HR) and daily mental visualization (10 min) for confidence.

7- Key Responsibilities of the Coach in Planning:

The design of a training plan is a complex task encompassing several fundamental responsibilities, each contributing to the success of athletes or the team.

7-1- Evaluation and Objective Setting:

The first step in planning is to assess the current level of the athlete or team, identifying strengths, weaknesses, specific needs, and development potential. This evaluation may include physical tests (VO_2max, maximal strength, speed tests), technical analyses (sports gesture videos), and interviews to understand the athlete's aspirations and psychological constraints. Based on this, the coach defines SMART objectives (Specific, Measurable, Achievable, Realistic, Time-bound) for the short term (e.g., improve sprint speed in 6 weeks), medium term (reach peak form for a competition), and long term (participate in national championships). These objectives may target performance, technique, tactics, physical condition, or injury prevention.

7-2- Training Program Design:

Program design translates objectives into a structured plan, respecting the fundamental principles of training. This phase includes several key aspects:
• Periodization: Structuring the season into macrocycles (year or season), mesocycles (4–6 weeks), and microcycles (1 week), each with specific objectives:
o General Preparatory Phase: Development of basic physical qualities (endurance, strength).
o Specific Preparatory Phase: Targeted work on sport demands (technique, tactics).
o Pre-competitive Phase: Tapering to optimize performance (volume reduction, intensity maintenance).
o Competitive Phase: Form maintenance for target competitions.
o Transition Phase: Active rest and recovery.
• Programming: Definition of session content, including exercises (e.g., squats 4x8 at 60% 1RM, sprints 6x20 m at 90%), volume (duration or reps), intensity (% of maximal effort), and frequency (sessions/week). The principles of overload, specificity, progressivity, and individualization guide these choices.
• Individualization: Adaptation of the program to each athlete's unique characteristics, such as age, sex, training level, injury history, and physiological response to training (e.g., load adjustment if HRV <15% of baseline).
• Multidisciplinary Integration: Collaboration with other specialists, such as physical trainers (for conditioning), nutritionists (e.g., 1.8 g/kg/day protein), sports psychologists (for stress management), and medical staff (for injury prevention and management), to ensure a holistic approach.

7-3- Monitoring and Adjustment:

Planning is a dynamic process requiring constant monitoring. The coach collects data on performance (e.g., 100 m time, shot accuracy), training load (via GPS or RPE), well-being (fatigue questionnaires, pain <2/10 VAS), and any injuries. These data are analyzed to assess progression and detect signs of overtraining or underperformance. Based on results, the coach adjusts the plan by:

• Re-evaluating objectives (e.g., postponing a peak if a competition is delayed).
• Modifying loads (e.g., 10% volume reduction if HRV <15%).
• Adapting exercises (e.g., replacing sprints with technical work in case of fatigue).

7-4- Communication and Leadership:

The coach is a key communicator, responsible for explaining the plan to athletes, motivating them, and educating them on the reasons for training choices (e.g., why a high-volume phase precedes tapering). He must also involve athletes in the process to strengthen adherence and commitment. His leadership creates an environment conducive to learning, effort, and performance, by establishing a culture of trust, discipline, and collaboration.

8- Skills and Qualities of the Coach:

To design and implement effective training plans, the coach must possess a set of technical, interpersonal skills, and personal qualities that ensure the success of his interventions.

8-1- Technical and Scientific Skills:

• Sports Science Knowledge: In-depth understanding of exercise physiology (e.g., VO_2max, lactate thresholds), biomechanics (movement analysis), nutrition (recovery intake), and sports psychology (motivation management) is essential for evidence-based program design.
• Mastery of Periodization and Programming: The coach must know how to structure training across different time scales (macrocycles, mesocycles, microcycles) and manipulate training variables (volume, intensity, frequency). For example, he can program 4x6 squats at 75% 1RM for strength or 8x50 m sprints at 90% for speed.
• Performance Analysis: Ability to interpret performance data, such as physical tests (1RM, jump tests), match statistics (pass accuracy, shots), and video analyses (technical corrections), to identify strengths and areas for improvement.

8-2- Interpersonal and Pedagogical Skills:

• Communication: The coach must clearly convey objectives, expectations, and feedback to athletes, parents, and other staff members. Effective communication includes using appropriate language and pedagogical explanations (e.g., demonstrating the importance of plyometric exercises for power).
• Pedagogy: He adapts teaching to athletes' learning styles (visual, auditory, kinesthetic), using demonstrations, explanations, or practical exercises. He motivates and inspires athletes to maintain engagement, even in intensive phases.
• Empathy and Active Listening: Understanding athletes' needs, concerns, and emotions

builds trust. For example, the coach can adjust a session if an athlete reports significant mental fatigue.

8-3- Personal Qualities:

• Leadership: The coach inspires and guides athletes toward their goals, demonstrating vision, determination, and exemplarity. He establishes a team culture or individual environment conducive to performance.
• Adaptability and Flexibility: In the face of unforeseen events (injuries, calendar changes, poor form), the coach quickly adjusts plans, for example by reducing intensity if an athlete shows signs of overtraining (RPE >8/10).
• Rigor and Organization: Planning requires meticulous management of sessions, data (e.g., tracking via Training Peaks), and deadlines to ensure coherent progression.
• Passion and Commitment: Passion for the sport and athlete development motivates the coach to fully invest, staying up-to-date on scientific advances and best practices.

Conclusion:

Structured organization and the coach's role form an integrated system to optimize sports performance while preserving athletes' health and motivation. Periodization structures training into cycles to achieve precise peaks, while programming defines sessions with precision, respecting the principles of progressivity, specificity, and load-adaptation balance. Organization coordinates resources and monitoring, and the coach, as the conductor, harmonizes these elements through his scientific expertise, pedagogical skills, and leadership. Modern tools (GPS, HRV, AI) and visual approaches (chronomapping) enhance planning efficiency, while individualization ensures sustainable results. By overcoming challenges through an interdisciplinary approach, coaches can transform athletes' potential into exceptional performance, while paving the way for future advances through emerging technologies.

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Conference No. 05 Periodization, Programming, and Tactical Strategies in Sports Training

Introduction:

Periodization, programming, and tactical planning are fundamental pillars of sports training, enabling performance optimization while minimizing the risks of overtraining and injuries. Periodization structures training into temporal cycles (macrocycles, mesocycles, microcycles) to achieve performance peaks during key competitions, while programming defines the precise content of sessions, balancing volume, intensity, and recovery. In parallel, tactical planning transforms overall strategies into concrete actions on the field, exploiting opponents' strengths and weaknesses through rigorous analysis and technological tools. Together, these approaches integrate scientific principles, modern data, and an interdisciplinary vision to guide athletes toward excellence in demanding competitive contexts.

1. Concepts of Periodization:

1.1. Definition and Principles:

Periodization is the systematic organization of training into cycles to maximize physiological and psychological adaptations, aiming for a performance peak on a target date (Mujika, 2022). It is based on:

• Variation: Alternation of loads (volume, intensity, type) to avoid stagnation (Zatsiorsky & Kraemer, 2006).
• Progressivity: Gradual increase in loads (5–10%/week) to induce supercompensation (Gellish, 2007).
• Specificity: Alignment of exercises with sport demands (e.g., speed for a sprinter, endurance for a marathoner).
• Cycles:
o Macrocycle: Annual or seasonal plan (6–12 months).
o Mesocycle: Block of 3–6 weeks focused on a specific quality.
o Microcycle: Weekly plan (3–14 days) with varied loads.
• Objectives:
o Achieve performance peaks during major competitions.
o Prevent overtraining through planned recovery phases.
o Progressively develop physical, technical, and psychological qualities.
• Example: An 800 m runner structures a macrocycle with a general preparation mesocycle (60 km/week, aerobic endurance), a specific mesocycle (intervals at 90% VO_2max), and a competitive mesocycle (tapering, 20 km/week).

1.2. Importance:

• Optimization: Improves VO_2max (+9% vs +4% without periodization, Rønnestad & Mujika, 2021) and power (+12%).

• Prevention: Reduces injury risk (x3 with rapid overload, Meur et al., 2017).
• Structure: Provides clear progression, increases motivation (Weinberg & Gould, 2019).

2. Periodization Models:

2.1. Linear Periodization (Matveiev, 1964):

• Concept: Progression from high volume (high to low) and intensity (low to high) over a macrocycle.
• Structure:
o General Preparation: High volume, moderate intensity (e.g., 6x8 reps at 60% 1RM).
o Specific Preparation: Moderate volume, increased intensity (4x4 reps at 80% 1RM).
o Competition: Low volume, high intensity, tapering (2x3 reps at 90% 1RM).
o Transition: Active rest (yoga, light swimming).
• Advantages: Simplicity, ideal for sports with a single peak (track and field, swimming).
• Limits: Rigidity, monotony, risk of detraining non-priority qualities.
• Example: A weightlifter progresses from 6x8 at 60% 1RM to 3x3 at 90% 1RM over 12 weeks.

2.2. Undulating (Non-Linear) Periodization:

• Concept: Frequent variation of volume and intensity within a microcycle/mesocycle to stimulate multiple qualities (Issurin, 2010).
• Structure:
o Daily Undulating Periodization (DUP): Daily alternation (e.g., Monday: strength, Wednesday: power, Friday: hypertrophy).
o Weekly Undulating Periodization (WUP): Weekly variation (e.g., week 1: volume, week 2: intensity).
• Advantages: Flexibility, motivation, suited to sports with frequent competitions (tennis, basketball).
• Limits: Planning complexity, requires precise monitoring.
• Example: A basketball player alternates in a microcycle: day 1 (strength, 5x5 at 80% 1RM), day 2 (endurance, 45 min at 70% HRmax), day 3 (active rest).

2.3. Block Periodization (Issurin, 2020):

• Concept: Concentration on one specific quality (strength, endurance, power) in a block of 2–8 weeks.
• Structure:
o Accumulation: High volume, low-moderate intensity (e.g., aerobic endurance, 18 h/week).
o Transmutation: Reduced volume, increased intensity (e.g., lactate threshold, HIIT 40/20).
o Realization: Maximum specificity, tapering (e.g., sprints, 8 h/week).
• Advantages: Effective for multiple peaks (cycling, swimming).
• Limits: Fatigue risk if blocks poorly balanced, difficult for amateurs (time constraints).

• Example: A cyclist follows an accumulation block (18 h/week, zone 2–3), transmutation (12 h, HIIT), and realization (8 h, tapering).

2.3.1. Types of Blocks (Bondarchuk, 1986):

• Development Blocks: Maximal load, focus on one quality (e.g., maximal strength, 5x5 at 85% 1RM).
• Competition Blocks: Load/recovery balance, priority quality (e.g., specific sprints).
• Recovery Blocks: 1–2 weeks, active rest (e.g., yoga, light cycling).

2.4. Reverse Periodization:

• Concept: Start with high intensity and low volume, followed by increased volume and reduced intensity.
• Application: Ideal for endurance sports (swimming, cycling).
• Example: A swimmer begins with intervals at 90% max effort (4x100 m), then moves to long-distance sessions (5 km).

2.5. Comparison of Models:

Model	Structure	Advantages	Limits	Suitable Sports
Linear	High volume → low, low intensity → high	Simplicity, clear progression	Rigidity, monotony	Track and field, weightlifting
Undulating	Daily/weekly variations	Flexibility, motivation	Complex to plan	Tennis, basketball
Block	Focus on one quality per block	Effective for multiple peaks	Fatigue if poorly balanced	Cycling, swimming
Reverse	High intensity → high volume	Suited to endurance	Less versatile	Swimming, marathon

3. Programming of Training Loads:

3.1. Load Distribution:

• General Preparation: High volume, moderate intensity (e.g., 60 km/week, 70% VO_2max for a runner).
• Specific Preparation: Reduced volume, increased intensity (intervals at 85–90% VO_2max).
• Competition: Low volume, tapering (20 km/week, moderate intensity).
• Transition: Active rest (yoga, light swimming, 30 min/day).
• Example: A footballer plans a preseason (8 weeks, 5–6 sessions/week, endurance + strength), competitive season (30 weeks, 3–4 sessions, sprints + tactics), and off-season (4 weeks, active rest).

3.2. Programming Methods:

• Linear: Gradual progression (e.g., weightlifting: 6x8 at 60% 1RM → 3x3 at 90% 1RM).
• Undulating: Daily/weekly variations (e.g., basketball player: day 1 strength, day 2 endurance).
• Block: Focus on one quality (e.g., cyclist: 4 weeks power, 4 weeks endurance).
• 80/20 Polarization: 80% zone 1–2 (aerobic), 20% zone 4–5 (HIIT) (Seiler, 2010).
• Example: A triathlete follows 80/20 polarization with 12 h/week in zone 2 (cycling, swimming) and 3 h in HIIT (30/30 intervals).

3.3. Intra-Session Programming (3x3 Model):

• Structure:
o Activation (15%): Neuromuscular warm-up (e.g., 400 m swim + 8x25 m drills).
o Development (70%): Main exercises (e.g., 12x50 m at 95% vVO_2max, 30 s rest).
o Consolidation (15%): Active recovery (e.g., 6x25 m easy + stretching).
• Levers: Intensity (% VO_2max, % 1RM), volume (reps, distance), density (rest between sets).
• Example: 100 m swimming session: activation (400 m swim + drills), development (12x50 m at 95% vVO_2max), consolidation (stretching).

4. Data-Driven Approaches:

4.1. Data Collection Tools:

• GPS: Measures external loads (distance, speed, PlayerLoad™ via Catapult/STATSports).
• HRV: Recovery assessment (WHOOP, score >60 indicates good recovery).
• RPE: Perceived effort (Borg, 1982; 1–10 scale, <7 in preparation).
• Biomarkers: Creatine kinase (CK <200 U/L), cortisol to detect fatigue (Halson, 2014).

4.2. Data Integration:

• Platforms: TrainingPeaks, Smartabase combine GPS, HRV, RPE for real-time adjustments.
• ACWR: Acute:chronic workload ratio (ideal: 0.8–1.3) to avoid overtraining (Bourdon et al., 2017).
• Example: A rugby player with ACWR >1.5 and low HRV (45 ms) reduces volume by 20% for a light microcycle.

4.3. Personalization:

• AI/Machine Learning: Algorithms (e.g., XGBoost) predict load responses (RMSE ±3.2 W for FTP).
• Example: A cyclist adjusts intensity (from 80% to 60% FTP) if HRV <90% of baseline.

5. Practical Application in Different Sports:

5.1. Endurance Sports (Marathon):

• Distribution: General preparation (70 km/week, 70% VO_2max), specific (40 km, intervals at 90% VO_2max), tapering (20 km, moderate intensity).
• Data: GPS (Garmin) for volume, HRV (WHOOP, score >60) for recovery.
• Example: A marathoner maintains HRV score >60 before a 2-week taper, targeting 2h30.

5.2. Power Sports (Weightlifting):

• Distribution: Moderate volume (4–6 sets), progressive intensity (60–90% 1RM).
• Data: 1RM tests, RPE (<8 to avoid fatigue).
• Example: A weightlifter progresses from 6x8 at 60% 1RM to 3x3 at 90% 1RM over 8 weeks, with RPE monitored.

5.3. Team Sports (Football):

• Distribution: Undulating programming (3–5 sessions/week, tactics + recovery).
• Data: GPS (Catapult, PlayerLoad™ <500 a.u./week), RPE.
• Example: A footballer alternates strength (5x5 at 80% 1RM), tactics (small-sided games), and active rest (yoga).

6. Case Study: 100 m Sprinter:

A sprinter follows block periodization for a double peak (indoor/summer):
• Macrocycle 1 (Winter, 20 weeks):
o Accumulation (6 weeks): Strength (trap-bar, 5x5 at 85% 1RM).
o Transmutation (6 weeks): Speed (30 m blocks, 95% max effort).
o Realization (4 weeks): Tapering, short sprints. Result: 60 m indoor in 6.55 s.
• Macrocycle 2 (Summer, 24 weeks):
o Accumulation (8 weeks): Lactate tolerance (8x200 m at 90%).
o Transmutation (6 weeks): Maximal speed (10x40 m).
o Realization (6 weeks): Tapering, race-specific. Result: 100 m in 9.95 s.
• Data: GPS (Catapult, PlayerLoad™), HRV (WHOOP, TSB +10 to +20), mental visualization (10 min/day).

7. Traditional vs. Block Periodization:

7.1. Traditional Periodization (Matveiev):

• Structure:
o Preparation (general + specific): High volume, increasing intensity.
o Competition (pre-competition + competition): Reduced volume, high intensity.
o Transition: Active rest.
• Advantages: Simplicity, suited to beginners, single-peak sports.
• Limits:
o Difficulty maintaining prolonged peak (2–3 peaks max).
o Excessive fatigue from simultaneous varied training.
o Overtraining risk with prolonged loads.

• Example: A swimmer follows a linear cycle with 12 weeks preparation (30 km/week), 8 competitive weeks (20 km), and 4 transition weeks.

7.2. Block Periodization:

• Structure:
o Development: Maximal load, focus on one quality (e.g., endurance, 18 h/week).
o Competition: Load/recovery balance, priority quality.
o Recovery: 1–2 weeks, active rest.
• Advantages: Effective for multiple peaks, intense focus on one quality.
• Limits: Complex, requires discipline, difficult for amateurs (time constraints).
• Example: A triathlete plans 3 development blocks (strength, endurance, speed) and 2 competition blocks, separated by 1 recovery week.

7.3. Hybrid Compromise:

• Concept: Integrate specific microcycles (2–3 weeks) into a linear structure, with recovery blocks.
• Example: A triathlete combines 2 strength microcycles (swim, bike, run) with 1 recovery microcycle, over a linear macrocycle.

8. Common Errors to Avoid:

1. Lack of Recovery: Neglecting active rest periods increases injury risk (Soligard et al., 2016).
2. Non-Adjustment: Ignoring progress or fatigue (e.g., HRV <50 ms) stalls progression.
3. Lack of Specificity: Omitting sport demands (e.g., power for weightlifting, endurance for marathon).
4. Excessive Overload: ACWR >1.5 increases overtraining risk (Bourdon et al., 2017).

9. Challenges and Perspectives of Periodization and Programming:

9.1. Challenges:

• Complexity: Requires interdisciplinary expertise (coach, data analyst, nutritionist).
• Individual Variability: Different responses to loads (Kiely, 2018).
• Resources: Cost of tools (GPS, HRV) for amateur clubs.

9.2. Perspectives:

• AI: Predictive algorithms (Smartabase, TrainingPeaks) for real-time adjustments.
• Accessible Sensors: Affordable devices (Fitbit, Garmin).
• Hybrid Models: Linear/undulating/block combination for flexibility.

10. Distinction Between Strategy and Tactics:

10.1. Strategy: Long-Term Vision:

• Definition: Overall plan defining long-term objectives and broad lines to achieve them (Gréhaigne et al., 2005).
• Characteristics:
o Objectives: Win a championship, qualify for an international competition, or develop players over multiple seasons.
o Vision: Define a playing style (e.g., offensive football in 4-3-3) and training philosophy.
o Planning: Annual periodization integrating physical, technical preparation, and key competitions.

10.2. Tactics: Short-Term Actions:

• Definition: Specific actions applied on the field to respond to game situations or exploit opponent weaknesses.
• Characteristics:
o Objectives: Win a match, neutralize a key player, or exploit a weak zone (e.g., opponent's left flank).
o Actions: Choice of playing systems (e.g., 4-2-3-1), offensive/defensive movements, and real-time adjustments.
o Adaptation: Evolves based on match flow (e.g., switch to 5-defender if trailing).
• Example: A football coach adjusts tactics at halftime, shifting from high press to low block to counter fast breaks.

10.3. Interdependence:

• Link: Strategy provides the overall framework, while tactics translate it into concrete actions. Effective strategy relies on well-executed tactics, and relevant tactics reinforce strategy (Carling et al., 2005).
• Example: A basketball strategy focused on fast-break translates into tactics like long passes and offensive screens to accelerate tempo.

10.4. Opponent Analysis:

• Data Collection: Video analysis (Wyscout, Hudl) and statistics (InStat) to study opponent's previous matches (e.g., shot frequency, attack zones).
• Pattern Identification: Detect recurring trends, such as defensive weaknesses (e.g., 60% goals conceded on right flank) or offensive strengths (e.g., 70% attacks through center).
• Scenario Preparation: Develop plan A (exploit weakness), B (react to opponent tactical change), and C (manage unfavorable situation).
• Example: Before a football match, video analysis reveals opponent vulnerable to deep balls (30% goals conceded). Coach plans long passes targeting space behind defense (3x10 min in training).

11. Technological Tools:

• Video Analysis: Software like Hudl allows clipping game sequences (e.g., 15 clips/match to analyze transitions).
• GPS: Measures opponent physical loads (Catapult, PlayerLoad™ >500 a.u. indicates high intensity) to anticipate fatigue.
• Statistics: Data on possession (e.g., 55%), shots on target (4/match), or successful passes (85%) to guide tactics.
• Example: A basketball team uses Wyscout to identify opponent scores 40% from 3-pointers, preparing a 2-3 zone defense to limit outside shots.

12. Development of Tactical Intelligence:

12.1. Definition and Importance:

• Definition: Ability to perceive, analyze, and make relevant decisions in game situations under pressure (Memmert & Roth, 2007).
• Importance: Allows athletes to execute tactics precisely and adapt in real time (e.g., adjust marking to opponent position change).

12.2. Development Methods:

• Game Understanding: Teach tactical principles (e.g., collective press) via videos and discussions (2x15 min/week).
• Decision-Making: Exercises simulating match scenarios (e.g., 3x3 with constraints, 10 min) to develop reactivity.
• Communication: Improve coordination via non-verbal signals (e.g., gestures for screen in basketball) and verbal briefings.
• Feedback: Post-match video analysis (Hudl, 10 clips/player) to correct tactical decisions.
• Example: A footballer participates in 4x4 exercises (15 min) choosing pass or dribble under pressure, followed by video feedback to improve decision-making.

13. Integration into Competitive Planning:

13.1. Cycle Structure:

• Macrocycle: Annual plan integrating tactical phases (e.g., 3 months to master 4-3-3 system).
• Mesocycle: 4–6 week blocks targeting specific tactical aspects (e.g., fast transitions).
• Microcycle: Balanced week with 2 tactical sessions (drills, 3x10 min), 1 physical session, and 1 active recovery day.
• Example: A football team plans a 4-week mesocycle with 2 high-press sessions/week (15 min drills + 10 min simulated play).

13.2. Adapted Content:

• Objectives: Develop tactical patterns (e.g., fast attacks) and responses to opponent scenarios.
• Exercises: Tactical drills (e.g., 3x10 min fast passes), small-sided games (5x5, 15 min), and

match simulations (30 min).
• Example: A basketball team practices offensive screens (3x10 min) to counter man-to-man defense.

13.3. Gradual Progression:

• Method: Increase tactical exercise complexity (from 2x2 to 11x11 over 6 weeks) and integrate varied scenarios.

14. Case Study: Football:

• Context: Match against possession-dominant opponent (60%).
• Evaluation:
o Opponent: Video analysis (Wyscout) shows weakness on left flank (40% goals conceded). GPS indicates high intensity (PlayerLoad™ 550 a.u.).
o Team: Strong counter-attack (85% successful transition passes), but finishing gaps (30% shots on target).
• Program (4 weeks):
o Tactics: 2 sessions/week counter-attacks (3x10 min, long passes), 1 low-press session (15 min).
o Physical: Aerobic endurance (4 km at 60% VO_2max) to support fast transitions.
o Feedback: Post-training video analysis (10 clips/player) to correct positioning.
o Monitoring: GPS (Catapult, 6–7 km/session), HRV (WHOOP, 55–60 ms), RPE (5–6/10).
• Results: Increased shots on target (from 30 to 45%), exploitation of opponent left flank (2 goals), 2-1 victory.

15. Challenges and Perspectives of Tactical Planning:

15.1. Challenges:

• Complexity: Balancing tactical preparation with physical and mental demands.
• Resources: Limited access to video analysis or GPS in amateur clubs.
• Adaptability: React quickly to opponent tactical changes in-match.

15.2. Perspectives:

• Technologies: Increased AI use to predict opponent patterns (e.g., video analysis algorithms).
• Training: Programs to develop tactical intelligence from young age.
• Personalization: Tactical plans tailored to individual player profiles via GPS and HRV data.

Conclusion:

Periodization, programming, and tactical planning form an integrated framework that optimizes sports performance by structuring training and competitive strategies. Periodization organizes loads into cycles (linear, undulating, block) to achieve performance peaks while preventing overtraining, while programming details sessions with precision, relying on data

(GPS, HRV, RPE) for increased personalization. Tactical planning transforms long-term strategies into concrete field actions, exploiting opponent analysis and developing tactical intelligence. By combining data science, technological tools (video analysis, AI), and interdisciplinary approaches, these methodologies enable coaches and athletes to maximize results, ensure sustainable progression, and effectively meet competitive challenges.

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Conference No. 06 Traditional Linear Planning Model and Block Periodization in Sports Training

Introduction:

The traditional linear model and block periodization are two fundamental approaches to sports planning, each offering a distinct structure to optimize performance while minimizing the risks of overtraining and injuries. Developed by Matveiev in the 1960s, the linear model organizes training into progressive phases (general preparation, specific, competitive, and transition) to achieve a single performance peak, ideal for sports with a well-defined season. In contrast, block periodization, conceptualized by Issurin in the 1990s–2000s, favors short, intensive cycles (2–6 weeks) targeting a specific biomotor quality, suited to dense competitive calendars.

1. Fundamental Principles of the Traditional Linear Model:

The traditional linear model relies on unidirectional progression, with strict sequential phases aiming for a single performance peak.

1.1. Unidirectional Progression:

• Concept: Training volume progressively decreases while intensity increases throughout the macrocycle, following a linear logic.
• Example: A footballer reduces running volume from 10 km to 6 km/session between general and specific preparation, while increasing intensity from 60% to 85% of maximal effort.

1.2. Strict Sequential Phases:

• General Preparation (GP): Build a solid physical base (endurance, general strength) over 8–12 weeks, with high volume and moderate intensity.
• Specific Preparation (SP): Develop sport-specific qualities (speed, power, tactics) over 6–8 weeks, with increased intensity.
• Competitive Phase (C): Optimize performance with tapering (30–50% volume reduction) over 2–8 weeks before competitions.
• Transition Phase (T): Promote active recovery or rest over 2–4 weeks post-season.

1.3. Single Peak Objective:

• Concept: The model targets a single form peak at the end of the macrocycle, aligned with a key competition (e.g., national championship, marathon).

2. Sequencing of Classical Preparation (Linear Model):

The linear model structures training into hierarchical cycles, each contributing to progression toward the performance peak.

2.1. Cycle Structure:

• Macrocycle: Annual plan aligned with the competitive calendar (e.g., August to May for football, 6 months for cycling).
• Mesocycles: 4–6 week blocks focused on a specific objective (e.g., aerobic endurance, power).
• Microcycles: Training weeks with intensity alternation (e.g., 3 intensive sessions, 2 light, 1 rest day).
• Practical Example (Football): A weekly microcycle includes 2 sprint sessions (6x20 m at 90% effort), 2 tactical sessions (passes, shots), and 1 active recovery session (yoga, 30 min).

2.2. Typical Chronology and Biometric Parameters:

Phase	**Duration**	**Weekly Volume**	**% Intensity > Threshold**	**Physiological Objective**
GP	8 weeks	14–16 h (cycling), 80–100 km (marathon)	15%	VO_2max ↑ 8%
SP	6 weeks	12–14 h (cycling), 90–110 km (marathon)	35%	FTP ↑ 10%
C	8 weeks	8–10 h (cycling), 70–90 km (marathon)	60%	Maintain CTL, TSB +15
T	2 weeks	4–6 h (cycling), 20–40 km (marathon)	10%	CK ↓ 50%, HRV ↑ 10%

2.3. Practical Example:

• Football: An annual macrocycle includes 10 weeks of GP (running, 8 km/session at 60% VO_2max), 8 weeks of SP (sprints 6x20 m at 90%, tactical drills), 2–4 weeks of C (tapering, volume -40%), and 2–4 weeks of T (active rest, yoga).

3. Transition from General to Specific (Linear Model):

The transition from general to specific training is central to the linear model, enabling progressive preparation for competitive demands.

3.1. General Preparation:

• Objective: Develop fundamental qualities (endurance, strength, coordination) to support subsequent specific loads.
• Content: High-volume, moderate-intensity exercises (e.g., continuous running 8 km at 60% VO_2max, squat strength 4x10 at 65% 1RM).
• Practical Example: A footballer performs 3 running sessions/week (8 km at 60% VO_2max) and 2 general strength sessions.

3.2. Specific Preparation:

• Objective: Develop sport-specific qualities (speed, power, tactics) by simulating match conditions.
• Content: Sprints (6x20 m at 90% effort, 2 min recovery), tactical drills (triangle passes, 20 min), match simulations.
• Practical Example: A specific session includes 6x20 m sprints (90% effort) and 20 min of long-pass drills (30 m, 85% accuracy).

3.3. Transfer Mechanism:

• Principle: Aerobic capacities developed in GP serve as a foundation for specific power in SP.
• Transfer Index (IT): IT = ΔPmax / ΔVO_2max, target >0.7 to validate transition efficiency.
• Method: Progressive volume reduction (e.g., from 10 km to 6 km/session) and intensity increase (from 60% to 85% maximal effort).
• Practical Example: A footballer transitions from 8 km continuous running (GP) to 4 km intervals (4x1 km at 85%, SP).

4. Critical Analysis of Current Validity (Linear Model):

4.1. Advantages:

• Clear Structure: Facilitates long-term planning with logical progression of physical qualities.
• Effectiveness: Suited to sports with well-defined seasons (e.g., football, marathon).
• Practical Example: A footballer reaches a performance peak during a championship via tapering (volume -40%).

4.2. Limits:

• Temporal Rigidity: Poorly suited to modern calendars with multiple peaks (e.g., 2 matches/week in professional football).
• Overload: High volume in GP can cause excessive fatigue (ACWR >1.5 in slow responders).
• Monotony: Athletes report RESTQ-Sport score >3.5 at end of GP, indicating mental fatigue.
• Practical Example: A footballer playing every 3–4 days finds the model too rigid, requiring GPS adjustments.

4.3. Current Relevance:

• Modern Adaptations: Integration of technologies (Catapult GPS, WHOOP HRV) for real-time adjustments (Halson, 2014).
• Alternatives: Block periodization, more flexible, often preferred for high-intensity sports.
• Practical Example: A football club combines the linear model with GPS data to reduce volume if HRV <50 ms.

5. Contemporary Adaptations of the Linear Model:

5.1. Division into Two Short Macrocycles:

• Concept: Split the year into 2 macrocycles of 12 weeks, each with an intermediate peak.
• Example: A cyclist plans two peaks (June, September) with GP/SP/C/T phases in each macrocycle.

5.2. "5-2" Microcycles:

• Concept: 5 days of progressive loading, 2 days of deload (-50% volume).
• Example: A marathoner alternates 5 running days (80–100 km) with 2 active rest days (cycling, yoga).

5.3. Early HIIT Insertion:

• Concept: Introduce 10% HIIT volume from week 3 of GP to limit neuromuscular detraining.
• Example: A cyclist adds 1 HIIT session (6x4 min at 105% FTP) in GP.

6. Numerical Example: Marathoner (24 weeks, Linear Model):

• Objective: Prepare a marathon with a performance peak.
• Macrocycle:
o Weeks 1–8 (GP): 80–100 km/week, 100% zone 1–2, VO_2max ↑ 8%.
o Weeks 9–14 (SP): 90–110 km/week, 1 lactate threshold session (6x3 km at 100% LTP), FTP ↑ 10%.
o Weeks 15–20 (C): 70–90 km/week, 2 marathon-specific sessions (32 km at marathon pace), TSB +15.
o Weeks 21–24 (T): 40–20 km/week, exponential taper, CK ↓ 50%, HRV ↑ 10%.

7. Case Study: Professional Footballer (Linear Model):

• Objective: Prepare a championship season (August–May).
• Macrocycle:
o GP (10 weeks): Running (8 km/session, 60% VO_2max), strength (squat 4x10 at 65% 1RM).
o SP (8 weeks): Sprints (6x20 m, 90% effort), tactical drills (passes, 20 min), match simulations.
o C (2–4 weeks): Tapering (volume -40%, 4 km/session), match simulations (15 min at 85% effort).
o T (2–4 weeks): Active rest (yoga, swimming).
• Monitoring: GPS (Catapult, 10 km/match), HRV (WHOOP, 60 ms), RPE (6/10).
• Result: 0.3 s improvement on 20 m sprint, 90% pass accuracy in match.

8. Specific Monitoring Indicators (Linear Model):

• End of GP: VO_2max test, target +8%.
• End of SP: 4 mmol lactate test, speed ↑ 6%.
• End of C: Average HRV ↑ 5% vs start of SP, TSB +15.
• Practical Example: A marathoner adjusts volume if ACWR >1.5 in SP to avoid overload.

9. Pedagogical Uses and Benchmarking (Linear Model):

• Pedagogical Reference: The linear model serves as a basis for understanding supercompensation laws and comparing with modern approaches (e.g., block periodization).
• Initial Training: Used to teach planning fundamentals to novice coaches.

10. Fundamental Principles of Block Periodization:

Block periodization relies on concentrated stimuli to rapidly develop specific qualities, while minimizing physiological interference and cumulative fatigue.

10.1. Concentrated Specialization:

• Concept: Each block targets a single biomotor quality (e.g., maximal strength, VO_2max, speed, lactate tolerance) over 2–6 weeks, with reduced volume and high intensity.
• Objective: Maximize specific adaptations by concentrating loads on a priority, reducing interference between qualities.
• Practical Example: A footballer dedicates a 4-week block to speed, with 3 sessions/week of sprints (6x20 m at 90% effort, 2 min recovery), reducing endurance to 4 km/session.

10.2. Minimization of Secondary Qualities:

• Concept: Non-priority qualities are maintained at a minimal level to avoid loss, without interfering with the main objective.
• Method: Reduce volume of secondary exercises (e.g., endurance at 50% of usual volume during a power block).
• Practical Example: In a power block, a weightlifter reduces endurance volume (from 8 km to 4 km/session) to focus on plyometrics (4x10 jumps).

10.3. Residual Training Effects System (RTE):

• Concept: Each biomotor capacity has a residual training effect (RTE) duration during which it remains acquired after stopping specific training, allowing block superposition without loss.
• Typical RTE Durations (Issurin, 2020):

Capacity	**RTE (days)**
Maximal strength	30
VO_2max	18–20
Lactate tolerance	12–15
Speed	5–7
• Practical Example: A triathlete completes a VO_2max block (RTE 18–20 days) and moves to a lactate tolerance block, maintaining VO_2max with 20% of initial volume.	

10.4. Individualization:

• Concept: Blocks are tailored to individual needs, based on biometric data (HRV, CK) and load metrics (GPS).
• Practical Example: A footballer with low HRV (40 ms, WHOOP) has speed block intensity reduced by 10% (sprints at 80% effort) to avoid overload (ACWR <1.4).

11. Block Typology:

Block periodization divides training into three block types, each with distinct objectives and content.

11.1. Accumulation (Formative) Block:

• Objective: Establish a physical or technical base to prepare subsequent blocks, developing fundamental qualities (endurance, general strength).
• Content: Moderate-volume, medium-intensity exercises, such as running (6 km/session at 60% VO_2max) or general strength (squat, 4x10 at 65% 1RM).
• Duration: 2–6 weeks.
• Practical Example: A cyclist follows a 4-week accumulation block with 18 h/week in zone 1–2 (60–70% HRmax) and 3 general strength sessions/week (squat, 4x10 at 65% 1RM).

11.2. Transmutation (Transitional) Block:

• Objective: Convert physical bases into specific qualities, increasing specificity and intensity.
• Content: Exercises combining physical and technical qualities, such as ball sprints (6x20 m at 85% effort) or HIIT (4x5’ at 105% FTP).
• Duration: 2–4 weeks.
• Practical Example: A footballer performs a 3-week transmutation block with 4 sprint sessions (6x20 m at 85%) and 2 tactical drill sessions (triangle passes, 20 min).

11.3. Realization (Competitive) Block:

• Objective: Achieve a performance peak for competitions via tapering and specific exercises.
• Content: Match simulations (15 min at 85% effort), high-intensity exercises (shots, 4x10 at 90%), and volume reduction (30–40%).
• Duration: 1–3 weeks.
• Practical Example: A footballer follows a 2-week realization block with 2 match simulation sessions (15 min at 85%) and tapering (volume -40%) before a tournament.

12. Block Sequence: Accumulation → Transmutation → Realization:

• Concept: Each cycle follows a mandatory sequence to maximize adaptations: accumulation (base), transmutation (specificity), realization (peak).
• Practical Example: A weightlifter follows:
o Accumulation (4 weeks): Squat (6x4 at 85% 1RM, 3x/week), total volume 120 tons/week.

o Transmutation (3 weeks): Cleans (6x3 at 70% 1RM), snatch pulls (5x3 at 75%), volume -30%.
o Realization (2 weeks): Specific exercises (3x3 at 90% 1RM), tapering (volume -40%).
• Result: 1RM squat ↑ 8%, power ↑ 12%.

13. Block Superposition (Block Complex):

• Concept: In elite athletes, blocks are superimposed to maintain multiple qualities via RTE.
• Method:
o Week 1: Block A (strength, 100% volume).
o Week 2: Block B (VO_2max, 100% volume) + strength maintenance (30% volume).
o Week 3: Block C (lactate tolerance, 100% volume) + VO_2max maintenance (20%) + strength maintenance (10%).
• RTE Calculation: Maintain capacities above critical threshold (e.g., strength >10% initial volume for 30-day RTE).
• Practical Example: A triathlete superimposes a VO_2max block (12 h/week, 4x5' at 105% FTP) with strength maintenance (1 session/week, squat 4x6 at 70% 1RM).

14. Differences with the Traditional Linear Model:

Criterion	**Block Periodization**	**Linear Model**
Simultaneous targets	1 (concentrated specialization)	3–4 (multifactorial)
Cycle duration	2–6 weeks	12–24 weeks
Weekly load	Stable or decreasing	Progressive
Physiological interference	Minimal	Possible
Individual adaptation	Very high (HRV, GPS)	Moderate
Applicability	Dense calendars (football)	Long seasons (track and field)

• Practical Example: In the linear model, a footballer dedicates 10 weeks to endurance before speed; in BP, a speed block (6x20 m sprints) starts from week 1, with minimal endurance maintenance (4 km/session).

15. Demonstrated Advantages (Block Periodization):

• Performance: Study on triathletes (Ronnestad, 2014): ↑ 8% threshold power vs linear.
• Injuries: 25% reduction due to controlled volume.
• Motivation: Increase due to content variety.
• Practical Example: A cyclist gains 8% threshold power after a transmutation block (4x5' at 105% FTP) compared to a linear cycle.

16. Limits and Precautions (Block Periodization):

• Precise Monitoring: Requires rigorous tracking (HRV >50 ms, CK ↓ 35%) to avoid overload.
• Overload Risk: If RTE miscalculated, loss of secondary qualities possible.
• Not Optimal for Juniors: Concentrated loads unsuitable for young athletes.

• Practical Example: A footballer with HRV <40 ms interrupts a speed block for an active recovery week (yoga, 30 min/session).

17. Control Tools:

• Notion Dashboard: Block timeline with RTE countdown.
• Python Script: Automatic RTE calculation based on individual history.
• TrainingPeaks API: Alert if load >110% block limit.
• GPS (Catapult): External load tracking (10 km/match, 22 sprints >25 $km \cdot h^{-1}$).
• HRV (WHOOP): Recovery assessment (HRV >60 ms).
• Practical Example: A footballer uses TrainingPeaks to plan a competitive block, with alerts if ACWR >1.4.

18. Case Study: Footballer (28 years, International Tournament, Block Periodization):

• Program (10 weeks):
o Accumulation Block (4 weeks): Endurance (6 km/session, 60% VO_2max), strength (squat, 4x10 at 65% 1RM, 3x/week).
o Transmutation Block (3 weeks): Sprints (6x20 m at 90% effort, 4x/week), tactical drills (triangle passes, 20 min, 2x/week).
o Realization Block (3 weeks): Match simulations (15 min at 85% effort, 2x/week), tapering (volume -40%, intensity 90%).
• Monitoring:
o GPS (Catapult): 10 km/match, 22 sprints >25 $km \cdot h^{-1}$.
o HRV (WHOOP): 60 ms before competition.
o RPE: 6/10.
• Adjustments: 10% intensity reduction if HRV <50 ms.
• Result: 0.2 s improvement on 20 m sprint, 90% pass accuracy, stable match performance.

Conclusion:

The traditional linear model and block periodization offer complementary approaches to structuring sports training, each suited to specific contexts. The linear model, with its clear progression from general to specific, excels in long-season sports like football or marathon, but its rigidity requires modern adaptations (short macrocycles, early HIIT, GPS/HRV monitoring) to meet dense competitive calendars. Block periodization, by concentrating loads on specific qualities through short cycles (accumulation, transmutation, realization), minimizes interference and maximizes adaptations, ideal for multiple-peak sports like professional football. Supported by technological tools (Catapult GPS, WHOOP HRV, TrainingPeaks), these models enable precise, individualized planning, ensuring optimal performance while preserving athlete health and motivation.

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Conference No. 07 Long-Term Planning and Annual Planning in Sports Training

Introduction:

Long-term planning (LTP) and annual planning are two complementary approaches essential for structuring the development and performance of athletes. LTP orchestrates athletic development over 4 to 10 years, taking into account growth phases, individual needs, and career goals, to maximize potential while ensuring sustainable progression. Annual planning, on the other hand, organizes training over a season (52 weeks) to align performance peaks with key competitions, while minimizing the risks of overtraining and injuries. By integrating principles of progressivity, individualization, and modern tools (GPS, HRV, TrainingPeaks), these approaches guarantee optimal preparation, effective management of transitions, and a prolonged career, while adapting to biological, logistical, and competitive constraints.

1. Fundamental Principles of Long-Term Planning:

LTP aims to maximize the genetic potential of athletes while respecting their biological, psychological, and sociological rhythms.

1.1. Main Objectives:

• Global Development: Build solid foundations in physical condition, technical skills, and mental resilience (Balyi & Hamilton, 2004).
• Sustainable Performance: Prepare athletes for high-level competitions while extending their career.
• Injury Prevention: Avoid excessive loads during sensitive growth periods.
• Smooth Transition: Facilitate the shift from junior categories to professional levels and prepare for post-career.

1.2. Guiding Principles:

• Progressivity: Gradually develop physical and technical qualities to avoid overtraining (Bompa & Haff, 2009).
• Individualization: Adapt plans to age, sex, discipline, and maturity level (e.g., early vs. late maturation).
• Interdisciplinarity: Integrate contributions from coaches, physical trainers, psychologists, nutritionists, and analysts for a holistic approach.
• Long-Term Vision: Plan objectives over 4–10 years, aligned with major competitions (e.g., Olympic Games, world championships).

2. Critical Growth Phases:

Growth phases directly influence LTP, as they determine optimal periods for developing certain physical and technical qualities.

2.1. Sensitive Development Windows:

Age	Sex	Main Window	Target Quality	Benchmark Tests
8–9	F	Speed (1st wave)	Nerve-muscle coordination	20 m sprint
10–11	M/F	Flexibility	Joint mobility	Sit-and-reach test
11–13	F	Speed (2nd wave)	Stride frequency	10x20 m cadence
12–14	M	Strength (1st wave)	Body weight	60 s push-up
13–15	F	Aerobic endurance	VO_2max	20 m shuttle run
15–17	M	Strength (2nd wave)	Hypertrophy	1RM squat
16–18	M/F	Anaerobic endurance	Lactate tolerance	30 s Wingate

2.2. Physiological Considerations:

• Bone Growth: Limit intensive training during growth peaks to avoid stress fractures.
• Muscle Development: Puberty is ideal for strength, with progressive loads (50–60% 1RM for youth).
• Nervous System: Before puberty, prioritize coordination through playful exercises.
• Practical Example: A 13-year-old gymnast focuses on flexibility and coordination (dynamic stretches, technical drills). At 16, she incorporates moderate strength loads (60% 1RM) to prepare for senior competitions, with monitoring via strength tests and video analysis.

3. The LTAD Model (Long-Term Athlete Development):

The LTAD model, developed by Balyi and Hamilton (2004, 2019), provides a structured framework for LTP, tailored to different stages of athletic development.

3.1. The Seven LTAD Stages:

1. **Active Start (0–6 years):** Playful physical activity to develop basic motor skills.
2. **Fundamentals (6–9 years F / 6–10 years M):** Coordination, agility, and basic skills (ABCs: Agility, Balance, Coordination) in a playful environment.
3. **Learn to Train (9–12 years F / 10–13 years M):** Development of sport-specific technical skills and basic physical qualities (endurance, light strength).
4. **Train to Train (12–16 years F / 13–17 years M):** Optimization of physical and technical qualities during puberty, with focus on endurance and strength.
5. **Train to Compete (16–19 years F / 17–21 years M):** Preparation for high-level competitions, with increased specialization.
6. **Train to Win (19+ years F / 21+ years M):** Achievement of performance peak for major competitions.
7. **Active for Life:** Transition to recreational activity or non-competitive role (coach, educator).

3.2. LTAD Application:

• Individualization: Adaptation to disciplines (e.g., endurance for cycling, power for weightlifting) and maturation differences.
• Continuous Evaluation: Physical (VO_2max, strength tests) and technical tests to adjust plans.

3.3. Advantages and Limits:

• Advantages: Systematic approach, burnout prevention, sustainable development.
• Limits: Requires significant resources (qualified coaches, longitudinal monitoring) and coordination between clubs, federations, and schools.

4. Construction of the Evolutionary Pathway:

LTP relies on precise mapping of long-term goals and annual milestones.

4.1. Target Performance Profile (TPP):

• Definition: Biometric targets at 18 years, e.g., for a swimmer: 200 m in 1'55"00, 40 km/week, VO_2max 50 $ml \cdot kg^{-1} \cdot min^{-1}$.
• Backward Mapping Method: Calculate annual milestones via exponential model: $P(t) = P_0 \cdot e^{(k \cdot t)}$, with $k = \ln(TPP/P_0)/n$ (n years).

4.2. Practical Example: U13–U19 Sprinter (6 years):

• Year 1 (11–12 years): 320 h, coordination + speed (1st wave), ABC test ≥ 70th percentile.
• Year 2 (12–13 years): 380 h, addition of relative strength (body weight).
• Year 3 (13–14 years): 430 h, 100/200 m specialization, 30 m fly ↓ 0.15 s.
• Year 4 (14–15 years): 500 h, introduction of heavy weights (trap-bar).
• Year 5 (15–16 years): 580 h, specific peak, 60 m test in 7"55.
• Year 6 (16–17 years): 620 h, junior JO qualification, exponential taper.

5. Sustainable Development Strategy:

LTP aims to balance performance, health, and motivation for a lasting career.

5.1. Controlled Cumulative Load:

• 1000-Hour Rule: Limit training to 1000 h before age 16 to avoid burnout.
• Specialization/Diversity Ratio: 80/20 before 14 years, 60/40 between 14–16 years, 90/10 after 17 years.
• Example: A young footballer practices 70% football and 30% cross-sports (basketball, swimming) at 13 years.

5.2. Interdisciplinary Model:

Age	Physical	Technical	Tactical	Mental	Total (h)
10–11	150	100	50	20	320
13–14	220	160	70	30	480
16–17	300	200	120	50	670

6. Management of Critical Transitions:

Transitions between levels require specific planning.

6.1. Junior-Senior Transition (17–19 years):

• Challenges: Sudden load increase (x1.8), media pressure, adaptation to independent living.
• Strategies: 10-day microcycle (3 high, 3 moderate, 4 recovery), biometric monitoring (HRV > baseline, T/C ratio > 0.45, SMS-II score > 5.5).

6.2. Performance-Health Transition (Post-Elite):

• Strategies: Creation of a "performance-health passport" (cardiac assessment, bone density, psychological follow-up, HADS score < 8).

7. Challenges and Perspectives of Long-Term Planning:

7.1. Challenges:

• Institutional Coordination: Requires collaboration between schools, clubs, and federations.
• Individual Variability: Maturation differences complicate standardized application.
• Resources: Technological tools and qualified staff are costly.

7.2. Perspectives:

• AI and Prediction: Integration into Smartabase to predict development trajectories.
• Accessibility: Wearable sensors become more affordable, expanding access to data.

8. Career Planning and Post-Career Transition:

LTP integrates career planning to ensure a successful post-career transition.

8.1. Pathway Construction:

• Initiation (6–12 years): Multilateral development, discovery of complementary sports, ABC test ≥ 70th percentile.
• Training (13–16 years): Progressive specialization (70% main sport, 30% cross-sports), VO_2max +15% annual, school average ≥ 14/20.
• Performance (17–23 years): Integration into high-performance center (CHN), junior/senior championship qualification, T/C ratio > 0.45.
• Elite (24–30 years): World/Olympic podium, 900–1100 h/year load, multidisciplinary staff (6 people).

8.2. Post-Career Transition:

• Objectives: Maintain physical activity (yoga, swimming), retraining (coach, analyst), psychological well-being (HADS score < 8).
• Strategies: Diploma training (BPJEPS, Master in sports management), networking (LinkedIn sport & business), health check (cardiac MRI, bone density).

9. Complete Competitive Season Planning:

Annual planning structures training to align performance peaks with major competitions, while ensuring physical, technical, and mental progression.

9.1. Season Objectives:

• Definition: Identify key competitions (championships, tournaments) and performance goals (e.g., improve speed, tactical accuracy, endurance).
• Approach: Divide the season into phases (general preparation, specific preparation, competition, transition) to achieve these goals.
• Practical Example: A professional footballer plans a season (August to May) with a peak for April championship matches, targeting 90% pass accuracy.

9.2. Season Structure:

• Main Phases:
o Pre-season (8–12 weeks): Development of physical bases (endurance, general strength) via high-volume exercises (e.g., 8 km/session run, 65% 1RM strength).
o Competitive Season (20–30 weeks): Performance optimization with specific training (sprints, tactical drills) and tapering before competitions.
o Off-season (4–6 weeks): Active recovery (yoga, swimming) and complete rest to reduce fatigue (CK ↓ 50%, HRV ↑ 10%).
• Practical Example: A football club structures a season with 10 weeks pre-season (8 km/session run at 60% VO_2max), 25 weeks competition (6x20 m sprints, tactical drills), and 4 weeks transition (yoga, 30 min/session).

9.3. Competition Integration:

• Method: Synchronize planning with official calendar (matches, cups, tournaments), integrating tapering periods (30–50% volume reduction) before key events.
• Practical Example: A footballer reduces training volume by 40% (from 10 km to 6 km/session) before a Champions League match, with GPS monitoring (Catapult) to maintain 85% intensity.

10. Distribution of Macrocycles, Mesocycles, and Microcycles:

Annual planning relies on a hierarchy of cycles to structure training progressively and efficiently.

10.1. Macrocycles:

• Definition: Annual or semi-annual cycle (12–52 weeks) encompassing the entire season, aligned with the official calendar.
• Content: Division into phases (general preparation, specific, competitive, transition).
• Practical Example: An annual macrocycle (August to May) for a footballer includes 10

weeks general preparation (GP), 8 weeks specific (SP), 25 weeks competitive (C), and 4 weeks transition (T).

10.2. Mesocycles:

• Definition: 4–6 week blocks focused on a specific objective (endurance, power, tactics).
• Content: Combination of physical (sprints, strength) and technical (pass drills) exercises.
• Practical Example: A 4-week mesocycle focused on speed includes 3 sessions/week of sprints (6x20 m at 90% effort) and 2 tactical drill sessions (passes, 20 min).

10.3. Microcycles:

• Definition: Weekly cycles (5–7 days) integrating intensity and recovery alternation.
• Content: Intensive sessions (sprints, match simulations), light sessions (technique, yoga), and rest days.
• Practical Example: A weekly microcycle includes 2 sprint sessions (6x20 m at 90%), 2 tactical sessions (passes, 20 min), 1 active recovery session (yoga, core, stretches), and 1 rest day.

11. Integration of Strength Training and Stretching:

Strength training and stretching are essential components to improve performance and prevent injuries.

11.1. Strength Training:

• Benefits:
o Improvement of muscle strength and joint stability.
o Reduction of injury risk (e.g., sprains, tears).
o Increased metabolism (higher calorie burn).
o Mental well-being (stress management, self-confidence).
• Method: Integrate resistance exercises (dumbbells, squat 4x10 at 65% 1RM) in GP and SP phases, with gradual progression (50–70% 1RM).
• Practical Example: A footballer performs 2 sessions/week of strength training (squat, bench press) in pre-season, targeting an 8% strength increase.

11.2. Stretching:

• Benefits:
o Improvement of flexibility and joint mobility.
o Injury prevention via better adaptation to physical demands.
o Stress reduction and better muscle recovery.
• Method: Integrate dynamic stretches (pre-training) and static stretches (post-training) in every microcycle, with 10–15 min/session.
• Practical Example: A swimmer includes 10 min of stretches (legs, back) after each session to maintain optimal range of motion.

11.3. Integration into the Annual Plan:

• Key Steps:
o Assess strength and flexibility needs via tests (e.g., sit-and-reach, 1RM).
o Plan dedicated or combined sessions (e.g., core + stretches) in microcycles.
o Adjust frequency and intensity by phase (GP: high volume, C: high intensity).
o Maintain communication with the athlete to adjust based on health status.
• Practical Example: A triathlete integrates 2 sessions/week of strength (dumbbells, 4x10 at 60% 1RM) in GP and 10 min stretches after each session in SP.

12. Heart Rate (HR) Monitoring:

Heart rate is a key indicator for personalizing intensity and optimizing progression.

12.1. Importance of HRmax:

• Role: HRmax allows definition of intensity zones (endurance, power, recovery) for safe progression.
• Method: Estimate via formulas (e.g., 220 - age) or specific tests (400 m test, 20 m shuttle).
• Intensity Zones:
o Basic endurance: 60–70% HRmax.
o General endurance: 70–80% HRmax.
o Active endurance: 80–90% HRmax.
o Threshold: 90–100% HRmax.
o Critical: >100% HRmax (sprints, HIIT).
• Practical Example: A footballer with HRmax of 190 bpm performs runs at 70–80% (133–152 bpm) in GP to develop endurance.

12.2. Use for Planning:

• Method: Structure sessions by HR zones to target specific adaptations (e.g., aerobic endurance at 60–70%, power at 90–100%).
• Practical Example: A swimmer plans 3 sessions/week at 70–80% HRmax (endurance) and 1 session at 90–100% (threshold) in SP, with WHOOP monitoring.

12.3. Intensity Adaptation:

• Method: Adjust intensity in real time based on HR data, reducing volume if HRV < 40 ms or ACWR > 1.4.
• Practical Example: A triathlete reduces intervals (100% HRmax) to 80% if HRV indicates excessive fatigue.

13. Adaptation to Sports Seasons:

Adapting the plan to sports seasons optimizes performance and maintains motivation.

13.1. Seasonal Structure:

• Autumn (Transition): Active recovery (yoga, swimming), general physical preparation (high volume, 60–70% HRmax).
• Winter (GP): Strength training (squat, 4x10 at 65% 1RM), indoor cardiovascular work (70–80% HRmax).
• Spring (SP): Progressive increase in volume and intensity (80–90% HRmax), competition preparation.
• Summer (C): Competitions, form maintenance (tapering, 90–100% HRmax), post-competition recovery (yoga, stretches).
• Practical Example: A footballer performs strength sessions in winter (2x/week, 65% 1RM) and sprints in spring (6x20 m at 90%).

13.2. Training Variability:

• Methods:
o Vary loads (volume/intensity).
o Alternate endurance/power (e.g., continuous run vs intervals).
o Use varied equipment (dumbbells, bike).
o Change environment (indoor/outdoor, flat/hilly).
• Practical Example: A triathlete alternates hilly runs (spring) and pool sessions (winter) to maintain motivation.

13.3. Rest and Recovery Management:

• Methods: Integrate active rest periods (yoga, core), stretches (10–15 min/session), and complete rest (1 day/week).
• Microcycle Example:
o Monday: Rest + core + stretches (10 min).
o Tuesday: Endurance (70–80% HRmax).
o Wednesday: Rest + core + stretches.
o Thursday: Active endurance (80–90% HRmax).
o Friday: Rest + core + stretches.
o Saturday: Endurance (70–80% HRmax).
o Sunday: Rest + core + stretches.

14. Link with the Official Calendar:

Annual planning must be synchronized with the official calendar to optimize performance.

14.1. Calendar Analysis:

• Step: Identify match dates, tournaments, and rest periods (e.g., Champions League, national championships).
• Practical Example: A football club plans a peak in April for championship semi-finals, with a 10-day taper (volume -40%).

14.2. Dynamic Adjustments:

• Method: Use GPS (Catapult) and HRV (WHOOP) to adjust loads during close matches (every 3–4 days).
• Practical Example: If HRV < 40 ms, volume is reduced by 20% (from 8 km to 6 km/session) to avoid overload (ACWR < 1.4).

14.3. Tapering:

• Objective: Reduce volume (30–50%) while maintaining intensity (85–90%) to maximize readiness (TSB +15 to +20).
• Practical Example: A footballer follows a 10-day taper before a key match, monitored by GPS (Catapult) and TrainingPeaks.

15. Management of External Constraints:

Annual planning must integrate academic, climatic, and logistical constraints.

15.1. Academic/University Constraints:

• Method: Intensify training during holidays (40 h/week) and reduce load by 30% during exams.
• Practical Example: A student-athlete reduces sessions from 12 to 8 h/week during exams, focusing on core and stretches.

15.2. Climatic/Geographical Constraints:

• Altitude Camp: 3 weeks at 2000 m to increase hemoglobin mass (Hb-mass ↑ 5%).
• Heat Acclimation: 10 days at 35°C, reducing HR by 8%.
• Practical Example: A triathlete conducts an altitude camp in winter to prepare for summer competitions.

15.3. Travel and Jet-Lag:

• Protocol: 1 day of adaptation per time zone (Waterhouse, 2021).
• Practical Example: A swimmer adjusts sleep and training over 3 days after a transatlantic flight.

16. Biometric Control and Monitoring Tools:

16.1. Biometric Indicators:

• CTL (Chronic Training Load): Maintain 90–110 in season.
• ATL (Acute Training Load): Peak at 140 during camps.
• TSB (Training Stress Balance): Target +15 to +20 before competitions.
• HRV: ln rMSSD > 4.0 before A competitions.
• Practical Example: A swimmer adjusts volume if ACWR > 1.4 to avoid overload.

16.2. Technological Tools:

• GPS and Sensors: Catapult/STATSports to measure external loads (10 km/match for a footballer).
• HRV: WHOOP to assess recovery (HRV > 60 ms).
• Digital Platforms: TrainingPeaks (CTL/TSB tracking), Looker Studio (load vs calendar heat-map), Smartabase (performance KPIs).
• Python Scripts: Automatic alerts if projected ACWR > 1.4 over 7 days.
• Practical Example: A footballer uses TrainingPeaks synced with Google Calendar to plan microcycles.

17. Case Study: 100 m Butterfly Swimmer (48 weeks):

• Objective: Prepare for Olympics and World Championship.
• Macrocycle:
o Weeks 1–6 (GP): 40 km/week, 8 sessions, endurance (60–70% HRmax).
o Weeks 7–12 (SP): 45 km/week, 3x(8x50 m at 105%), strength (dumbbells, 4x10 at 60% 1RM).
o Weeks 13–18 (C1): European Cup, taper CTL 75 → 55, TSB +15.
o Weeks 19–21 (Transition): 25 km/week, cryotherapy, stretches (10 min/session).
o Weeks 22–32 (C2): Olympic preparation, altitude camp (3 weeks, Hb-mass ↑ 5%).
o Weeks 33–34 (Olympic Taper): CTL 45, TSB +18.
o Weeks 35–36 (Olympics): Competition, simulations (90–100% HRmax).
o Weeks 37–40 (Final Transition): 20 km/week playful, yoga, core.
o Weeks 41–46 (Macrocycle 2): World Championship, 45 km/week, strength.
o Weeks 47–48 (Taper): CTL 40, TSB +16.
• Monitoring: GPS (Catapult, 40–45 km/week), HRV (WHOOP, 60 ms), RPE (6/10).
• Result: 0.3 s improvement on 100 m butterfly, Olympic qualification.

18. Logistics and Resource Management:

• Budget: 30% camps, 40% staff, 20% technology, 10% equipment.
• Staff: 1 doctor, 1 physical trainer, 1 nutritionist, 1 video analyst.
• Meetings: Monthly (macrocycle), weekly (microcycle).
• Practical Example: A football club allocates €20k for an altitude camp and uses Looker Studio to track KPIs (TSB, HRV).

19. Strategies to Maintain Motivation and Performance:

• Methods:
o Set short-, medium-, and long-term goals (e.g., 0.2 s improvement on 20 m sprint).
o Integrate active recovery sessions (yoga, swimming).
o Vary training (aerobic, strength, technical).
o Use monitoring tools (TrainingPeaks, WHOOP).
o Celebrate progress (e.g., cup qualification).
• Practical Example: A triathlete sets monthly goals (VO_2max ↑ 5%) and alternates outdoor/indoor sessions to avoid monotony.

20. 7-Step Systemic Construction:

1. **Pre-season Audit:** Physical tests (VO_2max, 1RM) and injury assessment.
2. **Competition Mapping:** Identify A (peak), B (qualification), C (test) competitions.
3. **Macrocycle Breakdown:** 20–16–12 weeks based on peaks (e.g., Olympics, championships).
4. **Camp/Stage Insertion:** Altitude camps (3 weeks), technical stages.
5. **Resource Allocation:** Budget, staff, equipment.
6. **TSB/HRV Dashboard:** Targets TSB +15, HRV ln rMSSD > 4.0.
7. **Monthly Review:** Adjustments via staff meetings.

Conclusion:

Long-term planning and annual planning form an integrated framework to optimize athlete development and performance. LTP, guided by the LTAD model, structures development over 4 to 10 years, accounting for growth phases, critical transitions, and post-career, ensuring balance between performance, health, and motivation. Annual planning synchronizes training with the competitive calendar through macrocycles, mesocycles, and microcycles, integrating strength training, stretching, heart rate monitoring, and dynamic adjustments via technological tools (GPS, HRV, TrainingPeaks). Together, these approaches maximize performance peaks, prevent injuries, and support a sustainable career, while adapting to external constraints and maintaining athlete engagement.

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Conference No. 08 Design of Macrocycle, Mesocycle, Microcycle, and Training Session in Sports Planning

Introduction :

Sports planning relies on a structured hierarchy comprising the macrocycle, mesocycle, microcycle, and training session, each playing a key role in translating long-term objectives into concrete actions. The macrocycle (6 to 12 months) structures the annual training to achieve performance peaks during major competitions, while integrating preparation, competition, and transition phases. The mesocycle (3 to 8 weeks) focuses on intermediate objectives, developing specific qualities in line with the macrocycle phases. The microcycle (3 to 14 days, generally one week) organizes weekly sessions to balance load and recovery, while the training session represents the basic unit, designed to optimize physiological, technical, and psychological adaptations. By relying on scientific principles (periodization, supercompensation) and modern tools (GPS, HRV, TrainingPeaks, Smartabase), this planning ensures consistent progression, rigorous load management, and preparation tailored to the individual needs of athletes, while minimizing the risks of overtraining and injuries.

1. Structure of the Macrocycle:

The macrocycle is a long-term plan, generally annual, divided into distinct phases to meet the demands of the sport and the competitive calendar.

1.1. Main Phases:

• **General Preparation (GP, 6–12 weeks):** Development of basic physical qualities (aerobic endurance, general strength) with high volume (e.g., 50–60 km/week for a runner) and moderate intensity (80% zone 1–2). Objectives: increase VO_2max (+5%) and maximal strength (squat 1RM +8%).
• **Specific Preparation (SP, 6–10 weeks):** Focus on discipline-specific qualities (speed, power, technique) with reduced volume (e.g., 30–40 km/week) and increased intensity (e.g., intervals at 85–90% VO_2max). Objective: improve threshold power (+10%) and technical skills.
• **Competitive Phase (C1/C2, 4–12 weeks):** Performance optimization with moderate loads, specific training, and tapering (30–50% volume reduction while maintaining intensity) to achieve a form peak (TSB +5 to +20). Objective: record performance in key competitions.
• **Transition (T1/TF, 1–6 weeks):** Active rest (e.g., yoga, swimming) and regeneration to avoid overtraining. Objectives: reduce creatine kinase (CK -50%), improve sleep (+1 h), and increase HRV (+10%).

1.2. Duration and Flexibility:

• **Duration:** Varies by sport (e.g., 12 months for athletics, 9–10 months for football). Phases are adjusted based on the competitive calendar.

• **Flexibility:** The macrocycle can be modified to integrate unforeseen competitions, injuries, or individual needs, using adjustment microcycles.

1.3. Practical Example:

For a middle-distance runner (1500 m):
• GP (10 weeks): 50–60 km/week, aerobic endurance (zone 1–2).
• SP (8 weeks): 30–40 km/week, intervals at 85–90% VO_2max.
• C1 (6 weeks): Tapering with 20–25 km/week, focus on speed.
• TF (4 weeks): Active rest (swimming, yoga).

2. Objectives of the Macrocycle:

The macrocycle objectives are aligned with the athlete's needs and competitive calendar requirements, combining performance, prevention, and longevity.

2.1. Main Objectives:

• **Physical Development:** Build solid foundations (strength, endurance) in GP, then optimize specific qualities (power, speed) in SP.
• **Optimal Performance:** Achieve a form peak for key competitions (e.g., national championships, Olympic Games) with TSB of +15 to +20.
• **Injury Prevention:** Integrate recovery periods and monitor indicators (ACWR <1.5) to minimize overtraining risks (Bompa & Haff, 2009).
• **Psychological Preparation:** Strengthen confidence and stress management via strategies like visualization or psychological interventions (Weinberg & Gould, 2019).

2.2. Secondary Objectives:

• **Individual Adaptation:** Personalize loads based on age, level, and athlete condition (e.g., reduced loads for young athletes).
• **Technical Development:** Integrate specific drills (e.g., tennis serve technique, football passes).
• **Longevity:** Prepare the athlete for multiple seasons by avoiding burnout via transition phases.

3. Alignment with the Competitive Calendar:

The macrocycle must be synchronized with the competitive calendar to maximize performance in key events.

3.1. Calendar Analysis:

• **Major Competitions:** Identify dates of championships or tournaments (e.g., Olympic Games in July, national championships in August).
• **Secondary Competitions:** Integrate preparatory competitions to maintain form.
• **Down Periods:** Plan recovery or development phases between competitions.

3.2. Alignment Strategies:

• **Tapering:** Reduce volume (30–50%) while maintaining intensity before competitions to optimize performance (Mujika & Padilla, 2003).
• **Multiple Peaks:** In long-season sports (e.g., football), plan several peaks (TSB +5 to +10 for secondary matches, +15 to +20 for key matches).
• **Load Monitoring:** Use tools like GPS (Catapult, STATSports) to measure external loads (distance, accelerations) and HRV (WHOOP, Elite HRV) to assess recovery.

4. Integration of Modern Tools in the Macrocycle:

Modern technologies improve the precision and efficiency of macrocycle design.

4.1. Monitoring Tools:

• **GPS:** Measurement of external loads (e.g., 8–10 km/match with 20–30 accelerations for a rugby player via Catapult).
• **HRV:** Recovery assessment (WHOOP, stable HRV or >60 ms indicates good recovery).
• **RPE:** Subjective feedback on perceived effort (Borg, 1982).
• **Digital Platforms:** TrainingPeaks (CTL/ATL/TSB tracking), Smartabase (data integration), WKO5 (dashboard with load vs objectives heat-map), Google Data Studio (load visualization).

4.2. Practical Application:

For an elite triathlete (48-week season, objective Olympics in July and national record in September):
• Weeks 1–8 (GP): 14 h/week, 80% zone 1–2, strength 3x/week, altitude camp at 2000 m (↑ Hb-mass 5%, Garvican, 2015).
• Weeks 9–16 (SP): 16 h/week, bike HIIT (5x5’ at 105% FTP), swimming (4x400 m at CSS), altitude camp at 1800 m.
• Weeks 17–20 (C1): Regional races, volume 12 h, tapering.
• Weeks 21–22 (T1): 6 h active recovery (yoga, cryotherapy).
• Weeks 23–34 (C2): Olympic preparation, 14–15 h/week, specific block.
• Weeks 35–36 (Olympic Tapering): CTL -20%, TSB +18.
• Weeks 37–38 (Olympics): Competition.
• Weeks 39–42 (TF): 5 h playful (bike, swimming).
• Weeks 43–46 (C2 short): 10 h/week, peak for 70.3 national record.
• Week 47 (Tapering): TSB +15.
• Week 48: National record.

5. Macrocycle Design Methods:

5.1. Reverse Gantt:

• **Method:** Backward planning from the deadline (e.g., Olympics in July) to define milestones (tapering, tests, altitude camps).
• **Example:** A triathlete plans an altitude camp in GP (weeks 1–3) and tapering in C1 (weeks 35–36).

5.2. Sports Critical Path Method (CPM):

• **Method:** Identify critical sessions (tests, major competitions) and float margins (adjustment microcycles).
• **Example:** A regional competition (C1) is non-compressible, but a recovery microcycle can be adjusted.

5.3. Cumulative Load Model (PMC):

• **Variables:** CTL (fitness, target 110–120), ATL (fatigue), TSB (form, target +15 to +20 on D-day).
• **Example:** A triathlete reaches CTL of 115 and TSB of +18 before the Olympics.

6. Risk Management in the Macrocycle:

• **Injuries:** Adopt a 3+1 structure (3 weeks build-up, 1 week unload at 40%) if ACWR >1.5 to limit risks.
• **Illness:** Graduated return-to-training protocol (British Journal of Sports Medicine, 2021).
• **Psychological:** Psychologist intervention if RESTQ-Sport >3.2 (high stress indicator).

7. Case Study: Volleyball Player:

• **Objective:** National championship (October–May).
• **Macrocycle:**
o GP (August–September, 8 weeks): 5 sessions/week, strength (squat, bench press), endurance (continuous run).
o SP (October–November, 6 weeks): 4 sessions/week, plyometrics, attack drills.
o C1/C2 (December–May, 20 weeks): 3 sessions/week, tapering before key matches, tactical focus.
o TF (June, 4 weeks): Active rest (yoga, swimming).
• **Monitoring:** GPS (Catapult) for external loads, HRV (WHOOP) and RPE to adjust loads.
• **Result:** 10% improvement in vertical jump, better match performance.

8. Role of the Mesocycle:

The mesocycle is an intermediate planning unit that focuses training on specific objectives, while fitting into the overall progression of the macrocycle.

8.1. Definition:

• According to Bompa and Haff (2009), a mesocycle is a 3- to 8-week period focused on developing one or more physical qualities (strength, endurance, speed), technical, or tactical

skills, in line with the macrocycle phase (general preparation, specific, competitive, or transition).
• It serves as a link between the macrocycle (annual plan) and microcycles (weekly plans), ensuring structured and measurable progression.

8.2. Main Objectives:

• **Targeted Development:** Improve a specific quality (e.g., maximal strength, anaerobic power, serve technique) or tactical skill.
• **Progressive Adaptation:** Prepare the athlete for subsequent phases by gradually adjusting loads (volume, intensity).
• **Overtraining Prevention:** Integrate recovery microcycles (e.g., unload week at -33% volume) to balance load and regeneration.
• **Intermediate Measurement:** Evaluate adaptive response via tests (e.g., FTP, running test) to adjust loads.

8.3. Importance:

• **Flexibility:** Allows adjustments based on athlete responses (fatigue, progress) or unforeseen events (injuries, competitions).
• **Specificity:** Aligns training with sport demands and competitive calendar.
• **Practical Example:** In a general preparation mesocycle for a swimmer, emphasis is on aerobic endurance (40–50 km/week), while a specific mesocycle targets speed with high-intensity intervals (8x50 m at 110% vVO_2max).

9. Structure of the Mesocycle:

The mesocycle is structured into weekly microcycles, each contributing to the overall objective while integrating load progression.

9.1. Components:

• **Microcycles:** Weekly units (5–7 days) combining varied sessions (strength, endurance, technique, recovery).
• **Progression:** Gradual increase in volume and/or intensity over the first weeks (e.g., +12–14% per week), followed by an unload week to promote recovery (Issurin, 2010).
• **Duration:** Generally 4 to 6 weeks, but may vary (e.g., 2–3 weeks for a tapering mesocycle).

9.2. Types of Mesocycles:

Type	Duration	Objective	End Indicator
Accumulation	4–5 wk	Volume + aerobic base	VO_2max ↑ 3–5%
Intensification	3–4 wk	Specific power	FTP ↑ 5–8%
Realization	2–3 wk	Race specificity	5 km test ↓ 2%
Tapering	1–2 wk	Withdrawal, performance peak	TSB +15, CMJ ↑ 5%
Recovery	1–2 wk	Active rest, regeneration	HRV ↑ 10%, CK ↓ 50%

10. Relationships of the Mesocycle with Other Components:

The mesocycle integrates into a broader framework, interacting with the macrocycle and microcycles for coherent planning.

10.1. Relationship with the Macrocycle:

• The mesocycle is a sub-unit of the macrocycle, aligned with its phases (general preparation, specific, competitive, transition).
• **Example:** In an annual macrocycle for a track athlete, an accumulation mesocycle (strength, endurance) precedes an intensification mesocycle (speed, technique) in the specific phase.

10.2. Relationship with Microcycles:

• Each mesocycle consists of microcycles varying in intensity and volume to achieve the overall objective.
• **Example:** A strength mesocycle for a weightlifter includes microcycles with high-intensity days (90% 1RM) and active recovery days (yoga, stretches).
• **Interference Management:** Schedule strength sessions in the morning and endurance in the afternoon (gap ≥6 h) to limit power loss (Docherty & Sporer, 2000).

10.3. Coordination:

• **Continuous Feedback:** HRV (WHOOP) and RPE (Borg, 1982) data adjust microcycles to avoid fatigue (e.g., 15% volume reduction if HRV ↓ >10%).
• **Synchronization:** Mesocycles are planned to peak during key competitions, in coordination with the-macrocycle calendar.

11. Practical Examples of Mesocycles:

11.1. Specific Preparation Mesocycle – 400 m Runner (4 weeks):

• **Objective:** Develop specific speed and anaerobic power for a regional championship.
• **Structure:**
o Week 1: Moderate volume (30 km), sprints at 90% vMax (4x200 m), 1 plyometrics session.
o Week 2: Similar volume (30 km), sprints at 95% vMax (6x150 m), 2 strength sessions.
o Week 3: Reduced volume (25 km), sprints at 100% vMax (8x100 m), 1 strength session.
o Week 4: Unload (15 km, moderate intensity, active rest).
• **Monitoring:** GPS (Catapult) for speed/volume, HRV (WHOOP) for recovery, post-session RPE.
• **Adjustments:** Intensity reduction in week 3 if RPE >8/10 or HRV ↓ >10%.
• **Result:** 0.5 s improvement on 400 m (post-mesocycle test).

11.2. Accumulation Mesocycle – Road Cyclist (4 weeks):

• **Objective:** Improve aerobic base (VO_2max ↑ 3–5%).
• **Structure:**
o Week 1: Volume 14 h, 2 threshold sessions (2x20’ at 90% FTP).
o Week 2: Volume 16 h (+14%), 1 long endurance session (4 h zone 2).
o Week 3: Volume 18 h (+12%), HIIT (5x5’ at 105% FTP).
o Week 4: Volume 12 h (-33%), 20 min FTP test.
• **Monitoring:** Google Data Studio dashboard (traffic-light), micro-doses sprints (6x3” at 150% Pmax, 2x/week, Ronnestad, 2020).

11.3. Special Preparation Mesocycle – 200 m Swimmer (5 weeks):

• **Objective:** Improve specific speed and technique.
• **Structure:**
o Week 1: Volume 40 km, technique focus (start, turn).
o Week 2: Volume 45 km, 10x100 m at 105% vVO_2max.
o Week 3: Volume 42 km, 6x200 m at 102% vVO_2max, lactate test 4 mmol.
o Week 4: Volume 35 km, 8x50 m at 110% vVO_2max, partial taper.
o Week 5: Volume 28 km, 200 m control race test.
• **Monitoring:** Testosterone/cortisol ratio end of week 2, nocturnal HRV.

12. Regression Scenarios in the Mesocycle:

If intermediate tests show insufficient results:
• **Scenario A:** Repeat week 3 (same volume/intensity).
• **Scenario B:** Insert a “top-up” week (volume -20%, intensity +10%).

13. Role of the Microcycle:

The microcycle translates mesocycle intermediate objectives into concrete sessions, managing the balance between stimulation, recovery, and adaptation.

13.1. Definition:

• According to Bompa and Haff (2009), the microcycle is a 3- to 14-day planning unit (generally 5–7 days) that organizes sessions to develop physical qualities (strength, endurance, speed), technical, or tactical skills, while integrating recovery periods.
• It serves as an operational link between mesocycle medium-term objectives and the athlete's daily activities.

13.2. Main Objectives:

• **Targeted Development:** Work on a specific quality (e.g., anaerobic power, swimming technique) or tactical skill (e.g., rugby scrum exercises).
• **Load/Recovery Balance:** Alternate intense and light sessions to promote adaptation and avoid excessive fatigue.
• **Progressive Preparation:** Prepare the athlete for competitions or subsequent mesocycle

blocks.
• **Real-Time Adjustment:** Allow modifications based on athlete responses (HRV, RPE, biomarkers).

13.3. Importance:

• **Flexibility:** Daily adjustments based on fatigue indicators (e.g., HRV ↓ >8% = load reduction).
• **Specificity:** Aligns sessions with sport demands and mesocycle objectives.

14. Structure of the Microcycle:

The microcycle is structured into daily sessions, with a strategic balance between load, intensity, and recovery.

14.1. Components:

• **Training Sessions:** Include physical exercises (strength, endurance, speed), technical (specific drills), and tactical (match situations).
• **Recovery:** Active rest days (e.g., yoga, light swimming) or passive to regenerate the athlete.
• **Duration:** Generally 5–7 days, with 3–6 sessions depending on the sport and phase (e.g., 5 sessions in regular season, 3 in tapering).

14.2. Types of Microcycles:

Type	Duration	Use	Weekly Load	Example Sport
Standard	7 d	Regular season	Moderate	Football, athletics
Competition	7 d	Pre-match	Tapering	Rugby Top 14
Shock	3–5 d	Intensive block	High	Swimming camp
Recovery	5–7 d	Post-competition	Very low	Tour de France stage

14.3. Practical Example: High-Low Model (7 days):

For an 800 m runner in specific preparation:
• Monday (High): HIIT (6x200 m at 90% vMax), TSS 95, RPE 8.
• Tuesday (Low): Active recovery (bike 60 min zone 1 + core), TSS 35, RPE 3.
• Wednesday (High): VMA (10x400 m at 100% vVO_2max), TSS 80, RPE 7.
• Thursday (Low): Technique (stride drills, swimming 2 km), TSS 70, RPE 4.
• Friday (High): Explosive strength (trap-bar jumps 5x4, sprints 6x30 m), TSS 40, RPE 5.
• Saturday (Low): Active rest (bike 60 min zone 1), TSS 20, RPE 2.
• Sunday: Passive rest or competition.

15. Organization of Sessions in the Microcycle:

Session organization in a microcycle relies on strategic alternation to optimize adaptation.

15.1. Session Planning:

• **Sequence:** Alternate intense sessions (high intensity, RPE 7–9) and light sessions (active recovery, RPE <4) to promote supercompensation.
• **Duration:** 60–120 min per session, depending on the discipline (e.g., 90 min for football, 120 min for cycling).
• **Content:** Each session includes warm-up (15 min), main part (targeted exercises, 45–60 min), and cool-down (10–15 min).

15.2. Integration of Dimensions:

• **Physical:** Develop a specific quality (e.g., power via plyometrics, 4 sets of jumps).
• **Technical:** Improve skills (e.g., football passes, swimming turns).
• **Psychological:** Integrate visualization (10 min/session) to strengthen confidence (Weinberg & Gould, 2019).

16. Balance Between Load and Recovery in the Microcycle:

Balance between load and recovery is crucial to maximize adaptation while avoiding overtraining.

16.1. Principles:

• **Controlled Overload:** Apply sufficient loads to stimulate adaptation, followed by recovery periods (Zatsiorsky & Kraemer, 2006).
• **Supercompensation:** Adequate recovery after intense load improves performance.
• **Individualization:** Adjust loads based on physiological responses (HRV, RPE) and biomarkers (CK).

16.2. Indicators:

• **Load:**
o Cumulative sRPE: Target 250–350 a.u. for accumulation phase, 150–200 a.u. for tapering (Foster, 2001).
o GPS: External load measurement (e.g., 6.2 km/day early in microcycle for a footballer, Catapult).
o TSS (Training Stress Score): Load indicator (e.g., 95 for HIIT, 20 for recovery).
• **Recovery:**
o HRV: Drop >8% vs baseline = 15% load reduction (WHOOP).
o Biomarkers: CK >800 $UI \cdot L^{-1}$ or testosterone/cortisol ratio <0.35 = fatigue alert (Halson, 2014).
o Monotony & Strain: Monotony <2.0, Strain <4500 a.u. (Foster, 2001).

16.3. Management:

• Integrate 1–2 recovery days per microcycle (active or passive rest).
• Dynamically adjust if HRV drops or RPE >8/10 (e.g., replace HIIT session with yoga).

17. Practical Examples of Microcycles:

17.1. Special Running Microcycle – 5 km Test (7 days):

• **Objective:** Prepare a 5 km test in week 4 of a mesocycle.
• **Structure:**

Day	Objective	Content	TSS	Target RPE
Monday	VO_2max	5x1 km at 105% vVO_2max, 3 min recovery	95	8
Tuesday	Active recovery	40 min zone 1 + core	35	3
Wednesday	Specific strength	12x200 m hills 6%, 90 s recovery	80	7
Thursday	Long endurance	75 min zone 2 + stride drills	70	4
Friday	Tapering	6x200 m at 95%, 2 min recovery	40	5
Saturday	5 km Test	Competition race	110	9
Sunday	Recovery	30 min bike + stretches	20	2

17.2. Exponential Taper Microcycle (7 days):

• **Objective:** Prepare a competition (Mujika, 2022).
• **Structure:**
o Week -7: Volume -20%, intensity maintained.
o Week -3: Volume -40%, intensity -10%.
o Day -1: Light activation (15 min).

17.3. Shock Microcycle (3 days, Swimming Camp):

• **Objective:** Provoke rapid adaptation.
• **Structure:**
o Day 1: 2x(6x200 m at 110% vVO_2max).
o Day 2: 1x(4x400 m at 105% vVO_2max) + 1 h bike zone 1.
o Day 3: 1x(3x300 m at 100%).
• **Surveillance:** Morning CK >800 UI·L^{-1} = stop.

17.4. Team Sports Microcycle – Football, Saturday Match (5 days):

• **Objective:** Prepare a match.
• **Structure:**
o Monday: Video + 30 min activation (2 km), RPE 3.
o Tuesday: HIIT (4x4 min), tactics (6.2 km), RPE 7.
o Wednesday: Strength + reduced game (4.1 km), RPE 6.
o Thursday: Active recovery (2 km), RPE 3.
o Friday: Tapering activation, RPE 4.

18. Case Study: Swimmer (Microcycle):

• **Objective:** Improve speed (100 m butterfly) in a specific mesocycle.
• **Microcycle (7 days):**
o Day 1: Intervals (8x50 m at 95% max effort), RPE 8, TSS 90.
o Day 2: Strength (plyometrics, 4 sets), RPE 6.
o Day 3: Active recovery (light swimming 30 min), RPE 3.
o Day 4: Technique (butterfly drills), RPE 4.
o Day 5: Intervals (6x100 m at 90%), RPE 7, TSS 80.
o Day 6: Passive rest.
o Day 7: Race simulation (200 m competitive), RPE 9.
• **Monitoring:** GPS (Catapult) for volume, HRV (WHOOP), post-session RPE.
• **Result:** 1 s improvement on 100 m butterfly (test).

19. Importance and Role of the Training Session:

• **Strategic Role:** The session directly influences performance by improving physical condition (strength, endurance, speed), technical skills (precision, coordination), and mental preparation. Rigorous planning ensures constant progression, maintains motivation, and reduces injury risks (↓ 25% with adapted structure).
• **Session Types:** Strength training (e.g., squat 4x10 at 65% 1RM), endurance (6 km run at 60% VO_2max), speed (6x20 m sprints), active recovery (yoga, 30 min), or tactical (pass drills).
• **Impact:** A well-designed session optimizes heart rate, promotes post-effort recovery, and targets specific objectives (e.g., 20 m sprint in 3 s).

20. Biomechanical Structure of a Session: 3P Model:

A session follows a three-phase structure (3P model: Preparation, Performance, Potentiation), each playing a specific role in preparation, development, and recovery.

20.1. Phase 1: Preparation (Warm-Up, 10–20 min):

• **Objectives:** Increase body temperature (↑ 1–2°C), heart rate (50–75% HRmax), joint mobility, and activate the neuromuscular system, while mentally preparing the athlete and reducing injury risks.
• **Content:**
o Cardiovascular Gradients: Light run (3–4 km/h, 5–6 min) or bike zone 1 (90 W).
o Dynamic Muscle Activation: Proprioceptive exercises (Y-Balance Test, 2x10), pogo jumps (2x20 for PAP if explosive strength), lunges, arm circles.
o Specific Joint Mobilization: E.g., swimming: 200 m breaststroke + 8x25 m catch-up drill.
• **Duration:** 10–15 min (up to 20 min for high-intensity sports), at 50–60% maximal effort.

20.2. Phase 2: Performance (Main Part, 20–90 min):

• **Objectives:** Develop specific qualities (strength, endurance, speed, coordination) or technical/tactical skills (pass precision, positioning) in line with the session objective.
• **Content:**

o Exercise Types: Strength (squat 4x10 at 65% 1RM), sprints (6x20 m at 90%), HIIT (2x20' at 95–100% FTP), tactical drills (4x10 triangle passes), match simulations (15 min at 85% effort).
o Internal 3x3 Rule: 3 objectives (technical, physiological, psychological), 3 levers (intensity, volume, density: I-V-D).
o Dosing Methods:
♣ Intermittent: 30"/30" (work/recovery ratio 1:1 to 1:0.5).
♣ Threshold Block: 2x20' at 95–100% FTP, 5' recovery.
♣ Force-Velocity Profile: Optimal load via F-V test on 5 loads (Samozino, 2022).
• **Tempo Management:**
o 0–20 min: Sensation 4/10 (integrated warm-up).
o 20–60 min: 7–8/10 (main stimulus).
o 60–90 min: 5–6/10 (consolidation).
• **Duration:** 45–90 min, at 70–90% maximal effort, depending on sport and objective.
• **Practical Example:** A "specific threshold" cycling session includes 2x20' at 97–100% FTP (5' recovery at 60% FTP) and 5x1' at 110% FTP (1' recovery at 50%).

20.3. Phase 3: Potentiation (Cool-Down, 5–15 min):

• **Objectives:** Reduce heart rate (↓ to 30–40% HRmax), eliminate metabolic waste, prevent soreness (DOMS ↓ 20%), and exploit the anabolic window.
• **Content:**
o Active Recovery: Bike zone 1 (80–90 W, 5 min), easy swim (200 m), slow walk.
o Stretching: PNF or static stretches (quadriceps, hamstrings, 5 min).
o Anabolic Window: 3:1 carbs/protein drink (1.2 $g \cdot kg^{-1}$ carbs, 0.3 $g \cdot kg^{-1}$ proteins) within 30 min post-session.
• **Duration:** 5–10 min (up to 15 min for intensive sports), at 30–40% maximal effort.
• **Practical Example:** A footballer finishes with 5 min static stretches (10 s/muscle), 3 min slow walk, and recovery drink (1.2 $g \cdot kg^{-1}$ carbs).

21. Time and Load Management in the Session:

Effective time and load management ensures balance between intensity, progression, and recovery.

21.1. Time Distribution

• **Standard Breakdown:** 20% warm-up (10–15 min), 70% main part (45–90 min), 10% cool-down (5–10 min).
• **Sport Adaptation:**

Sport	Total Duration	% Intensity > Zone 3	Intra-Recovery
100 m Swimming	90 min	25%	1:2
Football	105 min	15%	1:1
800 m Athletics	60 min	40%	1:3

• **Practical Example:** A 75 min football session includes 15 min warm-up, 50 min tactical/sprint drills, and 10 min cool-down.

21.2. Load Management:

• **External Loads:** Volume (distance, reps) and intensity (% HRmax, % FTP), measured via GPS (Catapult: 6 km, 22 sprints >25 $km \cdot h^{-1}$).
• **Internal Loads:** RPE (Borg, 1982; target 7/10 ±1), HRV (WHOOP, >60 ms post-session), lactate (target <8 $mmol \cdot L^{-1}$).
• **Practical Example:** A footballer covers 6 km at 80% maximal effort (Catapult GPS), with RPE 6/10 and HRV 60 ms.

21.3. Load Balance:

• **Alternation:** Intensive sessions (sprints, HIIT) followed by light sessions (yoga, technique) to maintain ACWR <1.4.
• **Practical Example:** A microcycle includes 2 intensive sessions (6x20 m sprints, tactics), 2 light sessions (yoga 30 min, short passes), and 1 rest day.

22. Orientation Toward a Specific Objective in the Session:

Each session must be designed to achieve a precise objective, aligned with the athlete's needs and competitive calendar.

22.1. Objective Definition:

• **Types:** Physical (speed: 20 m sprint in 3 s), technical (90% pass accuracy), tactical (positioning), psychological (confidence).
• **Specificity:** Alignment with sport demands (e.g., professional football).
• **Practical Example:** Footballer objective: achieve 85% accuracy on 20 long passes at 30 m.

22.2. Session Design:

• **Targeted Exercises:** Specific drills (long passes for accuracy, sprints for speed).
• **Progression:** Increasing intensity/complexity (e.g., short passes → long passes → match simulation).
• **Practical Example:** A tactical session starts with 10 min short passes (low intensity), 20 min long passes (moderate intensity), and 20 min match simulation (high intensity).

22.3. Monitoring and Adjustments:

• **Tools:**
o GPS (Catapult): External loads (6 km, PlayerLoad 750).
o HRV (WHOOP): Recovery (alert if ↓ >15%).
o Video Analysis (Hudl): Technical accuracy (90% passes).
o SmO_2 (Moxy): Muscle saturation (>30%).
o Lactate: 10% intensity reduction if >8 $mmol \cdot L^{-1}$.

• **Practical Example:** Hudl analysis shows 80% pass accuracy (target 85%), prompting an additional long-pass session.

23. Safety and Prevention in the Session:

• **Check-list 5S:** Surface (adapted terrain), Stretch (dynamic warm-up), Shoes (adapted footwear), Speed (gradual progression), Signs (monitored pain).
• **RAMP Protocol (Jeffreys, 2017):** Raise (HR), Activate (muscles), Mobilize (joints), Potentiate (PAP).
• **Practical Example:** A footballer follows RAMP with 5 min jogging (Raise), pogo jumps (Activate), lunges (Mobilize), and 3x30" sprints at 120% effort (Potentiate).

24. Integrated Example: "Specific Threshold" Cycling Session (75 min):

• 0–5 min: Bike zone 1 (90 W).
• 5–10 min: High-cadence drills (100 rpm) + hip mobility.
• 10–15 min: 3x30" at 120% FTP (PAP).
• 15–55 min: 2x20' at 97–100% FTP (5' recovery at 60% FTP).
• 55–65 min: 5x1' at 110% FTP (1' recovery at 50%).
• 65–70 min: Bike zone 1 (80–90 W).
• 70–75 min: Static stretches + recovery drink (1.2 $g \cdot kg^{-1}$ carbs, 0.3 $g \cdot kg^{-1}$ proteins).
• **Monitoring:** Lactate <8 $mmol \cdot L^{-1}$, SmO_2 >30%, sRPE 7/10.
• **Result:** 5% improvement in threshold power.

25. Challenges and Perspectives:

25.1. Challenges:

• **Complexity:** Coordination of phases with competitive calendar and between macrocycle, mesocycle, microcycle, and session.
• **Individual Variability:** Need for constant adjustments based on athletes' physiological and biomechanical responses.
• **Unforeseen Events:** Injuries or calendar changes disrupt the plan.

25.2. Perspectives:

• **Predictive AI:** Smartabase uses AI to anticipate load responses and optimize performance peaks.
• **Accessible Sensors:** Advances in wearables (e.g., NIRS sensors for EPOC, WHOOP, Catapult) for precise longitudinal monitoring.

Conclusion:

Sports planning, through the macrocycle, mesocycle, microcycle, and training session, forms an integrated system that translates long-term objectives into concrete actions. The macrocycle structures the year to align performance peaks with major competitions, while the mesocycle and microcycle refine intermediate and weekly objectives. The session, designed

according to the 3P model (Preparation, Performance, Potentiation), optimizes physiological, technical, and psychological adaptations. By integrating modern tools (GPS, HRV, TrainingPeaks, Smartabase) and protocols like RAMP, this approach ensures constant progression, rigorous load management, and injury prevention, while maintaining athlete motivation and longevity. Rigorous design, combined with dynamic adjustments based on biomarkers, ensures performance peaks aligned with the competitive calendar.

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Conference No. 09 Sports Planning for Individual vs Collective Sports and Individual Differences

Introduction:

Sports planning is a strategic process aimed at optimizing performance while minimizing the risks of overtraining and injuries. It relies on universal principles such as periodization, specificity, individualization, and load progression. However, individual sports (e.g., swimming, athletics) and collective sports (e.g., football, basketball) present distinct demands, requiring adapted approaches. Individual sports prioritize advanced personalization, centered on the specific needs of a single athlete, with cycles structured around key competitions. In contrast, collective sports require complex coordination to harmonize individual performances within a team dynamic, while managing a dense competitive calendar (Mujika et al., 2018). Furthermore, modern planning integrates individual differences (physiological, psychological, genetic, anthropometric), which influence up to 30% of training responses (Bouchard & Rankinen, 2001). By combining rigorous assessments, personalized adjustments, and modern technologies (GPS, HRV, Smartabase), this approach ensures optimal progression and risk prevention.

1. Theoretical Foundations of Sports Planning:

1.1. Principles of Periodization:

Periodization, conceptualized by Matveiev in the 1960s, structures training to optimize physiological adaptations (Issurin, 2010). According to Bompa and Buzzichelli (2019), it is based on:

• **Temporal Division:** Organization into hierarchical cycles:
o **Macrocycles:** Annual plan, covering a season or major objective (e.g., world championships).
o **Mesocycles:** Periods of 4 to 6 weeks, focused on specific objectives (e.g., aerobic endurance, maximal strength).
o **Microcycles:** Weekly units, detailing daily sessions (e.g., 1 week with 2 rest days).
• **Load Progression:** Gradual increase in volume (duration or repetitions) and intensity (% maximal effort) to stimulate adaptation without causing chronic fatigue.
• **Work/Recovery Alternation:** Balance between overload (training stimulus) and rest to promote supercompensation, where physical capacities exceed their initial level after recovery.
• **Specific Phases:**
o **Preparatory Phase:** Development of basic physical qualities (strength, endurance).
o **Competitive Phase:** Performance optimization to achieve a form peak.
o **Transitional Phase:** Active recovery and rest to prepare the next cycle.

1.2. Specificity and Individualization:

• **Specificity:** Exercises must correspond to the biomechanical, physiological, and technical demands of the discipline. For example, a marathon runner prioritizes aerobic endurance (70–80% VO_2max), while a sprinter focuses on explosive power (sprints at 95–100%).
• **Individualization:** Adaptation to physiological characteristics (VO_2max, maximal strength), psychological factors (motivation, stress management), and the athlete's level (beginner vs elite), including strengths, weaknesses, and injury history (Mujika et al., 2018).

2. Planning for Individual Sports:

2.1. Characteristics and Objectives:

Individual sports allow highly personalized planning, centered on a single athlete. Objectives include:
• **Individual Optimization:** Precise load adjustment based on strengths (e.g., aerobic endurance of a distance runner), weaknesses (e.g., start technique of a swimmer), and competitive goals (e.g., personal record).
• **Technical Mastery:** Perfection of specific gestures, such as turn technique in 400 m or arm stroke in crawl.
• **Targeted Physical Preparation:** Development of dominant qualities (strength for throwing, endurance for marathon, speed for sprint).
• **Pre-Competitive Tapering:** Progressive volume reduction (-50% over 2–3 weeks) while maintaining intensity for a form peak (Meur et al., 2013).
• **Mental Preparation:** Stress management, concentration, and confidence, essential without direct teammate support.

2.2. Temporal Structure:

• **Calendar Synchronization:** Cycles aligned with key competitions (e.g., Olympic Games, world championships). A 1500 m runner may plan 3 to 4 form peaks per year (Stellingwerff, 2012).
• **Physiological Monitoring:** Use of HRV (ln rMSSD >3.8), lactate (3–4 mmol/L), and creatine kinase (CK) to adjust loads in real time (Hellard et al., 2017).
• **Typical Structure:**
o **General Preparation Phase (4–6 weeks):** High volume, moderate intensity (e.g., 60–80 km/week for a runner).
o **Specific Preparation Phase (8–12 weeks):** Increased intensity, specific work (e.g., intervals at 95–100% vVO_2max).
o **Pre-Competitive Phase (4–6 weeks):** Volume reduction (-50%), intensity maintenance, competition simulations.
o **Competitive Phase (1–2 weeks):** Light activation, target competitions.
o **Transitional Phase (2–4 weeks):** Active rest, mental and physical recovery.

2.3. Case Study: Athletics (1500 m):

Stellingwerff (2012) describes the annual planning of a 1500 m runner targeting 3 to 4 form peaks:
• **Preparatory Phase (4–6 weeks):** Aerobic development (60–80 km/week at 70–80% VO_2max), general muscular strengthening (squat 4x8 at 60% 1RM).
• **Specific Phase (8–12 weeks):** High-intensity intervals (6x800 m at 95–100% vVO_2max), technical work (stride, turns).
• **Tapering (2 weeks):** 50% volume reduction (30–40 km/week), intensity maintenance (sprints 4x200 m at 95%), race simulations.
• **Competitive Phase:** Target races, light activation (20 min jogging, strides).
• **Transitional Phase:** Active rest (bike, light swimming, 2–3 h/week).

3. Planning for Collective Sports:

3.1. Organizational Constraints:

Collective sports present unique challenges:
• **Dense Calendar:** 9- to 10-month seasons with weekly matches (sometimes 2 matches/week), limiting general preparation periods.
• **Prolonged Performance:** Need to maintain a high level over a long period, unlike targeted peaks in individual sports.
• **Varied Squads:** Management of players with different physiological and technical profiles (e.g., endurance for a midfielder, power for a winger).
• **Collective Coordination:** Harmonization of individual performances to optimize cohesion and tactical strategies (Buchheit & Laursen, 2013).

3.2. Tactical and Collective Dimensions:

• **Tactical Development:** Acquisition of collective patterns (e.g., high pressing, quick transitions) via reduced games and situational drills.
• **Position-Specific Physical Qualities:** Load adaptation by position (e.g., aerobic endurance for a midfielder, explosive power for a striker).
• **Automatisms:** Training of player interactions (e.g., winger-striker combinations).
• **Synchronization:** Alignment of collective form peaks for key matches (e.g., finals) (Delgado-Bordonau & Mendez-Villanueva, 2012).

3.3. Case Study: Professional Football:

Malone et al. (2015) describe a weekly planning for a football team in competitive season:
• **Match Day (MD):** Maximal performance, competitive load (PlayerLoad™ ~600 a.u.).
• **MD+1:** Active recovery (light bike, 20–30 min at 50% HRmax) for starters; compensatory work (reduced games, 3x5 min at 80%) for substitutes.
• **MD+2:** Aerobic development (30 min jogging at 70%, 4x4 reduced games), technical work (passes, shots).
• **MD-3:** Strength and power (weight training, squat 4x6 at 75% 1RM; sprints 6x20 m at 90%).

• **MD-2:** Intensive tactics (offensive/defensive patterns, 11v11), agility work.
• **MD-1:** Light activation (20 min, strides, specific exercises), tactical setup (15 min).
• **Rest:** 1 full day per week, often post-match or MD+1 for non-starters.

4. Comparative Analysis: Individual vs Collective Sports:

4.1. Points of Convergence:

• **Initial Assessment:** Physical tests (VO_2max, 1RM, sprint tests) to establish a baseline.
• **Work/Recovery Alternation:** Balance to avoid chronic fatigue and promote supercompensation.
• **Continuous Monitoring:** Use of GPS (Catapult), HRV (WHOOP, ln rMSSD >3.8), and RPE (1–10 scale) to adjust loads.
• **Load Progression:** Gradual increase (e.g., +10% volume/week) to stimulate adaptation.

4.2. Fundamental Differences:

Aspect	Individual Sports	Collective Sports
Focus	Individual performance, personal optimization	Cohesion and collective performance, role harmonization
Periodization	Linear or block (targeted peaks)	Undulating or non-linear (prolonged performance)
Tapering	Precise, individualized (2–3 weeks, -50% volume)	Short, standardized (1–2 days, light activation)
Monitoring	Detailed, athlete-specific (HRV, lactate, CK)	Global with individual adjustments (GPS, RPE)

5. Assessment of Individual Differences:

Rigorous evaluation of physiological, psychological, genetic, and anthropometric profiles is essential to design adapted programs.

5.1. Physiological Differences:

• **Key Factors:** Aerobic capacity (VO_2max), muscular power, lactate threshold, injury susceptibility.
• **Assessment Methods:**
o Physiological tests: VO_2max test, blood lactate analysis, isometric strength tests (e.g., squat at 90°).
o HRV measurement: 5-minute orthostatic tracking (e.g., WHOOP) to assess recovery.
o Baseline creatine kinase (CK) analysis after 24 h rest to detect muscle fatigue.
• **Practical Example:** A footballer with VO_2max of 55 ml/kg/min requires an endurance-focused program (8 km at 60% VO_2max), while a teammate with 65 ml/kg/min focuses on speed (6x20 m sprints at 90% effort).

5.2. Psychological Differences:

• **Key Factors:** Motivation (self-determination theory, SDT), stress management, self-confidence, mental resilience.
• **Assessment Methods:**
o Questionnaires: CSAI-2 for competitive anxiety, SMS-II for motivation, BIG-5 for personality, RESTQ-Sport for stress and recovery.
o Interviews: Discussions with a sports psychologist to identify mental needs.
• **Practical Example:** A footballer with high CSAI-2 score (moderate competitive anxiety) benefits from 10 min/day visualization, while a goalkeeper anxious before key matches practices 10 min daily meditation.

5.3. Genetic and Anthropometric Differences:

• **Genetic Factors:** Genes like ACTN3 (strength vs endurance), ACE (endurance), and MSTN (muscle hypertrophy) influence training response.
• **Assessment Methods:** Panel of 8 SNPs (e.g., ACTN3 R577X, ACE I/D) via salivary tests (23andMe, DNAfit).
• **Anthropometric Factors:** Height, body fat, and joint biomechanics affect exercise prescription.
• **Practical Example:** A sprinter with ACTN3 RR genotype (strength-favorable) follows an intensive program of 4x4 squats at 90% 1RM, while a marathoner with ACE I/I prioritizes endurance with 10% increased volume.

5.4. Other Factors:

• **Hormonal:** Testosterone/cortisol ratio (T/C) and IGF-1 influence load tolerance.
• **Chronotype:** Morning or evening athletes (determined via K-Means on 6 sleep variables, forming 4 clusters: morning, intermediate, evening, erratic) require adapted schedules.
• **Practical Example:** An evening athlete schedules intensive sessions in the afternoon, while a morning athlete prioritizes morning HIIT (6x60 m at 105% vMax).

6. Personalization of Training Programs:

Personalization relies on adapting programs to individual profiles, adjusting loads, exercises, and mental strategies.

6.1. Adaptation to Physiological Profiles:

• **Method:** Design programs based on physiological strengths and weaknesses. For example, a football winger prioritizes speed (4 sessions/week of sprints, 6x20 m at 90% effort), while a midfielder focuses on endurance (8 km at 60% VO_2max).
• **4D Model:**
o **Dose (D1):** Volume and intensity via iTRIMP (load adjusted ±15% based on response index).
o **Duration (D2):** Block length (3 weeks build-up + 1 week unload at 40% for a marathoner).
o **Density (D3):** Session frequency (2x/week strength for a sprinter).
o **Shift (D4):** Schedule adapted to chronotype.

• **Practical Example:** A footballer with low lactate endurance follows 2 sessions/week of 4x1 km at 85% effort, while a fast responder (index >0.8) increases load by 15%.

6.2. Adaptation to Psychological Profiles:

• **Method:** Integrate strategies like visualization (10 min/day), meditation, or psychological interviews (1 h/week).
• **Practical Example:** An anxious goalkeeper practices specific drills (saves, 4x10) and 10 min daily meditation to build confidence before key matches.

6.3. Sex Considerations:

• **Method:** Adjust loads according to the menstrual cycle (Oosthuyse, 2010): +5% in follicular phase, -3% in luteal phase for female athletes.
• **Practical Example:** A female footballer increases sprints (6x20 m) in the follicular phase and reduces intensity in the luteal phase.

7. Integration of Biomechanical and Technological Data:

Modern technologies enable precise planning by combining biomechanical and physiological data.

7.1. Biomechanical Data:

• **Applications:** Stride analysis, muscular power, and specific movements (e.g., shot accuracy in football).
• **Tools:** Biomechanical sensors (Vicon, Qualisys), video analysis (Hudl).
• **Practical Example:** Vicon analysis reveals stride asymmetry in a footballer, leading to unilateral strengthening exercises (lunges, 3x10 per leg).

7.2. Technological Data:

• **Tools:**
o **GPS:** External load tracking (distance, speed) via Catapult (e.g., 12 km/match).
o **HRV:** Recovery assessment via WHOOP (HRV <50 ms indicates cumulative fatigue).
o **Platforms:** Smartabase for data integration, Athlete Cloud for individual dashboards with KPIs and automatic alerts.
o **QR Code:** Personalized sessions accessible via scan (real-time load adjustment).
• **Practical Example:** A footballer covering 12 km/match (Catapult GPS) with low HRV (40 ms) sees volume reduced by 20% (from 8 km to 6 km/session).

7.3. Predictive AI:

• **Method:** Algorithms like Random Forest predict performance improvements (e.g., ΔFTP with RMSE = 2.8 W) or injury risks.
• **Practical Example:** Smartabase analysis shows cumulative fatigue (HRV <50 ms), prompting replacement of a sprint session with active recovery (yoga, 30 min).

8. Case Study: Professional Footballer (Winger, 28 years old):

• **Initial Assessment:**
o **Physiological:** VO_2max of 60 ml/kg/min, 20 m sprint in 2.9 s, low lactate endurance.
o **Psychological:** High CSAI-2 score (moderate competitive anxiety).
o **Genetic:** ACTN3 RX genotype (mixed strength/endurance).
• **Personalized Program (4 weeks):**
o **Physical:** 3 sessions/week of sprints (6x20 m at 90% effort), 2 sessions of lactate endurance (4x1 km at 85% effort), 3+1 blocks (3 weeks build-up, 1 week unload at 40%).
o **Psychological:** Visualization (10 min/day), sports psychologist interviews (1 h/week).
o **Adjustments:** Volume reduction from 8 km to 6 km/session if HRV <50 ms.
• **Monitoring:**
o **GPS (Catapult):** 10 km/match, pass accuracy 85% (Hudl).
o **HRV (WHOOP):** Average 60 ms.
o **Biomechanics:** Stride analysis (Vicon) to correct asymmetry.
• **Results:** 0.2 s improvement on 20 m sprint, pass accuracy to 90%, better anxiety management in matches.

9. Monitoring and Feedback Loop:

• **Method:** Physiological re-tests every 4 weeks, automatic adjustments via TrainingPeaks API, quarterly meetings ("Individual Review Board") to evaluate progress.
• **Practical Example:** A marathoner with slow response index (<0.4) sees load reduced by 15% and density lowered by 20% after a re-test showing low HRV.

10. Challenges and Perspectives:

10.1. Challenges:

• **Organizational Complexity:** Collective sports require coordination between coaches, physical trainers, tactical analysts, and medical staff.
• **Limited Individualization:** Large squads in collective sports make advanced personalization difficult.
• **Technology Costs:** Advanced tools (Catapult, WHOOP) may be inaccessible for budget-limited clubs or athletes.
• **Complexity of Individual Differences:** Need to integrate physiological, psychological, genetic, and anthropometric data into planning.

10.2. Perspectives:

• **AI and Predictive Analysis:** Algorithms to anticipate injury risks (HRV thresholds <15% baseline) and optimize loads.
• **Wearable Technologies:** Development of affordable sensors (smartwatches with HRV).
• **Hybrid Approaches:** Combination of linear periodization (form peaks) and non-linear (flexibility) to adapt to unforeseen events and individual needs.

Conclusion:

Sports planning, whether for individual or collective sports, relies on fundamental principles (periodization, specificity, individualization) but requires specific adaptations. Individual sports favor fine personalization, with linear or block cycles aligned with key competitions, supported by detailed monitoring (HRV, lactate, CK). Collective sports adopt an undulating approach to manage a dense calendar, harmonizing individual performances with tactical cohesion. Accounting for individual differences (physiological, psychological, genetic, anthropometric) is essential to optimize performance and reduce risks. Modern technologies (GPS, HRV, Smartabase) and predictive AI enhance this individualization, enabling real-time adjustments for precise and effective planning.

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Conference No. 10 Sports Planning for Young Athletes and Elite Athletes

Introduction:

Sports training planning is a strategic process aimed at optimizing performance while minimizing the risks of overtraining and injuries. For elite athletes, it relies on a scientific, individualized, and multifactorial approach, targeting precise performance peaks during major competitions (Mujika et al., 2018). For young athletes, it requires an approach adapted to their physiological, psychological, and social particularities, prioritizing long-term athlete development (LTAD) rather than immediate performance (Lloyd & Oliver, 2012). In both cases, planning is based on universal principles (periodization, specificity, individualization, progression) and integrates modern tools (GPS, HRV, platforms like TrainingPeaks) to meet specific needs, while taking into account differences related to age, biological maturity, and competitive demands.

1. Specificities of Young Athletes' Development:

1.1. Growth and Maturation:

• **Growth Phases:** Rapid growth spurts affect coordination, strength, and flexibility, increasing injury risk (Malina et al., 2004).
• **Biological Maturation:** Biological age (bone and hormonal development) varies relative to chronological age, requiring program personalization.
• **Growth Cartilages:** Open epiphyseal zones are vulnerable to overloads, limiting the use of heavy loads (<60% 1RM).
• **Example:** A 14-year-old footballer in full growth spurt (height +8 cm/year) follows a program focused on proprioception (plank, 3x30 s) to avoid knee injuries.

1.2. Physiological Development:

• **Aerobic Capacities:** Young athletes have good relative VO_2max (45–55 ml/kg/min), but their immature cardiovascular system requires progressive and playful training.
• **Strength and Power:** Before puberty, strength gains rely on neuromuscular adaptation (bodyweight exercises, 3x10 squats). Post-puberty, muscle hypertrophy is favored by hormones (Faigenbaum et al., 2009).
• **Flexibility and Coordination:** Varied activities (games, drills) improve these qualities essential for motor skills.
• **Example:** A 12-year-old gymnast practices coordination exercises (slalom, 10 min) and dynamic stretching (15 min) to optimize flexibility.

1.3. Psychological and Social Development:

• **Intrinsic Motivation:** Pleasure and play are crucial for maintaining engagement (Deci & Ryan, 2000).
• **Cognitive Capacities:** Understanding of complex strategies evolves with age, requiring simple instructions for younger athletes.

• **Social Skills:** Sport promotes teamwork, respect, and emotion management.
• **Self-Esteem:** Progressive successes build confidence (e.g., mastering a new movement).
• **Example:** A young basketball player (13 years) participates in playful games (3x3, 10 min) to maintain motivation and receives positive feedback to strengthen confidence.

2. Principles of Adapted Planning for Young Athletes:

2.1. Long-Term Athlete Development (LTAD):

• **Progressive Specialization:** Avoid early specialization (before 15 years) to reduce overuse injuries (-30% with multisport practice, Jayanthi et al., 2015).
• **Fundamental Skills:** Priority to motor bases (running, jumping, throwing, agility) before specific training.
• **Pleasure and Engagement:** Integrate playful activities to maintain intrinsic motivation.
• **Example:** A young athlete (10 years) practices football, swimming, and athletics to develop a broad motor base.

2.2. Training Load Management:

• **Progressivity:** Gradual increase in volume (+10%/week) and intensity (50–70% VO_2max).
• **Individualization:** Adapt loads to biological age and fatigue level (RPE <6/10).
• **Variability:** Alternate training types (technical, physical, playful) to avoid monotony.
• **Recovery:** Integrate 1–2 active rest days per microcycle (e.g., yoga, 20 min).
• **Example:** A 15-year-old footballer follows a microcycle with 3 sessions (2 technical, 1 physical) and 2 active rest days (light cycling, 30 min).

2.3. Injury Prevention:

• **Warm-Up and Cool-Down:** 10–15 min dynamic warm-up (lunges, jumps) and 5–10 min static stretching post-training.
• **Balanced Strengthening:** Core exercises (plank, 3x30 s) and antagonist muscles (e.g., quadriceps vs hamstrings).
• **Correct Technique:** Teaching basic movements (e.g., dribbling in football) to reduce joint stress.
• **Adapted Equipment:** Shoes suited to morphology and sport.
• **Body Listening:** Encourage young athletes to report pain or fatigue (e.g., via a logbook).
• **Example:** A 13-year-old swimmer uses proprioception exercises (single-leg balance, 3x20 s) and adapted shoes to prevent sprains.

3. Planning and Programming Adapted for Young Athletes:

3.1. Cycle Structure:

• **Macrocycle:** Annual or semi-annual plan focused on LTAD (e.g., 6 months to develop endurance and coordination).
• **Mesocycle:** 4–6 week blocks targeting a specific quality (e.g., agility).

• **Microcycle:** Balanced week with 2–3 light sessions (technical, playful) and 2 rest days.
• **Example:** A young footballer follows a 4-week mesocycle with 2 technical sessions (passes, 15 min), 1 physical session (4 km at 50% VO_2max), and 2 active rest days.

3.2. Adapted Content:

• **Objectives:** Develop coordination, aerobic endurance, and technical skills via playful exercises.
• **Content:** Technical drills (e.g., passes, 3x10 min), reduced games (3x3, 15 min), and light strengthening (bodyweight squats, 3x10).
• **Example:** A session for a 14-year-old basketball player includes 10 min dynamic warm-up, 20 min shooting drills, and 10 min playful games.

3.3. Gradual Progression:

• **Method:** Increase volume (e.g., from 3 to 4 km/session over 6 weeks) and intensity (from 50% to 60% VO_2max) according to biological maturity.

4. Scientific Foundations of Planning for Elite Athletes:

4.1. Fundamental Principles:

• **Progressive Overload:** Optimal stimulation of physiological adaptations.
• **Specificity:** Correspondence between training and competitive demands.
• **Individualization:** Adaptation to the athlete's unique characteristics.
• **Variability:** Systematic modulation of training loads.
• **Recovery:** Strategic integration of regeneration phases.

4.2. Multifactorial Approach:

• Integration of physical, technical, tactical, and mental components.
• Synchronization of different qualities for a performance peak.
• Analysis of discipline-specific limiting factors.
• Optimization of overall load (sport and non-sport).

5. Advanced Periodization Models for Elite Athletes:

5.1. Traditional Periodization (Matveiev):

• Structure in major periods (preparation, competition, transition).
• Sequential development of qualities (volume → intensity).
• Application in sports with single or double form peak.

5.2. Block Periodization:

• Concentration of training loads.
• Successive blocks with distinct objectives (accumulation, transformation, realization).

• Residual training effect and optimal sequencing.
• Application in technical and strength-power sports.

5.3. Undulating Periodization (Poliquin):

• Frequent variation of training parameters.
• Daily, weekly, and monthly undulations.
• Prevention of plateaus and stagnation.
• Application in team sports and complex disciplines.

5.4. Polarized Periodization:

• Polarized intensity distribution (80% low intensity, 20% high intensity).
• Minimization of moderate-intensity volumes.
• Optimization of stress/recovery ratio.
• Application in elite endurance sports.

6. Hierarchical Organization of Planning for Elite Athletes:

6.1. Career Plan (8–12 years):

• Long-term vision of athlete development.
• Progression of overall loads and specialization.
• Management of transitions (junior to senior, category changes).
• Projection of target performances over multiple Olympic cycles.

6.2. Multi-Year Plan (2–4 years):

• Organization around major competitions (Olympics, World Championships).
• Progression of intermediate objectives.
• Programmed evolution of training methods.
• Anticipation of technological and methodological innovations.

6.3. Annual or Semi-Annual Macrocycle:

• General structure of the sports season.
• Strategic positioning of main and preparatory competitions.
• Distribution of volumes and intensities by period.
• Programming of training camps and altitude stages.

6.4. Mesocycle (2–6 weeks):

• Functional unit centered on a specific adaptation objective.
• Progressive load dynamics (2–3 weeks load, 1 unload).
• Evaluation of adaptations and adjustments.
• Systematic variation of training stimuli.

6.5. Microcycle (5–10 days):

• Weekly organization of sessions.
• Optimal distribution of loads by quality.
• Work/recovery alternation.
• Adaptation to the competitive calendar.

6.6. Training Session:

• Optimal structure (warm-up, main part, recovery).
• Organization of contents by objective.
• Precise dosing of load parameters.
• Optimal exercise sequencing.

7. Tapering and Performance Peak for Elite Athletes:

7.1. Scientific Principles of Tapering:

• Non-linear volume reduction (40–60%).
• Maintenance or slight intensity increase.
• Maintenance of training frequency.
• Increased recovery time.

7.2. Optimization Parameters:

• Optimal duration by discipline (1–4 weeks).
• Volume reduction kinetics (exponential vs. linear).
• Individual tapering response profile.
• Multifactorial supercompensation strategies.

7.3. Multiple Performance Peaks:

• Strategies to maintain several peaks in a season.
• Mini-tapering cycles for intermediate competitions.
• Post-competition recovery and reconstruction.
• Psychological load management between peaks.

8. Monitoring and Adjustments:

8.1. Monitoring Tools:

• **Young Athletes:**
o **GPS:** External load measurement (Catapult, PlayerLoad™ <300 a.u./session).
o **HRV:** Recovery assessment (WHOOP, score >55 indicates good recovery).
o **RPE:** Subjective scale (Borg, 1982; <6/10 to avoid fatigue).
o **Adapted Tests:** 20 m sprint (speed), Cooper test (endurance), logbook (fatigue, motivation).
• **Elite Athletes:**
o **External Load Monitoring** (GPS, accelerometers, sensors).

o **Internal Load Tracking** (HR, HRV, RPE, questionnaires).
o **Biological Markers** (hormonal profiles, inflammatory markers).
o **Specific Field and Lab Tests.**

8.2. Data Analysis and Interpretation:

• Establishment of individual reference profiles.
• Early detection of overload or under-recovery signs.
• Multifactorial performance analysis.
• Predictive performance modeling.
• **Example (Young):** Low HRV (40 ms) in a young swimmer leads to 20% volume reduction (from 5 to 4 km/session).

8.3. Strategic Adjustments:

• Proactive vs reactive modifications.
• Individualization of adjustments based on responses.
• Planning flexibility without losing overall coherence.
• Effective communication between staff and athlete.

9. Integration of Peripheral Factors for Elite Athletes:

9.1. Optimized Recovery:

• Active and passive recovery strategies.
• Physical recovery modalities (cryotherapy, compression, etc.).
• Sleep and circadian rhythm management.
• Periodized nutritional recovery.
• **Example:** A tennis player uses a cold bath (10°C, 10 min) after a match to reduce inflammation, with HRV monitoring showing return to 60 ms after 24 h.

9.2. Periodized Nutrition:

• Nutrition-training synchronization.
• Periodization of carbohydrate and caloric intake.
• Phase-specific nutritional strategies.
• Targeted supplementation and optimal timing.
• **Example:** A cyclist works with a nutritionist to adjust carbohydrate intake (7 g/kg/day).

9.3. Integrated Mental Preparation:

• Periodization of mental skills.
• Competitive stress management.
• Optimization of peak performance mental state.
• Individualized pre-competitive routines.
• **Example:** A gymnast integrates sports psychology sessions (2x30 min/week) to manage pressure in international competitions.

9.4. Environmental Management:

• Preparation for competition conditions (heat, altitude, etc.).
• Acclimatization and habituation strategies.
• Travel and jet lag management.
• Creation of specific training environments.

10. Case Studies:

10.1. Young Footballer (15 years):

• **Initial Assessment:**
o **Physiological:** VO_2max 50 ml/kg/min, 20 m sprint in 3.2 s, early biological maturity.
o **Psychological:** High motivation, low match confidence (low score on Youth Sport Motivation Inventory).
• **Program (6 weeks):**
o **Physical:** 2 sessions/week endurance (4 km at 50% VO_2max), 1 coordination session (ball drills, 15 min).
o **Technical:** 2 sessions passes and dribbles (3x10 min), reduced games (3x3, 15 min).
o **Psychological:** Positive feedback, playful games (10 min/session) to build confidence.
o **Prevention:** Dynamic warm-up (10 min), proprioception (plank, 3x30 s), adapted shoes.
• **Monitoring:** GPS (Catapult, 5–6 km/session), HRV (WHOOP, 55–60 ms), RPE (4–5/10).
• **Results:** 0.1 s improvement on 20 m, pass accuracy to 85%, and better match confidence (score +20% on questionnaire).

10.2. Cyclic Individual Sports (Swimming, Athletics):

• Double or triple annual periodization.
• Importance of energy specificity.
• Polarized intensity approach.
• Prolonged tapering (2–3 weeks).

10.3. Strength/Power Sports (Weightlifting, Sprint):

• Block periodization.
• Fine neuromuscular fatigue management.
• Frequent stimulus variations.
• Short but pronounced tapering (7–10 days).

10.4. Endurance Sports (Cycling, Cross-Country Skiing):

• Large base volumes.
• Polarized or pyramidal periodization.
• Strategically placed altitude camps.
• Moderate tapering (10–14 days).

10.5. Team Sports and Combat Sports:

• Undulating periodization.
• Maintenance of multiple qualities.
• Relative and prolonged form peak.
• Micro-taperings for final phases.

11. Specificities of Planning for Elite Athletes:

11.1. Advanced Individualization:

• **Definition:** Program adaptation to the athlete's unique characteristics: strengths, weaknesses, injury history, and physiological responses (Bompa & Haff, 2009).
• **Methodology:** Initial assessment (VO_2max, maximal strength tests) and continuous monitoring (HRV via WHOOP, >55 ms) to adjust loads.
• **Example:** A 400 m runner with VO_2max of 60 ml/kg/min receives a program focused on anaerobic power (4x200 m at 95% max speed) to address end-of-race weakness.

11.2. Advanced Periodization:

• **Definition:** Structuring of cycles (macrocycle, mesocycle, microcycle) to achieve precise form peaks (Mujika et al., 2018).
• **Types:**
o **Macrocycle:** Annual plan targeting a major competition (e.g., Olympic Games).
o **Mesocycle:** 4–6 week blocks (strength, endurance, tapering).
o **Microcycle:** Balanced week (4 intense trainings, 2 active recoveries).
• **Tapering:** Volume reduction (-40–60%) over 7–14 days before competition, maintaining intensity (>85% VO_2max).
• **Example:** A swimmer plans a 10-day tapering before a championship, reducing volume from 50 to 20 km/week while maintaining sprints (8x50 m at 90%).

11.3. Load and Recovery Management:

• **Training Load:** Monitoring external loads (GPS, Catapult, PlayerLoad™ <600 a.u./session) and internal loads (RPE <7/10, HRV >55 ms) to avoid overtraining.
• **Recovery:** Active techniques (stretching, 20 min) and passive (sleep, 8–9 h/night), post-effort nutrition (30 g protein, 60 g carbs within 30 min).
• **Example:** A tennis player uses a cold bath (10°C, 10 min) after a match to reduce inflammation, with HRV monitoring showing return to 60 ms after 24 h.

11.4. Integration of Non-Sport Factors:

• **Aspects:** Stress management (meditation, 10 min/day), work/family balance, and career planning (contracts, reconversion).
• **Impact:** Poor management can reduce performance (-10% reaction time under high stress) and increase burnout risk.
• **Example:** A gymnast integrates sports psychology sessions (2x30 min/week) to manage pressure in international competitions.

11.5. Multidisciplinary Collaboration:

• **Team:** Coaches, physical trainers, nutritionists, psychologists, and physiotherapists collaborate via weekly meetings.
• **Tools:** Management software (Sportifeo) to centralize data (GPS, nutrition, sleep).
• **Example:** A cyclist works with a nutritionist to adjust carbohydrate intake (7 g/kg/day) and a psychologist to improve focus before a race.

12. Challenges and Perspectives:

12.1. Challenges:

• **Complexity:** Balancing physical, technical, and mental development while respecting biological maturity (youth) and high loads with injury prevention (elite).
• **Resources:** Limited access to tools (GPS, HRV, nutritionists) in amateur clubs or for unsponsored athletes.
• **External Pressure:** Expectations from parents or coaches for early results (youth) or competitive outcomes (elite), increasing burnout risk.
• **Stress:** Management of pressure from major competitions.

12.2. Perspectives:

• **Accessible Technologies:** Development of affordable sensors (Fitbit, Garmin) to monitor loads and recovery.
• **AI and Predictive Analysis:** Use of algorithms to anticipate injury risks (e.g., HRV thresholds <15% baseline).
• **Education:** Training of coaches and parents on LTAD and advanced periodization.
• **Mental Health:** Systematic integration of psychologists in teams.

Conclusion:

Sports planning for young athletes and elite athletes relies on common principles (periodization, individualization, recovery) but adapts to specific needs. For young athletes, emphasis is on long-term development, injury prevention, and enjoyment, respecting their biological and psychological maturity. For elite athletes, planning targets precise performance peaks via advanced periodization, fine load management, and multidisciplinary collaboration. The integration of modern technologies (GPS, HRV, AI) and strategies like periodized nutrition and mental preparation ensures sustainable performance optimization while preserving athletes' health and longevity.

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Conference No. 11 Competition Planning and Management

Introduction:

The planning and management of sports competitions are a critical stage to ensure that athletes reach their performance peak during key events, whether championships, cups, or international competitions such as the Olympic Games.

1. Pre-Competition Loading:

Pre-competitive loading prepares the athlete for an optimal state through a combination of high intensity and reduced volume.

1.1. Loading Structure:

• **Objective:** Maximize physical and technical readiness.
• **Content:** High-intensity exercises (sprints 6x20 m at 90%, tactical drills) and match simulations.
• **Practical Example:** A footballer follows a 7-day microcycle before a match with 3 sprint sessions (6x20 m at 90%) and 2 tactical drill sessions (passes, 20 min, 85% accuracy).

1.2. Pre-Competitive Timeline (Competition A):

• **J-10:** Last long specific training, CTL (Chronic Training Load) stabilized at 90–110.
• **J-7:** Lactate or HRV test, plan validation (HRV >50 ms).
• **J-5:** Volume reduced by 25%, intensity maintained (80–90%).
• **J-3:** Short activation (15–20 min, 2–3 sprints at 90%).
• **J-1:** Active rest (15 min, bike zone 1) + mental visualization (10 min).
• **Practical Example:** A marathoner reduces volume from 60 km to 30 km/week over 10 days, with 4x30" at 105% MP (Maximum Pace) at J-3.

1.3. Pre-Competitive Logistics:

• **Transport:** Arrival with ≤2 time zones to limit jet lag (Waterhouse, 2021).
• **Thermal Acclimatation:** 5 days if ΔT >10°C (HR ↓8%).
• **Nutrition:** Carbohydrate plan of 10–12 $g \cdot kg^{-1}$ 36 h before competition.
• **Practical Example:** A triathlete arrives 5 days before a race at 35°C, with a carbohydrate dinner (3 $g \cdot kg^{-1}$) at J-1.

2. Post-Competition Transitional Loading:

Post-competition loading promotes recovery while maintaining gains.

2.1. Objectives:

• **Recovery:** Reduce physical fatigue (CK ↓50%) and mental fatigue (HADS score <8).
• **Maintenance:** Preserve physical qualities without overload (ACWR <1.4).

• **Practical Example:** After a match, a footballer follows an active recovery session (yoga, 30 min) and a light run (3 km at 50% VO_2max).

2.2. Structure:

• **Content:** Light activities (stretching, stationary bike 20–30 min zone 1) and low-intensity technical exercises (short passes).
• **Duration:** 1–3 days depending on intensity (Competition A: 5–7 days; Competition B: 3–4 days; Competition C: 1–2 days).
• **Practical Example:** A footballer performs 2 days of active recovery (yoga, stretching) after an intense match (10.8 km, 22 sprints >25 km·h^{-1}, PlayerLoad 750, GPS Catapult).

2.3. Re-Athleticization in Case of Injury:

• **Protocol:** 4 phases (mobility, stability, strength, specific) over 7–14 days.
• **Practical Example:** A footballer with a sprain follows progressive re-athleticization: mobility (J+1–3), stability (J+4–6), strength (J+7–10), specific drills (J+11–14).

3. Temporal Programming and Management of Multiple Competitions:

Temporal programming aligns training with the competitive calendar to optimize performance.

3.1. Calendar Analysis:

• **Step:** Identify match dates, tournaments, and rest periods to plan peaks.
• **Practical Example:** A triathlete plans peaks for the World Cup (March), Olympics (July), and World Championship (October), with macrocycles of 20, 16, and 12 weeks.

3.2. Sequencing of Multiple Peaks:

• **Method:** Combine preparation blocks (endurance, strength) and competitive blocks (match simulations) for several peaks.
• **Practical Example:** A footballer plans a 12-week macrocycle with 4 weeks PPG (6 km/session), 4 weeks PPS (6x20 m sprints), and 4 weeks tapering (volume -40%) for two major competitions.

4. Timing of Performance Peak:

Timing of performance peaks is essential to align optimal form with key competitions.

4.1. Peak Planning:

• **Objective:** Achieve a physical, technical, and mental peak during major competitions.
• **Method:** Tapering (volume -40–60%, intensity 80–90%) and specific simulations (15 min at 85% effort).
• **Practical Example:** A marathoner plans a peak for a marathon with 14-day tapering (volume -50%, 4x30” at 105% MP) and a target TSB of +18.

4.2. Peak Monitoring:

• **Tools:**
o **GPS (Catapult, STATSports):** External load measurement (10.8 km/match, 22 sprints >25 $km \cdot h^{-1}$).
o **HRV (WHOOP):** Recovery (HRV >60 ms).
o **Video Analysis (Hudl):** Technical accuracy (90% passes).
o **Smartabase:** Data integration (TSB, CTL, ACWR).
• **Practical Example:** An HRV of 60 ms and 90% pass accuracy (Hudl) confirm a peak before a key match.

5. Psychological Preparation:

Mental preparation is crucial for managing pressure and optimizing performance.

5.1. Stress and Anxiety Management:

o **Relaxation:** Deep breathing, meditation (10 min/day).
o **Visualization:** Successful match scenarios (e.g., crossing the finish line).
o **Cognitive Reframing:** Transform stress into positive activation.
• **Practical Example:** A footballer practices 10 min of visualization (penalty shootout scenarios) before a semifinal.

5.2. Goal Setting and Routines:

• **Process Goals:** Focus on controllable actions (e.g., maintaining running technique).
• **Pre-Competitive Routines:** Warm-up sequence (15 min zone 1), visualization, and positive self-talk.

5.3. Confidence and Self-Efficacy:

• **Methods:** Positive feedback, competitive stress simulations, recall of past successes.
• **Practical Example:** A triathlete reviews past performances (video analysis) to build confidence before a championship.

6. Tactical Preparation:

Tactical preparation optimizes game strategies to maximize performance.

6.1. Methods:

• **Tactical Drills:** Triangle passes, positioning, shots (20 min, 85% accuracy).
• **Video Analysis:** Opponent study via Hudl or Coach Paint.
• **Simulations:** Match scenarios (e.g., defense under pressure).
• **Practical Example:** A footballer performs 20 min of tactical drills (long passes) and analyzes opponents via Hudl before a match.

6.2. Integration into Planning:

• **Method:** Integrate tactical drills into pre-competitive microcycles (2–3 sessions/week).
• **Practical Example:** A swimmer includes 2 sessions/week of video analysis and start drills to optimize race strategy.

7. Load Management for Multiple Competitions:

Load management is essential to maintain performance in a dense calendar.

7.1. Load Analysis:

• **Method:** Evaluate metrics (distance, sprints, PlayerLoad) via GPS (Catapult) and RPE (4–6/10).
• **Practical Example:** A footballer covering 10.8 km/match (22 sprints >25 km·h^{-1}, PlayerLoad 750) adjusts training to maintain HRV >50 ms.

7.2. Load Distribution:

• **Strategy:** Alternate intense training (sprints, drills) and light recovery (yoga, stretching) between matches.
• **Practical Example:** In a week with 2 matches, a footballer limits training to 2 light sessions (short passes, 20 min, RPE 4/10).

7.3. Competition Prioritization:

• **Method:** Reduce volume (30%) before A competitions (e.g., Champions League) and maintain normal training for C competitions.
• **Practical Example:** A club reduces volume from 8 km to 5 km/session before a cup match, with a focus on sprints (6x20 m).

8. Real-Time Monitoring During the Event:

Real-time monitoring optimizes performance and load management.

8.1. Tools:

• **GPS (Catapult, 10 Hz):** Distance, sprints, PlayerLoad.
• **Capillary Lactate:** Half-time measurements (football, <4 mmol·L^{-1}).
• **SmO_2 (Moxy):** Muscle oxygen saturation (>35% for cyclists).
• **WHOOP Live:** HR, HRV, real-time sleep.
• **Coach Paint:** Video analysis (tackles, sprints).
• **Practical Example:** A footballer is monitored via GPS (10.8 km/match) and lactate (3.5 mmol·L^{-1} at half-time) to adjust intensity in the second half.

8.2. Alerts:

• **GPS Live API:** Alert if distance >110% of seasonal average.
• **Python Script:** Notification if ACWR >1.4 over 7 days.

• **Practical Example:** A GPS alert reduces a footballer's intensity if distance exceeds 12 km/match.

9. Management of Contingencies:

Planning must anticipate contingencies to maintain performance.

9.1. Weather:

• **Plan B:** Indoor tactical training or drill adjustments.
• **Practical Example:** In case of rain, a footballer switches to indoor drills (short passes, 20 min).

9.2. Acute Injury:

• **Protocol:** Emergency medical kit, SCAT5 for concussions.
• **Practical Example:** A footballer with suspected concussion follows SCAT5 and 7-day re-athleticization.

10. Case Study: Footballer (29 years old, Season with Championship and Cup):

• **Planning (12 weeks):**
o **Block 1 (4 weeks, PPG):** Endurance (6 km/session, 60% VO_2max), strength training (squat, 4x10 at 65% 1RM).
o **Block 2 (4 weeks, PPS):** Speed (6x20 m, 90% effort), tactical drills (passes, 20 min, 85% accuracy).
o **Block 3 (4 weeks, Pre-competitive):** Tapering (volume -40%, match simulations, 15 min at 85% effort).
• **Before Match (7 days):** Sprints (6x20 m, 90%), tapering (volume -40%, 4 km/session), visualization (10 min/day).
• **Match Day:**
o **17 h (J-1):** Carbohydrate dinner (3 $g \cdot kg^{-1}$).
o **6:30:** Warm-up (15 min zone 1, 4x30" at 90%).
o **Match:** 10.8 km, 22 sprints >25 $km \cdot h^{-1}$, PlayerLoad 750 (GPS Catapult).
• **Post-Match (3 days):** Active recovery (yoga, 30 min), light run (3 km at 50% VO_2max), cryotherapy (12°C, 10 min).
• **Monitoring:** HRV (WHOOP, 60 ms), RPE (5/10), video analysis (Hudl, 90% passes).
• **Adjustments:** 20% volume reduction if HRV <50 ms.
• **Result:** 0.2 s improvement on 20 m sprint, 90% pass accuracy, stable performances over 3 consecutive matches.

Conclusion:

Competition planning and management require an integrated approach combining rigorous periodization, precise tapering, load management adapted to multiple competitions, and in-depth psychological and tactical preparation. Modern tools (GPS, HRV, Smartabase, Hudl)

enable real-time monitoring and dynamic adjustments to optimize performance while preserving athlete health. Successful planning relies on understanding individual needs, constant adaptation, and effective communication between the athlete and their staff.

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Conference No. 12 Recovery, Regeneration, and Nutrition in Sports Planning

Introduction:

Recovery, regeneration, and nutrition are fundamental pillars of sports planning, playing a role as crucial as training itself in optimizing performance, minimizing fatigue, reducing injury risks, and preventing overtraining (Kellmann et al., 2018; Burke et al., 2011). Recovery, far from being mere rest, is a proactive variable integrated from the design of training cycles, directly influencing load tolerance and sports longevity. Nutrition, in turn, supports available energy, muscle recovery, training adaptation, and overall athlete health. Individualized planning, tailored to the sport type, training intensity, and specific goals (strength, endurance, weight loss), is essential to maximize physiological adaptations and transform these elements into competitive advantages.

1. Importance of Recovery in Sports Training:

1.1. Physiological Role:

Recovery enables the body to repair and adapt to training stress, thereby improving long-term performance (Kellmann et al., 2018).

- **Energy Restoration:** Replenishment of muscle and liver glycogen stores (e.g., 1–2 g/kg carbohydrates post-exercise).
- **Tissue Repair:** Protein synthesis to repair muscle micro-damage (20–30 g protein post-training).
- **Physiological Adaptation:** Supercompensation via recovery, increasing strength, endurance, or power.
- **Fatigue Reduction:** Elimination of metabolic waste (lactate, H^+) and reduction of oxidative stress.
- **Injury Prevention:** Reduction of overtraining and muscle injury risks (30% decrease with optimal recovery, Halson, 2014).

1.2. Different Types of Recovery and Their Impacts:

Sports recovery can be classified into two broad categories: passive and active.

- **Passive Recovery:** Complete rest, very light activities (slow walking, gentle stretching).
- **Active Recovery:** Light to moderate activities (low-intensity cycling, light swimming).

The nature of recovery depends on the level of stimulation desired by the coach. Passive recovery allows optimal nervous, muscular, and metabolic regeneration. Active recovery promotes blood circulation and helps eliminate toxins accumulated during intense effort.

1.3. Advantages of Passive Recovery for Performance:

Passive recovery offers several significant benefits for sports performance. It promotes better nervous, muscular, and metabolic recovery, which is crucial for maintaining high training intensity over the long term. This type of recovery supports the qualitative aspect of training, allowing athletes to perform more sets or repetitions at maximum intensity.

1.4. When to Opt for Active Recovery:

The decision to opt for active recovery depends on the intensity and duration of the effort, as well as the specific training goals. It is particularly beneficial after low-to-moderate intensity sessions, where the goal is to promote blood circulation without imposing additional stress. Active recovery should not be confused with additional training but designed as an integral part of the recovery process, aiming to optimize muscular and metabolic regeneration without inducing excessive fatigue.

1.5. Adjusting Recovery According to the Athlete:

Adjusting recovery is essential to optimize performance and prevent injuries. Each athlete is unique, and the duration and type of recovery must be personalized based on training intensity, physical condition, and personal goals. Active recovery may include low-intensity running, walking, or another sport. Passive recovery emphasizes the qualitative aspect, allowing more sets/repetitions at maximum intensity.

1.6. Challenges of Recovery in Elite Sport:

Professional athletes, due to their high level of commitment, are subject to strict recovery demands. Targeted recovery is essential to maintain optimal performance and prevent injuries. Requirements include:
• A balanced, nutrient-rich diet.
• Active and passive rest periods.
• Specialized care such as physiotherapy or massages.
• Use of advanced recovery technologies.
These strategies must be integrated into a structured training plan to maximize performance while minimizing risks of overwork or injury.

1.7. Obstacles to Effective Recovery and How to Overcome Them:

Overcoming obstacles to effective recovery requires a holistic approach considering physical and mental aspects. Strategies include:
• Recognition of early signs of inadequate recovery.
• Adjustment of training intensity and duration based on recovery capacity.
• Adoption of a balanced, nutrient-rich diet.
• Implementation of a passive recovery routine after intense efforts.
Mental preparation is crucial for managing post-competition stress and promoting optimal recovery.

2. Foundations of Regeneration and Nutrition:

2.1. Role of Nutrition in Recovery:

Nutrition plays a crucial role in recovery by providing the nutrients needed for muscle repair and energy reserve restoration. A balanced diet is essential to support recovery and improve

daily performance. Natural, nutrient-rich foods should be prioritized, while prepared meals and fast food should be avoided.
• **Lean Proteins:** Essential for muscle repair (chicken, fish, legumes).
• **Complex Carbohydrates:** Provide sustained energy (sweet potatoes, quinoa).
• **Lipids:** Necessary for energy and cellular health (avocados, nuts).
Rehydration is fundamental, with water and electrolyte intake to maintain fluid balance.

2.2. Essential Nutrients for Optimal Regeneration:

For optimal regeneration, it is crucial to incorporate essential nutrients supporting muscle repair and energy reserve restoration:
• **Lean Proteins:** Chicken, fish, legumes for muscle tissue repair.
• **Complex Carbohydrates:** Sweet potatoes, quinoa to replenish glycogen.
• **Vitamins and Minerals:** Fresh fruits and vegetables (B vitamins, C, antioxidants) to combat oxidation and strengthen the immune system.
• **Hydration:** Water and electrolyte-enriched drinks to restore fluid balance.

2.3. Avoiding Counterproductive Foods:

Highly processed foods, rich in added sugars and saturated fats, can cause inflammation, slow muscle regeneration, and negatively affect performance. To avoid:
• Fast food and ready-made meals.
• Foods high in added sugars.
• Highly processed products.
• Saturated fats.
Prioritizing natural foods (fruits, vegetables, lean proteins, whole grains) improves recovery and performance.

3. Nutritional Needs of Athletes:

3.1. Carbohydrates: Primary Fuel:

• **Role:** Provide energy for intense efforts and replenish muscle and liver glycogen post-exercise (Thomas et al., 2016).
• **Intake:** 5–10 g/kg/day for endurance sports (350–700 g for 70 kg), 3–5 g/kg/day for strength sports.
• **Sources:** Brown rice, sweet potatoes, fruits (bananas, apples), vegetables, quinoa.
• **Example:** A cyclist consumes 500 g of carbohydrates/day (rice, 200 g; bananas, 3 units) before a 100 km race to maximize glycogen stores.

3.2. Proteins: Repair and Growth:

• **Role:** Support muscle recovery, prevent catabolism, promote hypertrophy (Phillips & Van Loon, 2011).
• **Intake:** 1.2–2.0 g/kg/day (84–140 g for 70 kg), with 20–30 g per meal to optimize protein synthesis.

• **Sources:** Chicken (100 g = 30 g protein), eggs (2 = 12 g), lentils (100 g = 9 g), Greek yogurt.
• **Example:** A weightlifter consumes 30 g of protein (whey shake) within 30 min post-training to accelerate recovery.

3.3. Lipids: Energy and Hormones:

• **Role:** Provide sustained energy for low-intensity efforts, support hormonal production, absorb fat-soluble vitamins (A, D, E, K).
• **Intake:** 20–35% of total energy (70–100 g for 3000 kcal/day), favoring unsaturated fats.
• **Sources:** Olive oil (1 tbsp = 10 g), avocados, salmon (100 g = 13 g lipids), almonds.
• **Example:** A marathoner incorporates 80 g of lipids/day (salmon, 150 g; avocado, 1 unit) to support long-duration training.

3.4. Micronutrients: Metabolic Functions:

• **Role:** B vitamins (energy metabolism), vitamin D and calcium (bone health), iron (oxygen transport), antioxidants (vitamins C, E, selenium) to reduce oxidative stress.
• **Intake:** Iron 15–18 mg/day for female athletes, vitamin D 2000 IU/day in case of deficiency.
• **Sources:** Spinach (iron, 2.7 mg/100 g), oranges (vitamin C, 70 mg/unit), Brazil nuts (selenium).
• **Example:** A swimmer takes a vitamin D supplement (1000 IU/day) in winter to maintain optimal levels (50 nmol/L).

3.5. Hydration: Basis of Performance:

• **Role:** Regulate body temperature, transport nutrients, maintain performance (Sawka et al., 2007).
• **Intake:** 500 ml/h during exercise, plus 1.5 L/kg of weight lost post-training. Isotonic drinks (6–8% carbohydrates) for efforts >1 h.
• **Example:** A footballer drinks 500 ml of an isotonic drink (sodium 20 mmol/L) every 15 min during a match at 30°C.

4. Training Planning and Management of Rest Days:

4.1. Importance of Non-Training Days:

Non-training days are crucial to allow the body to regenerate and avoid overtraining, which can have severe consequences on performance and health. Rest days are an active recovery phase where the body repairs and builds muscle mass. Key points:
• Ensure balance between training and rest days.
• Distribute sessions to avoid overloading a muscle group.
• Avoid consecutive intense training without adequate rest.
Neglecting non-training days can lead to performance stagnation and, in extreme cases, overtraining requiring months or even years of recovery.

4.2. Balance Between Training and Recovery:

Finding the right balance between training and recovery is crucial to optimize performance. Recovery should not be seen as lost time but as an essential component of training. Passive recovery promotes nervous, muscular, and metabolic regeneration.

4.3. Planning Strategies to Maximize Regeneration:

To maximize regeneration, a strategic and personalized approach is essential:
• Regular assessment of the athlete's form.
• Adjustment of the recovery plan based on athlete feedback.
• Integration of varied recovery techniques (passive, active, nutritional).
Recovery is an active component of athlete development, requiring adaptability and continuous communication between coach and athlete.

4.4. Personalization of Recovery According to Individual Needs:

Personalization is crucial to optimize performance and health. The duration and type of recovery must be adjusted based on training intensity, physical condition, and goals. Factors influencing the choice between passive and active recovery include effort intensity, activity duration, and competition proximity. Coaches must evaluate these parameters to tailor recovery.
• **Post-Training Stretching:** Maintain body tone and flexibility.
• **Electrostimulation:** Relieve post-training pain.

5. Nutritional Periodization:

5.1. Definition and Objectives:

• **Definition:** Adjustment of nutritional intake according to training phases (macrocycle, mesocycle, microcycle) to optimize physiological adaptations (Jeukendrup, 2017).
• **Objectives:** Support training, maximize energy reserves, promote recovery.

5.2. Periodization Phases:

• **General Preparation:** Balanced intake (55% carbohydrates, 20% proteins, 25% lipids) to support high volume (4–5 h/week). Focus on micronutrients (iron, calcium).
• **Specific Preparation:** Increased carbohydrates (7–10 g/kg/day) for intense training, high proteins (1.6–2.0 g/kg/day) for recovery.
• **Competition:** Carbohydrate pre-loading (10 g/kg/day, 3 days before), optimized hydration (500 ml/h). Pre-competition meal rich in carbohydrates (200–300 g, 3 h before).
• **Recovery/Transition:** Carbohydrates (5–7 g/kg/day) and proteins (20–30 g/meal) to replenish glycogen and repair muscles, plus antioxidants (fruits, vegetables).
• **Example:** A triathlete adjusts carbohydrate intake from 5 g/kg/day (general preparation) to 8 g/kg/day (specific preparation) before an Ironman, with 500 g of carbohydrates 2 days before the race.

6. Dietary Supplements:

6.1. Utility and Effectiveness:

• **Validated Supplements:**
o **Creatine:** 3–5 g/day to increase power (weightlifting, sprints).
o **Caffeine:** 3–6 mg/kg 1 h before effort to improve endurance and alertness (200 mg for 70 kg).
o **Protein Powder:** 20–30 g post-training for recovery.
o **Isotonic Drinks:** Carbohydrates (6–8%) and sodium (20–30 mmol/L) for prolonged efforts.
• **Example:** A sprinter uses 5 g of creatine/day for 6 weeks, increasing maximal power by 5% (30 m sprint test).

6.2. Precautions:

• **Certification:** Choose certified supplements (NSF Certified for Sport®) to avoid banned substances.
• **Supervision:** Consult a sports nutritionist to assess needs and avoid overdosing.
• **Limits:** Supplements do not replace a balanced diet. Some (BCAA without adequate protein intake) lack solid evidence.
• **Example:** A swimmer avoids an uncertified multivitamin supplement, opting for a vegetable-rich diet (spinach, 200 g/day).

7. Integration into Sports Planning:

7.1. Cycle Structure:

• **Macrocycle:** Annual plan integrating nutritional phases aligned with goals (e.g., mass gain in general preparation).
• **Mesocycle:** 4–6 week blocks adjusting intake according to intensity (+20% carbohydrates in specific phase).
• **Microcycle:** Week with planned meals (5 meals/day, 20–30 g protein each) and tracking via food diary.
• **Example:** A footballer follows a 4-week mesocycle with 7 g/kg/day carbohydrates (490 g for 70 kg) to support 5 intense training sessions/week.

7.2. Monitoring and Tools:

• **Food Diary:** Recording intake (MyFitnessPal) to adjust calories and macronutrients.
• **Sensors:** GPS (Catapult, PlayerLoad™ <500 a.u./session) and HRV (WHOOP, >55 ms) to correlate training loads with energy needs.
• **Weighing:** Pre/post-training control to monitor dehydration (<2% weight loss).
• **Example:** A runner uses a food diary to maintain 3000 kcal/day (60% carbohydrates) and checks <1% weight loss after a 10 km session.

8. The Future of Recovery and Regeneration:

The evolution of knowledge and technologies promises to transform recovery and regeneration. Personalization will become standard with the emergence of technologies precisely measuring recovery status. Coaches and athletes will be able to adjust rest periods and recovery types more effectively.

- New strategy to facilitate muscle regeneration after injury.
- Increased use of recovery measurement technologies.
- Personalized approaches based on individual data.

9. Case Study: Endurance Cyclist:

- **Context:** 100 km race, 5 h effort.
- **Assessment:** Weight 70 kg, VO_2max 65 ml/kg/min, HRV 60 ms, energy needs 3500 kcal/day.
- **Program (6 weeks):**
  - **Nutrition:** 7 g/kg/day carbohydrates (490 g, rice/sweet potatoes), 1.8 g/kg/day proteins (126 g, chicken/whey), 25% lipids (olive oil, salmon).
  - **Periodization:** Carbohydrate pre-loading (10 g/kg/day, 700 g, 3 days before), 500 ml/h isotonic drink during the race.
  - **Supplements:** Caffeine (200 mg, 1 h before), creatine (5 g/day).
  - **Monitoring:** Food diary (MyFitnessPal), GPS (6–7 km/h at 70% VO_2max), HRV (55–60 ms).
- **Results:** Optimized glycogen stores, race time reduced by 2% (5h to 4h54), rapid recovery (HRV >60 ms after 24 h).

10. Challenges and Perspectives:

10.1. Challenges:

- **Individualization:** Adapt nutrition and recovery to preferences, cultural constraints, physiological needs, and form level.
- **Resources:** Cost of certified supplements, limited access to nutritionists or technologies (GPS, HRV) in amateur clubs.
- **Compliance:** Maintain dietary discipline and recovery routines despite travel or competition constraints.
- **Overtraining:** Increased risk in professional athletes due to high demands.

10.2. Perspectives:

- **Technologies:** Tracking apps (MyFitnessPal, Nutrium) and affordable sensors (Fitbit, Garmin) to personalize dietary and recovery plans.
- **Research:** Studies on the impact of specific diets (e.g., ketogenic) and new post-injury regeneration strategies.
- **Education:** Training coaches and athletes on nutrition and recovery to improve adherence.
- **Mental Health:** Integration of mental preparation to manage stress and optimize recovery.

Conclusion:

Recovery, regeneration, and nutrition are essential components of sports planning, acting as levers to optimize performance and preserve health. Recovery, whether passive or active, must be integrated as an active phase of the training process, tailored to individual needs to maximize muscular, nervous, and metabolic regeneration. Nutrition, through precise periodization of carbohydrate, protein, lipid, micronutrient, and hydration intake, supports energy, recovery, and physiological adaptations. A collaborative approach with nutritionists and the use of tools like food diaries, GPS, and HRV ensure individualized planning. By overcoming obstacles (limited resources, compliance, overtraining) through advanced technologies, personalized strategies, and increased education, athletes can transform recovery and nutrition into major competitive assets.

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Conference No. 13 Reathletisation in the Context of Sports Planning

Introduction: The Indispensable Bridge to Performance

In the world of elite sport, where performance is pushed to its limits, injuries are unfortunately inevitable. However, an injury should not be perceived as the end of a career, but as a strategic pause offering an opportunity for reconstruction and strengthening. Reathletisation represents this essential bridge between the end of medical care (rehabilitation) and the full return to competition at the highest level. It goes beyond simple recovery, constituting an adapted training phase aimed at restoring and optimizing the athlete's physical, technical, tactical, and psychological capacities, while minimizing the risks of recurrence. Neglecting or mismanaging this stage can lead to relapses, decreased performance, or even premature career termination. Thus, its harmonious and strategic integration into overall sports planning is crucial to ensure a safe and high-performing return.

1. Definition and Distinction: Reathletisation vs. Medical Rehabilitation

1.1. Definition of Reathletisation :

Reathletisation is a systematic and structured process that follows medical rehabilitation or injury treatment and precedes the full resumption of competitive sports activity. According to Bizzini (2020), it aims to "restore biomotor, technical, and psychological qualities to levels compatible with competition." It focuses on the athlete's overall performance, going beyond mere tissue healing to include physical reconditioning, reintegration of sport-specific gestures, and mental preparation for competition. The primary objective is to return the athlete to their pre-injury performance level, or even improve it, while preventing recurrence risks.

1.2. Difference Between Medical Rehabilitation and Reathletisation :

Although complementary and successive, medical rehabilitation and reathletisation have distinct objectives, stakeholders, environments, and approaches.
The following table summarizes the key differences:

Characteristic	**Medical Rehabilitation (Therapeutic Phase)**	**Reathletisation (Transition/Performance Phase)**
Primary Objective	Healing of injured tissues, restoration of joint ranges of motion and basic muscle strength.	Restoration of sport-specific physical qualities, performance optimization, and recurrence prevention.
Key Stakeholders	Sports physician, physiotherapist, osteopath.	Strength and conditioning coach, head coach, physiotherapist (in collaboration), physician.
Environment	Physiotherapy office, clinic, medical center.	Sports field, weight room, athletics track.
Type of Exercises	Passive/active assisted exercises, isolated	Functional exercises, sport-specific, high-intensity, with progressive loading.

	strengthening, joint mobilization.	
Approach	Injury-centered, pain elimination.	Athlete-centered and sport demands, preparation for maximal effort.
Phase End	Minimal residual pain, full joint ranges, near-normal strength.	Return to specific gestures without pain, physical capacities close to pre-injury level.

Medical rehabilitation forms the foundation, focused on healing and basic functional recovery, while reathletisation builds on this base to return the athlete to competitive performance level. For example, after an anterior cruciate ligament (ACL) rupture, rehabilitation restores knee mobility (0–120° ROM) and basic strength, while reathletisation integrates sprints (6x20 m at 90%) and changes of direction to prepare for return to play.

2. Key Roles and Place in General Planning :

2.1. Role of the Coach and Strength and Conditioning Specialist :

Reathletisation relies on close collaboration between the head coach, the strength and conditioning specialist, and the medical team. Each plays a specific role:

• **Head Coach:** Guardian of sport specificity, mastering the technical and tactical demands of the discipline as well as the athlete's competitive environment. Their role is to integrate technical gestures (e.g., passes for a footballer, throws for a basketball player) and tactical situations into the reathletisation program while maintaining the link to overall performance. They collaborate with the strength specialist to align athletic goals with technical and tactical needs.

• **Strength and Conditioning Specialist:** Designs and implements an individualized training program based on principles of loading, periodization, progression, and specificity. They adapt exercises to progressively stress the injured area while developing overall physical qualities (strength, power, endurance, speed, plyometrics). They account for pre-existing gaps and injury-induced deficits, adjusting loads to avoid overload and minimize recurrence risks.

• **Medical Team:** Oversees the transition between rehabilitation and reathletisation, validates progression milestones, and monitors warning signs (pain, inflammation). The physiotherapist remains involved for therapeutic continuity, while the physician gives clearance for each new phase.

This ongoing collaboration is essential to adjust sessions, prevent overload, and ensure safe progression toward performance goals.

2.2. Positioning in General Planning :

Reathletisation is not an isolated phase but a "micro-macrocycle" integrated into the annual plan (macrocycle). It fits as a specific phase, adjusted according to the severity and duration of unavailability caused by the injury.

• **Integration as a Specific Phase:** Depending on the injury type, reathletisation may replace or modify traditional planning phases (general preparation, specific preparation). For

example, after an ACL rupture, reathletisation (12–16 weeks) may take the place of general preparation, focusing on functional rehabilitation and rebuilding athletic foundations.
• **Adaptation of the Original Plan:** An unforeseen injury requires revision of the annual plan. If the main objective (e.g., Olympic participation) is maintained, prior phases must be recalculated to integrate reathletisation as the starting point of a new preparation cycle. This involves reevaluating goals, loads, and timelines.
• **Progression of Return to Performance:** Return to competition is not binary ("on/off") but a progressive continuum. Each step is validated by objective criteria (strength, functional tests, pain) before moving to the next. This meticulous planning is crucial to avoid relapses and optimize long-term performance.

2.3. Positioning in the Planning Cycle :

In an annual plan, reathletisation is situated between medical rehabilitation and full resumption of team training or individual competition. It can be considered an advanced specific preparatory phase with a strong risk management component. Its duration typically ranges from 6 to 16 weeks, depending on the injury, and is structured into several mesocycles (3–6 weeks) and microcycles (1 week). Each microcycle has precise objectives in terms of load, intensity, volume, and specificity.

3. Functional Phases of Reathletisation and Key Principles :

3.1. Phases of Reathletisation :

Reathletisation is structured into progressive functional phases adapted to the athlete's evolution. Although terminologies may vary, the logic remains consistent. Here are the detailed phases with their objectives and specific content:

Phase 1: Mobilization and Stability (2–3 weeks):
• **Objectives:** Restore range of motion (ROM), joint stability, and motor control of the injured area. Transition from analytical (isolated) to global movements.
• **Content:**
o Proprioceptive exercises (e.g., bosu, slackline, 3x15 repetitions).
o Light muscle strengthening (e.g., adductors, 3x15 at 30% 1RM).
o Physiotherapy sessions with neuromuscular electrical stimulation (NMES, 3x/week).
o Heart rate variability (HRV) monitoring: reduce load if HRV <15% of baseline.
• **Focus:** Joint stability, local muscular endurance, coordination.
• **Example:** A footballer post-ankle sprain performs slackline exercises to improve proprioception.

Phase 2: Strength and Local Endurance (3–4 weeks):
• **Objectives:** Develop muscle hypertrophy and endurance specific to the injured area and associated muscle groups.
• **Content:**
o Squats (4x8 at 60–70% 1RM).

o Concentric isokinetic exercises (60°/s).
o Copenhagen plank to strengthen adductors (3x30 s).
o Asymmetry monitoring (<10% between injured and healthy side).
• **Focus:** Global muscle strengthening, strength endurance.
• **Example:** A runner post-pubalgia strengthens adductors with 3x12 repetitions at 70% 1RM to reduce asymmetry.

Phase 3: Specific Qualities (3–4 weeks):
• **Objectives:** Restore power, speed, and sport- and position-specific technical gestures.
• **Content:**
o Plyometrics (e.g., 3x6 drop-jumps from 30 cm).
o Progressive sprints (5x20 m at 90%).
o Lactate tests (3 mmol/L at specific speed).
o Technical exercises with increasing intensity (e.g., passes or shots for a footballer).
• **Focus:** Explosive power, speed, anaerobic endurance, technique.
• **Example:** A swimmer post-shoulder injury integrates swim sprints (8x50 m at 85%) with biomechanical analysis.

Phase 4: Return to Competition (2–3 weeks):
• **Objectives:** Tolerate global competitive loads, regain confidence, and prepare mentally and physically for resumption.
• **Content:**
o Match or competition simulations (e.g., friendly match at 60% initial intensity).
o Simulated competition microcycles.
o Specific tapering (40% volume reduction over 5 days).
• **Focus:** Tactical endurance, power endurance, mental preparation.
• **Example:** A tennis player post-ACL rupture participates in a friendly match (2 sets at 60% intensity) before an official tournament.

3.2. Principles of Individualized Post-Injury Planning :

Reathletisation is a highly individualized process tailored to each athlete and injury. Key principles include:
• **Absolute Individualization:** The program is designed based on:
o Type and severity of injury (muscular, ligamentous, joint).
o Practiced sport and athlete's position (e.g., goalkeeper vs. winger in football).
o Injury history and pre-injury fitness level.
o Recovery capacities (e.g., VO_2max, HRV).
• **Gradual and Logical Progression:** Load (volume, intensity, density) is increased progressively, respecting supercompensation and adaptation principles. For example, 10% weekly volume increase and 5% intensity.
• **Specificity:** Exercises evolve toward sport-specific movements as phases progress (e.g., shots for a footballer, jumps for a basketball player).
• **Balance and Harmony:** Global strengthening to avoid compensations (e.g., balancing

quadriceps and hamstrings to prevent knee injuries).
• **Therapeutic Continuity:** The physiotherapist remains involved for monitoring and advice, even as the strength coach and head coach take the lead.

3.3. Continuous Evaluation and Load Adjustment :

Reathletisation relies on constant evaluation and real-time adjustments to ensure safe progression:
• **Evaluation Tests:**
o **Strength:** Isokinetic tests (peak torque ≥90% healthy side) and isometric (dynamometer, asymmetry <10%).
o Power: Hop test (≥95%), jump tests (VALD ForceDecks), sprints (maximal speed).
o Specific Functional Tests: Reproduce sport movements (e.g., changes of direction, shots, throws).
o Pain and Well-Being: Subjective scales (VAS ≤2/10, NRS), well-being questionnaires (fatigue, mood).
o Biomechanical Analysis: 3D sensors (IMU) or cameras to detect movement compensations.
o Psychology: Scales like ACL-RSI (score ≥56) for confidence and TSK (≤37) for kinesiophobia.
• Plan Adjustment:
o Reduce load if pain >2/10 or HRV <15% of baseline.
o Reorient goals if persistent deficit detected (e.g., asymmetry >10%).
o Increase intensity if rapid progression and validated tests.
o Integrate athlete's subjective feedback (pain, comfort, motivation).

4. Multidisciplinary Role and Technological Tools :

4.1. Multidisciplinary Teamwork :

Reathletisation is a collective effort requiring close collaboration among several professionals for optimal management:
• **Sports Physician:** Makes initial diagnosis, monitors injury evolution, validates phase transitions, and oversees general health.
• **Physiotherapist:** Manages functional rehabilitation (ROM restoration, basic strength, proprioception) and ensures transition to reathletisation.
• **Strength and Conditioning Coach:** Designs and supervises physical reconditioning program focused on performance and injury prevention.
• **Sport Coach:** Integrates gains into technical and tactical gestures and supervises reintegration into team training or competition.
• **Osteopath/Chiropractor:** Corrects biomechanical or joint restrictions.
• **Nutritionist:** Develops a dietary plan to optimize healing (e.g., 1.8 g/kg/day protein, 2000 IU vitamin D) and support recovery.
• **Sports Psychologist:** Manages stress, frustration, fear of recurrence, and builds confidence and motivation (30 min/week sessions).

This team communicates regularly, shares data (tests, observations), and makes joint decisions to ensure athlete well-being and performance.

4.2. Technological Tools for Monitoring :

Technological advances have revolutionized reathletisation by providing objective data to guide decisions:

• **Load and Recovery Tracking Platforms:**

o **Catapult (GPS/IMU):** Measures movement metrics (distance, speed, accelerations, decelerations, impacts, PlayerLoad™ <600 a.u./session). These data quantify external load and compare it to pre-injury level to validate progression.

o **VALD Performance (ForceDecks, NordBord):** Provides data on strength (isometric/isokinetic tests, asymmetry <10%), power (force-velocity jump profiles), and bilateral symmetry.

• Biometric Data Systems:

o Heart Rate and HRV: Monitors (Whoop, Oura Ring) to assess fatigue and recovery via heart rate variability (e.g., ln rMSSD >3.8). Low HRV (<15% baseline) indicates overload, requiring intensity reduction.

o **Sleep Tracking:** Analysis of sleep quality and duration to detect accumulated fatigue.

o **RPE (Rating of Perceived Exertion):** Daily subjective scales filled by the athlete (fatigue, mood, pain <7/10) to complement objective data.

• **Specific Applications:** For example, the "Return2Play" app offers a dashboard to track test and load progression.

• **Biofeedback and Kinematic Analysis:** IMU sensors and 3D cameras to analyze movements and detect biomechanical compensations.

These tools enable precise individualized planning, turning each session into an opportunity for real-time evaluation and adjustment, avoiding under- or over-training.

5. Transition Criteria and Return to Competition :

5.1. Transition Criteria from Rehabilitation to Reathletisation :

The transition from medical rehabilitation to reathletisation is validated by objective criteria, as defined by the IOC Consensus (2022):

Criterion	Threshold	Clinical Test
Pain	≤2/10 (VAS) at rest and during effort	Visual Analog Scale (VAS)
Isometric Strength	≥90% healthy side	Dynamometer
ROM Deficit	≤5%	Goniometer
Functional Test	≥90%	Y-Balance Test, Hop Test
Psychology	TSK ≤37	Kinesiophobia Scale

These criteria ensure the athlete is ready to move to a more intense training phase without recurrence risk.

5.2. Final Return to Competition Criteria :

Return to competition is a multidisciplinary decision based on objective and subjective criteria:
• **Isokinetic Strength:** ≥95% compared to healthy side.
• **Functional Tests:** Hop Test ≥95%, Y-Balance Test (composite score ≥95%).
• **Psychology:** ACL-RSI score ≥56 to assess self-confidence.
• **Competitive Load:** Tolerance to global loads (e.g., PlayerLoad™ 600 a.u./session).
• **Multidisciplinary Decision:** "Go/No-Go" meeting involving medical staff, strength coach, head coach, and athlete.

6. Integrated Example: 800 m Runner – Pubalgia :

• **Injury:** Long adductor.
• **Phase 1 (2 weeks):** Physiotherapy + light adductor exercises (3x15 at 30% 1RM), proprioception (slackline).
• **Phase 2 (3 weeks):** Squats (4x8 at 70% 1RM), Copenhagen plank (3x30 s), asymmetry monitoring (<10%).
• **Phase 3 (3 weeks):** Sprints (6x150 m at 90%), technical exercises (specific strides).
• **Phase 4 (2 weeks):** 600 m race test at competitive intensity, tapering (5 days, –40% volume).
• **Results:** Return to competition in 10 weeks, performance of 1'52 vs. 1'50 pre-injury, no recurrence.

7. Injury Management within Planning :

7.1. Injury Prevention :

Prevention is the first step to minimize injury impact in sports planning:
• **Risk Assessment:** Analysis of injury history, muscle imbalances, mobility deficits, technical errors, and environmental factors (e.g., playing surface). Regular functional tests (e.g., Y-Balance Test) identify vulnerabilities.
• **Training Optimization:**
o Warm-up and stretching to prepare the body and improve flexibility.
o Balanced muscle strengthening targeting stabilizers (e.g., Copenhagen plank for adductors).
o Training load control: Avoid rapid increases (>10%/week) to prevent overload injuries.
o Biomechanical correction: Movement analysis to reduce joint stress.
• **Lifestyle and Recovery Habits:** Sleep (7–9 h/night), nutrition (1.8 g/kg/day protein, adequate hydration), and active recovery techniques (massages, cryotherapy).

7.2. Rehabilitation and Return to Play :

• **Acute Phase:** Reduce pain and inflammation via RICE/PRICE protocol (rest, ice, compression, elevation).
• **Functional Recovery Phase:** Restore range of motion, strength, and proprioception (e.g., bosu exercises).

• **Reathletisation Phase:** Prepare for sport-specific demands with plyometrics, sprints, and sport movement simulations.
• **Return to Play Criteria:**
o Absence of pain/inflammation during specific movements.
o Muscle strength and endurance comparable to healthy side (e.g., ≥95% in isokinetic test).
o Validated functional tests (Hop Test, changes of direction).
o Psychological preparation: Confidence and absence of recurrence fear (ACL-RSI ≥56).
o Multidisciplinary decision involving medical team, coach, and athlete.

Conclusion :

Reathletisation is a fundamental link in the sports performance chain, transforming an injury into an opportunity for global strengthening. It is not limited to simple resumption of physical activity but constitutes a planned, individualized, and integrated process within the annual plan. Its success relies on:
• Multidisciplinary collaboration among physicians, physiotherapists, strength coaches, head coaches, nutritionists, and psychologists.
• Dynamic planning with regular evaluations (strength, functional tests, biometrics).
• Strategic use of technologies (Catapult, VALD, HRV) to adjust loads in real time.
• An individualized approach respecting the specific needs of the athlete and their sport.
By adopting a long-term vision, reathletisation ensures a safe, high-performing, and sustainable return, extending the athlete's career and optimizing performance. A well-managed injury thus becomes an opportunity to strengthen resilience and refine future planning.

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Conference No. 14 Adaptation of Planning to Environmental Constraints

Introduction:

Environmental constraints such as altitude, heat, humidity, cold, and pollution profoundly influence sports performance, physiology, and athlete health. In the context of climate change, these factors are becoming more frequent and intense, making their consideration essential in training planning (Sawka et al., 2015).

1. Impact of Environmental Constraints :

1.1. Altitude :

• **Physiological Effects:** Hypoxia (reduced partial pressure of oxygen above 1500 m) increases ventilation (+20–30%), heart rate (+10–15 bpm), and stimulates erythropoiesis after 2–3 weeks (Levine & Stray-Gundersen, 1997).
• **Impact on Performance:** Reduction in VO_2max (-7% per 1000 m above 1500 m), decreased aerobic power, and increased fatigue in endurance sports (Wilber, 2004).
• **Example:** A long-distance runner at 2500 m sees their VO_2max drop from 60 to 52 ml/kg/min, affecting their 10 km times (+5–10%).

1.2. Heat and Humidity :

• **Physiological Effects:** Heat increases core body temperature (+1–2 °C), dehydration (2–3% body weight loss), and heart rate (+10–20 bpm). Humidity reduces sweat evaporation efficiency (Cheuvront & Haymes, 2001).
• **Impact on Performance:** Decline in aerobic (-10–15%) and anaerobic performance, risk of heat stroke (core temperature >40 °C).
• **Example:** A footballer playing at 35 °C and 80% humidity reduces distance covered from 8 to 6 km per match (GPS Catapult).

1.3. Cold :

• **Physiological Effects:** Vasoconstriction preserves heat but reduces muscle blood flow, lowering muscle temperature (-1–2 °C). Shivering increases metabolism (+20–30%) (Castellani & Young, 2012).
• **Impact on Performance:** Loss of strength (-5–10%), coordination, and risk of hypothermia (core temperature <35 °C).
• **Example:** A skier at -10 °C shows an 8% reduction in maximal power during sprints.

1.4. Air Pollution :

• **Physiological Effects:** Pollutants (PM2.5, ozone) cause lung inflammation, reduce lung capacity (-5–10%), and increase oxidative stress (Carlisle & Sharp, 2001).
• **Impact on Performance:** Decrease in VO_2max (-5%) and increased fatigue, particularly in endurance sports.

• **Example:** A cyclist in a polluted urban area (AQI >150) reduces maximal effort time by 10% (e.g., 30 to 27 min at 80% FTP).

2. Adaptation Strategies :

2.1. Adaptation to Altitude :

• **Live High, Train High (LHTH):** Stay at altitude (2000–3000 m) for 3–4 weeks to stimulate erythropoiesis (+5–10% red blood cells). Intensity reduced (-20%) for the first 7 days.
• **Live High, Train Low (LHTL):** Live at altitude (>2000 m) and train at low altitude (<1000 m) to maintain intensity. Improves VO_2max (+3–5%) after 4 weeks (Levine & Stray-Gundersen, 1997).
• Intermittent Hypoxia: Use of hypoxic chambers (10–15 h/week, 12–16% O_2) to simulate altitude.
• Adjustment: Reduce volume (-10–20%) and intensity (-15%) at the start of exposure, with HRV monitoring (WHOOP, >55 ms).
Example: A cyclist follows an LHTL protocol (4 weeks at 2500 m, training at 800 m), increasing VO_2max from 62 to 65 ml/kg/min.

2.2. Adaptation to Heat and Humidity :

• **Acclimatation:** Progressive exposure over 7–14 days (60 min sessions at 60% VO_2max in 30–35 °C). Reduces heart rate (-5–10 bpm) and core temperature (-0.5 °C) (Sawka et al., 2015).
• **Hydration:** Consumption of 500 ml/h of water or electrolyte drinks (sodium 20–30 mmol/L). Losses monitored via pre/post-training weighing (<2% body weight).
• **Cooling:** Cooling vests (15 °C, 10 min pre-exercise) or iced drinks (4 °C, 200 ml/15 min).
• **Adjustment:** Morning training (T° <25 °C), volume reduction (-20%) if RPE >7/10.
Example: A marathoner acclimates over 10 days (running at 32 °C, 60 min/day), reducing core temperature from 39 to 38.5 °C.

2.3. Adaptation to Cold :

• **Clothing:** Breathable layers (merino wool, Gore-Tex) to maintain core temperature (>36 °C).
• **Warm-Up:** 15–20 min dynamic warm-up (jogging, jumping jacks) to increase muscle temperature (+1–2 °C).
• **Nutrition:** Increased energy intake (+10–15%, e.g., 500 kcal/day) to compensate for elevated metabolism.
• **Protection:** Gloves, hat, and insulated shoes to prevent frostbite.
Example: A Nordic runner at -15 °C extends warm-up (20 min) and wears thermal layers, maintaining stable performance.

2.4. Management of Air Pollution :

• **Monitoring:** Check air quality index (AQI <100 recommended, AirNow). Avoid training if AQI >150.
• **Schedule/Location:** Morning sessions (AQI reduced by 20–30%) or in green areas (parks, -40% pollutants).
• **Indoor Training:** Use treadmills or stationary bikes if AQI >150.
Example: An urban runner (AQI 180) switches to indoor training (treadmill, 5 km at 60% VO_2max) to preserve lung capacity.

3. Integration into Planning :

3.1. Cycle Adjustment :

• **Macrocycle:** Integrate acclimatation periods (2–4 weeks) before competition in extreme environments (e.g., Olympics at 2000 m altitude).
• **Mesocycle:** 4–6 week blocks with specific training (hypoxia, heat) to prepare physiological adaptations.
• **Microcycle:** Reduce intensity (-10–20%) and include active recovery days (yoga, 20 min) in extreme conditions.
Example: A triathlete plans a 4-week mesocycle with 2 sessions/week in a hypoxic chamber (12% O_2, 60 min) before a 2000 m race.

3.2. Adapted Programming :

• **Content:** Specific exercises (e.g., intervals at 70% VO_2max in heat) and recovery strategies (cold baths, 15 °C, 10 min).
• **Tools:** GPS (Catapult, PlayerLoad™ <500 a.u./session), HRV (WHOOP, >55 ms), and RPE (<7/10) to adjust loads.
• **Example:** A footballer reduces volume (from 8 to 6 km/session, GPS) in heat (35 °C) if HRV <90% of baseline.

4. Case Study: Marathoner in Heat

• **Context:** Marathon at 32 °C, 75% humidity.
• **Assessment:** VO_2max 60 ml/kg/min, HRV 60 ms, RPE 5/10 under normal conditions.
• **Program (6 weeks):**
o **Acclimatation:** 10 days of training at 30–32 °C (5 km/day, 60% VO_2max).
o **Hydration:** 500 ml/h electrolyte drink (sodium 25 mmol/L).
o **Cooling:** Iced drinks (4 °C, 200 ml/15 min) and cooling vest (15 min pre-race).
o **Monitoring:** GPS (6–7 km/session), HRV (55–60 ms), RPE (5–6/10).
• **Results:** Marathon time improved by 3% (2h45 to 2h40), core temperature stable (<39 °C).

5. Challenges and Perspectives :

- **Challenges:**
  • **Complexity:** Integrating environmental constraints into planning without compromising performance goals.

• **Resources:** High cost of tools (hypoxic chambers, GPS) and limited access for amateur clubs.
• **Individual Variability:** Differences in physiological responses to the environment (e.g., heat acclimatation).

- **Perspectives:**
• **Technologies:** Affordable sensors (Garmin, Fitbit) to monitor HRV and external loads.
• **Research:** Studies on combined effects (e.g., heat + pollution) to refine strategies.
• **AI:** Predictive algorithms to adjust loads based on environmental and physiological data.

Conclusion:

Environmental constraints (altitude, heat, cold, pollution) pose major physiological challenges that require adapted planning. By integrating strategies such as acclimatation, hydration, load adjustments, and tools like GPS and HRV, coaches can optimize performance while protecting athlete health. In the era of climate change, these approaches become essential to ensure sustainable and safe performance, especially under extreme conditions.

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Conference No. 15 Future Perspectives: Artificial Intelligence and Sports Planning

Introduction:

Sports planning, once guided by the empirical expertise of coaches and traditional periodization models, is undergoing a revolution through the integration of modern technologies and artificial intelligence (AI). AI, capable of analyzing vast volumes of data, identifying complex patterns, and generating predictions, is redefining the design of training programs, performance optimization, and athlete health protection. Wearable devices (GPS watches, biometric sensors), Big Data, and platforms such **as Smartabase or TrainingPeaks** enable unprecedented personalization, real-time monitoring, and informed decision-making. Far from replacing human expertise, AI acts as an augmentation tool, enhancing the capabilities of coaches and athletes to achieve unprecedented levels of performance and well-being.

1. Technological Foundations of Modern Planning :

Modern sports planning is built on a structured technological chain around four stages (4A): **acquisition**, **aggregation**, **analysis**, and **action**, integrating advanced technologies to optimize processes.

1.1. Data Acquisition :

Wearable sensors and connected devices collect physiological and biomechanical data in real time:
• **GPS (10–18 Hz):** Measures distance, speed, and accelerations (e.g., Catapult for football, recording 12 km and 30 accelerations per match).
• **Power Sensors:** Quantify power output in cycling (e.g., dual-sided powermeter, ±1% accuracy, to adjust zones at 97% FTP).
• **Optical HRV (24 h):** Assesses heart rate variability to monitor recovery (e.g., WHOOP 4.0, detecting a drop >10% vs. 7-day average).
• **Force Plates:** Analyze force and biomechanical balance (e.g., VALD, Hawkin Dynamics to optimize a squat, 6x4 at 85% 1RM).
• **Smart Clothing:** Collects data such as heart rate and respiration (e.g., Hexoskin for rugby).
• **Practical Example:** A footballer uses a Catapult sensor to record 12 km covered and 25 accelerations, enabling weekly load adjustment (ACWR 0.8–1.3).

1.2. Data Aggregation ::

Data from multiple sources (sensors, videos, questionnaires) are standardized via formats such as FIT, TCX, or JSON, and centralized through REST APIs for seamless integration into platforms like **Smartabase** or **TrainingPeaks**.
Example: A football club transfers Catapult GPS data to Smartabase for centralized analysis.

1.3. Data Analysis:

AI algorithms, such as machine learning (ML) and deep learning, identify trends and generate predictions:
• **ML Models:** XGBoost or LSTM predict performance or injury risk (e.g., Random Forest with AUC = 0.87 for muscle injuries, Rossi, 2022).
• **Video Analysis:** Software like Dartfish assesses movement angles or drag coefficients in swimming.
• **Practical Example:** A swimmer uses Dartfish to correct hand entry angle, improving stroke efficiency.

1.4. Action :

Analyses translate into practical recommendations:
• Automatic training load adjustment (e.g., Deep-Fit adjusts loads with RMSE = 2.1 W over 48 h).
• Alerts to coaches (e.g., alert if HRV drops 12%).
• Generation of personalized sessions (e.g., GPT-like models creating HIIT variants).
• **Practical Example:** A runner adjusts their marathon plan via TrainingPeaks, integrating HRV and RPE to maintain ACWR < 1.3.

2. Current and Emerging AI Applications :

AI transforms sports planning by optimizing performance, personalization, injury prevention, and competitive strategies.

2.1. Performance Analysis and Talent Detection :

AI processes massive data volumes for detailed insights:
• **Biomechanical Analysis:** Movement evaluation to correct technique (e.g., Dartfish analyzes hand entry angle in swimming).
• **Tactical Analysis:** Analysis of game patterns and opponent strategies in team sports (e.g., Hudl for basketball, reducing goals conceded by 20%).
• **Talent Detection:** Identification of high-potential young athletes via physiological and biomechanical data (e.g., Wyscout for junior football testing).
• **Practical Example:** A football team uses Hudl to adjust defensive patterns, improving offensive efficiency by 15%.

2.2. Personalization of Training Programs :

AI creates hyper-personalized plans based on physiology, fitness level, goals, recovery, and preferences:
• **Dynamic Adjustment:** Algorithms like Deep-Fit (LSTM) predict improvements (e.g., ΔFTP with RMSE = 2.1 W) and adjust loads in real time.
• **Intelligent Coaching:** Platforms like TrainingPeaks generate adapted plans (e.g., volume adjustment after low HRV).
• **Practical Example:** A cyclist uses TrainingPeaks to adjust power zones (97% FTP), achieving peak form (estimated VO_2max +5%).

2.3. Injury Prevention and Recovery Management :

AI identifies early signs of fatigue or overload:
• **Predictive Analysis:** Models based on ACWR, HRV, sleep, and injury history (e.g., Zone7 with >80% accuracy).
• **Continuous Monitoring:** Biometric sensors (WHOOP) track sleep, oxidative stress, and recovery, generating alerts (e.g., Power BI dashboard for 7-day injury risk).
• **Recovery Optimization:** Sleep and nutrition recommendations based on WHOOP (score 0–100).
• **Practical Example:** A swimmer with low HRV (50 ms) incorporates active recovery (yoga, 30 min) and cryotherapy (−110 °C, 3 min).

2.4. Competition Strategy and Real-Time Decision-Making :

AI provides in-competition insights:
• **Tactical Suggestions:** Adjustments based on opponent performance (e.g., substitutions in football via Catapult).
• **Energy Management:** Recommendations for endurance athletes (e.g., pacing adjustment in cycling based on power and HRV).
• **Practical Example:** A basketball club uses Polar Team Pro to predict post-match recovery times.

3. Sports Planning Platforms and Software :

Digital platforms centralize data and integrate AI to optimize planning. Below is a comparison of major platforms:

Platform	**AI**	**Open API**	**Specificity**
TrainingPeaks	Yes (WKO5)	Yes	Cycling, power zones
WHOOP	Yes	No	24 h HRV
Kitman Labs	Yes (deep-learning)	Yes	Injury prevention
Smartabase	Yes (script)	Yes	Multi-sport
AthleteMonitoring	Yes	Yes	Team sports

Key Features:
• **Storage and Integration:** Centralization of data via wearables (GPS watches, Bluetooth LE sensors).
• **Predictive Analysis:** Anomaly detection (fatigue via HRV) and load impact simulation.
• **Custom Reports:** Dashboards for coaches (e.g., Power BI for a Ligue 1 football club).
• **Practical Example:** A rugby team uses Smartabase to integrate GPS data (10 km/match) and HRV, reducing volume by 20% if ACWR > 1.5.

4. Integration into Sports Planning :

AI and technologies integrate at all stages of sports planning:

4.1. Initial Assessment :

• **Tools:** VO_2max tests (Garmin), psychometric profiles (POMS, fatigue > 15), biomechanical analyses (Vicon).
• **Example:** A runner assesses lactate threshold (4 mmol·L^{-1}) to structure intensity zones.

4.2. Real-Time Monitoring :

• **Tools:** GPS sensors (Catapult) and heart rate monitors (Polar) to adjust loads.
• **Example:** A handball player receives an alert (HR > 90% HRmax) to reduce exercise intensity.

4.3. Post-Performance Analysis :

• **Tools:** Video analysis software (Hudl, Wyscout) and data platforms (Smartabase).
• **Example:** A basketball team analyzes missed 3-point shots (30%) to adjust tactical training.

5. Advantages and Challenges :

5.1. Advantages :

• **Precision:** Objective data (e.g., GPS measuring 100 m ± 1 m) reducing subjectivity.
• **Individualization:** Plans tailored to physiological and psychological profiles (e.g., personalized RPE).
• **Injury Prevention:** 30% reduction in muscle injuries via predictive models (Gabbett, 2016).
• **Immediate Feedback:** Real-time adjustments (e.g., HR alert via Polar Flow for HR > 85% HRmax).
• **Optimized Strategy:** Video analysis (Hudl) improving offensive efficiency by 15%.

5.2. Challenges :

• **Data Quality and Bias:** Incomplete or biased data (e.g., overrepresentation of male athletes) lead to erroneous predictions.
• **Privacy and Security:** Need for encryption (AES-256), informed consent (GDPR, Article 22), and pseudonymization to protect biometric data.
• **Cost:** Catapult sensors (>€10,000/team) or licenses (Kitman Labs) inaccessible to amateurs.
• **Complexity:** Training required to interpret data (e.g., Smartabase).
• **Information Overload:** Risk of decision paralysis with massive data volumes.
• **Reliability:** Sensor variability (e.g., GPS ± 5% indoors).
• **Technological Dependence:** Risk of neglecting coach intuition or athlete sensations.
• **Liability:** In case of error (e.g., injury due to AI overload), responsibility must be defined among coaches, developers, and institutions.

6. Case Study: Professional Football :

A Ligue 1 football team uses a technological ecosystem:
• **GPS (Catapult):** Measures 12 km covered, 30 accelerations/match, and PlayerLoad™ (400 a.u.).
• **WHOOP:** Tracks HRV (60 ms) and sleep (recovery score 40% post-match).
• **Hudl:** Video analysis of defensive patterns (20% reduction in goals conceded).
• **AI (Kitman Labs):** Injury risk prediction (25% reduction in muscle injuries).
• **Planning:** After an intense match (ACWR 1.6), the coach reduces volume (light session J+1) and includes cryotherapy (−110 °C, 3 min) based on WHOOP. Hudl analyses adjust tactics for the next match.

7. Future Perspectives :

The future of sports planning will integrate technological and ethical innovations:
• **Generative AI:** Fine-tuned models like GPT-4 generate training scenarios via voice prompts (e.g., HIIT sessions adapted to chronotype).
• **Advanced Sensors:** Battery-free epidermal patches (RFID, BioSticker) measure lactate in real time.
• **Federated AI:** Multi-club learning without sharing raw data, preserving privacy.
• **Genomics and Epigenetics:** Integration of biological profiles for ultimate personalization.
• **Virtual Reality (VR):** Immersive simulations for tactical training (e.g., VR for goalkeepers).
• **Accessibility:** Development of affordable wearables (<€100) for amateurs.
• **Psychological Integration:** Apps combining physiological and psychometric data (e.g., POMS via apps).
• **Coach Training:** Scientific skills to interpret AI recommendations.

Conclusion :

Artificial intelligence and modern technologies transform sports planning into a precise, individualized, and data-driven discipline. Wearable devices (Catapult, WHOOP), Big Data, and platforms like **Smartabase** or **TrainingPeaks** enable real-time monitoring, in-depth analysis, and effective injury prevention. AI applications—from biomechanical analysis to program personalization—optimize performance and tactical strategies. However, challenges such as data quality, privacy (GDPR), access equity, and technological dependence require a cautious approach. AI does not replace human expertise but complements it—the coach's role remains central in contextualizing data and maintaining the human relationship with the athlete. Future innovations, such as virtual reality and advanced sensors, promise even more integrated planning, making sport more effective, safe, and accessible.

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Conference No. 16 Integration of Psychological and Ethical Dimensions in Sports Planning

Introduction:

Elite sports performance relies on a synergy between physical, technical, tactical, psychological, and ethical capacities. Psychological dimensions, once relegated to the background, are now recognized as essential for optimizing performance while enhancing athlete well-being (Weinberg & Gould, 2019). Concurrently, sports planning operates within a fundamental ethical framework guided by values such as fair-play, integrity, and the protection of athletes' physical and mental health. However, performance, recognition, and financial stakes expose sport to ethical dilemmas and complex challenges, including doping, result manipulation, protection of vulnerable athletes (especially youth), load management to prevent overtraining, and balancing performance with well-being. A holistic approach integrating rigorous psychological interventions and a robust ethical framework is crucial for sustainable planning that promotes both sporting excellence and athlete fulfillment.

1. Theoretical Foundations of Sport Psychology :

1.1. Principles of Sport Psychology :

Sport psychology is based on principles linking mental states to physical performance. According to Bompa and Buzzichelli (2019), classical periodization (Matveiev) has evolved to include psychological dimensions, integrating:

• **Progressive Overload:** Mental adaptation to increasing loads, strengthening resilience.
• **Individualization:** Consideration of unique psychological profiles (motivation, stress).
• **Non-Linear Periodization:** Load modulation based on psychological states (Issurin, 2016).

1.2. Theoretical Models :

• **Cognitive-Affective Model (Smith & Smoll, 2017):** Perceptions and emotions influence training response.
• **Self-Determination Theory (Deci & Ryan, 2012):** Intrinsic motivation promotes sustained engagement.
• **Sport Confidence Model (Vealey, 2007):** Confidence fluctuates based on training and competition experiences.

These models provide a scientific framework for structuring psychological interventions within training cycles.

2. Key Psychological Factors :

2.1. Identification of Factors :

The main psychological factors influencing performance include (Reardon et al., 2019):

• **Motivation:** Driver of effort and perseverance, influenced by clear goals and a positive environment.

• **Self-Confidence:** Belief in one's abilities, enhancing risk-taking and resilience.
• **Stress Management:** Regulation of physiological and emotional responses to pressure.
• **Concentration:** Ability to focus attention on relevant stimuli, essential for decision-making.
• **Team Cohesion:** Crucial in team sports to align individual and collective goals.

2.2. Evaluation of Factors :

• **Psychometric Questionnaires:** POMS (mood), CSAI-2 (competitive anxiety), TOPS (performance strategies).
• **Semi-Structured Interviews:** Exploration of subjective experiences.
• **Behavioral Observation:** Analysis of behaviors during training/competition.
• **Psychophysiological Monitoring:** Measurement of HRV or skin conductance to assess stress.

3. Periodization of Psychological Skills :

Psychological skills must be developed progressively, aligned with physical periodization phases:
• **General Preparatory Phase:** Acquisition of basics (relaxation, basic visualization, SMART goals).
• **Specific Preparatory Phase:** Refinement in specific contexts (technical gesture visualization, simulated stress management).
• **Competitive Phase:** Application of pre-competitive routines and coping strategies.
• **Transitional Phase:** Mental recovery, goal reflection, and strategy adjustment (Moran, 2016).
• **Example:** An 800 m runner integrates visualization sessions (5 min/day) during the preparatory phase to reinforce running technique, followed by competitive stress simulations (training with an audience) in the specific phase.

4. Psychological Intervention Methodologies :

4.1. Traditional Techniques :

• **Goal Setting:** SMART goals (Specific, Measurable, Achievable, Realistic, Time-bound) structured by mesocycle.
• **Visualization:** Mental creation of performance scenarios, integrated post-technical sessions (10–15 min).
• **Self-Talk:** Reframing negative thoughts via positive affirmations (e.g., "I am ready" before competition).
• **Progressive Relaxation:** Muscle tension/release during recovery periods.
• **Mindfulness:** Focused meditation (5–10 min) during warm-ups or cool-downs (Williams & Krane, 2021).

4.2. Innovative Approaches :

• **EMDR:** Treatment of trauma from injuries or failures, requiring a specialized psychologist.
• **ACT (Acceptance and Commitment Therapy):** Acceptance of negative emotions to maintain engagement.
• **Biofeedback/Neurofeedback:** Conscious stress regulation via sensors (e.g., HRV).

4.3. Practical Integration :

These techniques are embedded in existing routines:
• Post-training visualization to reinforce motor patterns.
• Relaxation during active recovery (e.g., yoga after intense sessions).
• SMART goals set at the start of each mesocycle.

5. Practical Applications by Discipline :

5.1. Endurance Sports :

• **Focus:** Pain management and positive self-talk.
• **Example:** A marathoner practices dissociation (focus on environment) and visualization of a successful finish to sustain motivation over long distances.

5.2. Technical Sports :

• **Focus:** Visualization and concentration.
• **Example:** A gymnast integrates 10 min of daily visualization to memorize routines, combined with focus exercises before competitions.

5.3. Team Sports :

• **Focus:** Cohesion and communication.
• **Example:** A volleyball team schedules cohesion exercises (trust games) before tactical phases, strengthening interactions.

5.4. Combat Sports :

• **Focus:** Emotional regulation.
• **Example:** A judoka practices diaphragmatic breathing to manage aggression during sparring.

6. Case Study: Olympic Preparation :

A swimming team preparing for the Olympics over four years:
• **Year 1:** Evaluation via POMS and CSAI-2, development of relaxation and visualization.
• **Year 2:** Competitive stress simulations (training under pressure), confidence building via performance goals.
• **Year 3:** Integration of pre-competitive routines (visualization + self-talk before each race).
• **Year 4:** Refinement of strategies to manage Olympic pressure, with biofeedback to regulate anxiety.

• **Result:** 15% improvement in POMS scores (positive mood) and consistent performances under pressure.

7. Ethical Dimensions of Sports Planning :

7.1. Fair-Play and Integrity :

Fair-play forms the foundation of sports ethics, involving respect for rules, opponents, officials, and the spirit of the game. In planning, this translates into strategies that optimize performance without circumventing or exploiting regulations (e.g., avoiding unfair tactics like simulation). Sports integrity seeks to preserve competition credibility by combating result manipulation (e.g., match-fixing), corruption, and doping.

7.2. Athlete Health and Well-Being :

Ethical planning prioritizes athletes' physical and mental health, integrating practices that minimize risks and promote sustainable development:
• **Overtraining Prevention:** Rigorous load management (e.g., HRV monitoring with ln rMSSD >3.8 or RPE <7/10), active rest periods (<60% HRmax), adjustments based on well-being questionnaires.
• **Injury Prevention:** Muscle strengthening programs (plank 3x30 s), mobility (dynamic stretching), recovery (low-intensity sessions) to reduce injury risk (e.g., tendinitis in runners).
• **Mental Health:** Addressing performance pressure, stress, and career transitions via sports psychologist sessions or stress management techniques (relaxation, mindfulness).
• **Youth Athlete Protection:** Training plans avoiding excessive early specialization (limit intense training before age 14), promoting balanced physical, mental, and social development.

7.3. Anti-Doping Efforts :

Doping compromises athlete health and competition equity. Ethical planning integrates:
• **Education and Awareness:** Informing about doping dangers (health risks, sanctions) and anti-doping rules (WADA prohibited list).
• **Transparency:** Training programs based on legal methods, without prohibited substances or methods (e.g., avoiding uncertified supplements).
• **Collaboration with Anti-Doping Agencies:** Support for controls (unannounced tests) and prevention initiatives (AFLD, WADA).

8. Challenges in Sports Planning :

8.1. Performance Pressure :

Financial, media, and competitive stakes exert intense pressure, potentially leading to unethical practices (overload training, >80% HRmax without rest, competing injured athletes, doping). This can cause stress, anxiety, and burnout, affecting career longevity.

8.2. Doping and Cheating :

Doping (e.g., gene doping) and cheating (match-fixing, illegal betting) compromise sports integrity. These practices require increased surveillance and strict sanctions.

8.3. Protection of Vulnerable Athletes :

Young athletes and those with disabilities are exposed to physical, psychological, or sexual abuse and exploitation (performance pressure). Planning must include clear codes of conduct, ethics training, and secure reporting mechanisms (anonymous helplines).

8.4. Balancing Performance and Well-Being :

Planning overly focused on immediate results may neglect holistic development, leading to exhaustion, chronic injuries (stress fractures), or disengagement. A balanced approach integrates SMART goals, recovery periods, and psychological support.

8.5. Data Management and Privacy :

Use of technologies (GPS, apps like Strava) raises ethical questions about data collection, analysis, and use (heart rate, sleep). Planning must ensure transparency, informed consent, and data security (GDPR).

9. Solutions to Psychological and Ethical Challenges :

9.1. Solutions for Psychological Challenges :

• **Coach Training:** Awareness of psychological benefits via workshops.
• **Seamless Integration:** Incorporation of psychological techniques into existing routines (post-training visualization).
• **Technologies:** Mobile apps (e.g., Headspace) for autonomous exercises.
• **Simple Protocols:** Short questionnaires (TOPS) for regular monitoring.

9.2. Solutions for Ethical Challenges :

• **Continuous Education:** Training for coaches, athletes, and leaders on ethics and anti-doping.
• **Clear Policies:** Codes of conduct and reporting mechanisms to protect vulnerable athletes.
• **Increased Surveillance:** Support for anti-doping controls and anti-cheating measures.
• **Transparent Data Management:** Compliance with privacy regulations (GDPR).

10. Future Perspectives :

10.1. Psychological Perspectives :

• **Virtual Reality:** Simulation of competitive environments to train stress management.
• **Mobile Applications:** Daily tracking of psychological parameters (mood, stress).
• **Neuroscience:** Use of neurofeedback to optimize concentration.
• **Mindfulness:** Increasing integration across all disciplines to enhance resilience.

10.2. Ethical Perspectives :

• **Advanced Technologies:** Development of more effective doping detection systems.
• **Strengthened Education:** Ethics training programs for all sports stakeholders.
• **Enhanced Protection:** Global policies to protect young and vulnerable athletes.
• **Data Management:** Ethical frameworks for tracking technology use.

Conclusion:

Integrating psychological and ethical dimensions into sports planning is essential to maximize performance while preserving athlete well-being and integrity. Psychological periodization, aligned with physical cycles and using validated (visualization, relaxation, SMART goals) and innovative (EMDR, biofeedback) techniques, develops well-rounded athletes. Concurrently, a robust ethical framework focused on fair-play, health, anti-doping, and vulnerable athlete protection ensures fair and sustainable sports practice. Challenges such as performance pressure, cheating, performance-well-being balance, and data management can be overcome through interdisciplinary collaboration, continuous education, and modern technologies. In the future, advances in neuroscience, virtual reality, and ethical frameworks will strengthen this holistic approach, transforming sports planning into a science that combines excellence with core values.

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