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The Ten Performance Pillars: An evidence-informed expert statement for teams preparing for the FIFA Men's World Cups and elite international tournaments

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ABSTRACT

Expanded FIFA Men's World Cups place increasing demands on national football (soccer) teams, with additional teams, extended knockout stages, compressed schedules, extensive travel, and extreme environmental challenges. The question arises: can peak performance still be sustained under these tournament conditions? These increased demands intensify physiological strain, as well as cognitive and tactical complexity, putting even the most prepared and well-resourced teams under pressure. This expert-informed statement presents a multidimensional roadmap to help navigate these challenges. It integrates scientific research and practical insights from elite football practitioners. We introduce the Integrated World Cup Performance Model, a conceptual framework built around three critical domains: physiological, neurocognitive, and tactical-collective. Applied considerations include the management of sleep, nutrition, hydration, fatigue, travel, substitutions, decision-making, and team cohesion. By raising awareness of what should be monitored and managed, the statement aims to provide actionable guidance for proactive decision-making, risk mitigation, and sustaining player readiness and performance. Embedded within the model, the Ten Performance Pillars are intended to help translate complex scientific evidence into daily practice, enabling teams to anticipate challenges and support recovery processes. In the context of the FIFA Men's World Cup, performance is not determined by isolated physical, tactical, or psychological factors. Success depends on the ability of national teams to integrate load management, physical and neurocognitive readiness, and collective resilience into a coherent, adaptive performance system throughout the tournament. This evidence-informed statement moves beyond isolated best practices by proposing a unified, decision-oriented framework explicitly designed for congested international tournaments. While providing a comprehensive and practically oriented framework, this statement is based on a structured expert-informed synthesis process rather than a systematic review or meta-analysis. Its implementation depends on national-team context, including cultural variability and disparities in financial, logistical, and staffing resources.

1. Introduction

Contemporary elite football is evolving at an unprecedented pace, reflected not only in documented increases in match intensity and high-speed running demands [1,2], but also in the expanding role of technology, multidisciplinary support staff, media exposure, and scientific performance support. In parallel, fixture congestion, extensive travel demands, and increasingly complex tournament formats have intensified the contextual and logistical challenges facing elite teams [2–5]. The era of coaching based purely on intuition is no longer sufficient to meet the demands of play. Today's game operates in a multidimensional ecosystem where science, data, and practical experience must coexist and interact to optimize performance outcomes. Otherwise, teams risk reactive decision-making, workflow problems, and short-term performance gains that potentially mask fatigue- and health-related issues. Players are confronted with substantial physiological, cognitive and environmental demands, especially during international tournaments [6]. These tournament-specific stressors, including compressed inter-match recovery windows, intercontinental travel across time zones, loss of habitual training environments, and knockout-stage psychological pressure, are distinct from domestic competition and require dedicated preparation strategies. National team coaching and support staff must adopt evidence-based training approaches tailored to the specific competitive context of tournaments [7].

Despite growing scientific research in elite football performance, existing frameworks frequently address physiological, neurocognitive, and tactical-collective domains in isolation, leaving a critical gap in integrated, tournament-specific guidance for national teams [8]. This statement integrates applied sport science and coaching expertise in relation to the tournament-specific constraints faced by national teams. It presents the "Ten Performance Pillars": a framework of evidence-informed principles designed to guide national teams, coaching staff, sport scientists, and decision-makers. They are designed to support national teams in preparing squads for major international football tournaments, including the FIFA Men's World Cup, while accounting for expanded competition formats and increased tournament match demands [1]. These pillars are built on recent work showing how scientific guidance can support performance under pressure [8], enabling teams to optimize readiness, adapt to context, and enhance the chance of success in high-stakes tournaments. This framework's novelty lies not in new metrics, but in how existing data are systematically translated into prioritized, context-sensitive decisions during tournament play. The statement also provides practical operational tools and actionable recommendations that teams can apply immediately in preparation and competition.

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The rationale for this expert framework is also to reduce the risk of a growing gap between the complexity of elite international football tournaments and the fragmented application of scientific knowledge. The aim is to help teams translate scientific knowledge into applied strategies – not to replace intuition, but to help refine it. Data and technology serve as tools to implement scientific knowledge and must support decision-making. They enhance situational awareness, support resource management guided by evidence-informed principles, and facilitate more coherent decision-making at both squad and individual-player levels. Teams that successfully operate within these principles may be better positioned to enhance performance, reduce avoidable uncertainty, and optimize player readiness, health, and resilience under the immense demands of elite international football tournaments [9].

Our Ten Performance Pillars are structured within the ***Integrated World Cup Performance Model*** (Fig. 1), which operationalizes these principles across three interconnected domains: physiological (Pillars 1–4), neurocognitive (Pillars 5–7), and tactical-collective (Pillars 8–10). The Integrated World Cup Performance Model is proposed as a heuristic framework to structure multidisciplinary decision-making rather than as a definitive taxonomy of performance determinants. A distinguishing feature of the model is the explicit integration of logistical architecture (e.g., base camp organization, travel sequencing, information flow) as a performance-relevant variable. This original, evidence-informed model provides a unified, actionable framework for integrating insights across all performance domains. Framing performance within this unified model can help teams systematically address each domain while understanding their interdependencies. For example, the model considers how physical demands interact with mental fatigue and how tactical adjustments are mediated by neurocognitive readiness.

The first domain addresses the physiological foundations of performance and the environmental factors that influence them. Factors include load management, physiological fatigue resistance, injury prevention, recovery, nutrition, and training adaptations. The second domain explores neurocognitive dimensions, emphasizing focus, perceptual-cognitive efficiency, and the Psychomotor Fatigue Threshold (PFT), an emerging concept describing how cognitive and mental fatigue may affect motor performance [10,11]. These elements are considered important determinants of perception, decision selection, and action execution under match pressure. The third domain covers tactical and strategic aspects, highlighting data interpretation, tactical training, substitution management, and social components of team performance. The latter include collective mental resilience, leadership, and team cohesion, which define the team's capacity under match pressure. By framing the Ten Performance Pillars within this integrated model, our expert statement provides a roadmap for translating multidimensional evidence into practical interventions that support both individual and team performance during tournaments at the elite international level. The model also incorporates the Transition Principle – an overarching implementation layer connecting all Ten Performance Pillars and ensuring their coordinated application across club-to-national team transitions. This principle is presented as an addendum rather than an additional pillar, reflecting its integrative rather than domain-specific function. Our manuscript aims to provide a comprehensive and practice-oriented integration of current evidence and elite-level expertise within a unified tournament-performance framework. It represents a shift away from siloed approaches toward a holistic, synergistic strategy for tournament football (Fig. 1). It also provides a reference point for researchers and practitioners seeking to advance evidence-based strategies for preparing teams for FIFA Men's World Cups and other major international tournaments.

2. Methods

This expert statement was developed using a structured multi-round iterative expert consensus process involving 31 experts with extensive experience in elite international football. The expert panel comprised professionals from diverse functional backgrounds, including sport science, strength and conditioning, performance analysis, sport psychology, nutrition, medicine, elite coaching, and academy management. Experts were selected based on the following inclusion criteria: (a) a minimum of 8 years of professional experience in elite football environments; (b) active professional roles encompassing sport science, coaching, performance analysis, sport psychology, nutrition, or medical support at elite or international level; and (c) representation across five continental football confederations (UEFA, CONMEBOL, CAF, AFC, CONCACAF). Experts were excluded if they lacked documented

Fig. 1. Integrated World Cup Performance Model: Three domains guiding peak performance via Ten Performance Pillars.

experience in elite football contexts or presented unmanageable conflicts of interest. The consensus process comprised five iterative rounds of structured review and refinement. Each expert participated in a minimum of three rounds. Feedback was collected through written submissions and open-ended commentary addressing the scientific rationale, practical applicability, and operational feasibility of each pillar. Agreement was operationally defined as a minimum of 80% endorsement of each retained recommendation among participating experts [12]. Items that did not reach this threshold were subject to moderated discussion, with final decisions made by the coordinating author following iterative deliberation. This process does not constitute a formal Delphi procedure. Rather, it represents a structured expert-informed consensus refinement designed to translate multidisciplinary expertise into practical guidance for elite tournament environments [12].

The consensus process was complemented by a narrative synthesis of peer-reviewed literature relevant to elite football performance, recovery, and tournament preparation. Electronic databases including PubMed, SPORTDiscus, Web of Science, and Scopus were searched using terms related to elite football performance, tournament preparation, load management, recovery, neurocognitive performance, tactical analysis, and team cohesion. Inclusion criteria comprised peer-reviewed studies involving elite or professional players, studies published within the last 20 years, and seminal reference works of established scientific importance regardless of publication date. Study relevance was judged primarily according to study design, population specificity, ecological validity, and applicability to elite tournament preparation. Studies were excluded if they were not peer-reviewed, involved exclusively recreational or youth populations without relevance to elite contexts, or lacked direct applicability to tournament preparation. Where direct evidence from elite men's football was limited, findings were carefully extrapolated from related populations or adjacent sports, with such distinctions explicitly acknowledged throughout the manuscript [13]. The narrative synthesis prioritized studies commonly cited in the applied sport science literature and those considered most relevant to elite international tournament environments [13].

2.1. Implementation and operational guidance

Building on the priority levels and defined roles, the tables are designed to support staff in planning, monitoring, and adjusting interventions before and during tournaments. Each row provides actionable items (Intervention/Action), a brief rationale (Description), and measurable indicators (Key Parameters/Monitoring Criteria). Guidance on implementation timing (Frequency/Timing) allows staff to translate evidence-informed recommendations into practical routines under real-world constraints. Certain columns are standardized for clarity, while others are intentionally flexible to guide adaptation under dynamic tournament conditions. Staff should first identify High Priority actions, check feasibility, then adapt interventions according to individual player responses, recording adjustments in the Adaptive Recommendations column.

2.2. Priority levels and evidence certainty

Practical recommendations are organized by Priority Level to support effective implementation and clear accountability. We recognize that tournament schedules, limited training time, and competing demands mean not all actions can be addressed at once. Prioritizing interventions allows staff to focus on what is most essential for maintaining performance, recovery, and team cohesion. These classifications align with contemporary performance and recovery monitoring frameworks [14,15], and evidence supports prioritizing interventions that directly affect physiological and cognitive readiness. Focus first on High Priority actions. While these interventions are often supported by stronger evidence, priority classification reflects overall strategic importance within the tournament context, which may also account for operational impact, risk mitigation, and feasibility considerations, and not solely evidence strength. To mitigate the risk of overestimating interventions with limited empirical support, readers are encouraged to interpret Priority Level and Evidence Certainty in combination. A High Priority intervention supported by Expert-Informed evidence reflects operational necessity under tournament constraints rather than strong empirical validation and should be implemented with appropriate contextual judgment. The Evidence Certainty column in each table serves as the primary indicator of empirical support, while Priority Level reflects strategic and operational importance within tournament settings. Medium Priority and Supporting actions can be subsequently implemented as time and resources allow:

- High Priority: Actions that are critical for maintaining players' physical and mental readiness, managing injury risk, and supporting optimal performance levels during congested tournament schedules.
- Medium Priority: Supportive actions that enhance efficiency, stability, and overall team performance. While their implementation is beneficial and recommended, omission does not constitute a critical failure.
- Supporting Actions: Additional actions that enhance team coordination, education, and preemptive strategies. These interventions aim to complement high and medium priority actions, strengthening cohesion, consistency, and long-term team effectiveness.

For transparency and practical guidance, each operational strategy in the tables is assigned an Evidence Certainty level (High, Moderate, Expert-Informed) based on the current scientific literature and structured expert consensus, indicating the relative strength of supporting evidence. This hierarchy clarifies confidence in each recommendation, indicating where research evidence is strong and where expert-informed guidance supplements the literature. Evidence certainty ratings were assigned through structured author consensus informed by established evidence quality appraisal principles [16], evaluating: (a) consistency of findings across studies; (b) study design quality, prioritizing controlled and longitudinal designs; (c) sample characteristics, with preference for elite football populations; and (d) ecological validity with respect to elite international tournament contexts. Where multiple high-quality studies showed consistent findings in elite football populations, recommendations were classified as High certainty. Moderate certainty was assigned where evidence existed but was limited by small samples, indirect populations, or inconsistent findings. Expert-Informed classifications were applied where empirical evidence was scarce or absent, reflecting structured practitioner consensus rather than empirical research. This structure allows staff to implement interventions efficiently, focusing on actions that are both highly critical and well-supported by evidence first. Evidence Certainty serves as a guide for prioritization and does not replace expert judgment or contextual decision-making by coaching and support staff. The conceptual foundation aligns with evidence-based practice integrating research evidence, practitioner expertise, and contextual decision-making [17,18].

- High: Supported by multiple peer-reviewed studies, preferably including controlled or longitudinal designs in elite football or analogous high-performance sports, with generally consistent findings.
- Moderate: Evidence exists but may be limited to small cohorts, single-case studies, and/or indirect evidence; findings are context-dependent.
- Expert-Informed: Based on structured consensus among experienced practitioners when direct empirical evidence is scarce or absent; these recommendations supplement, but do not replace, empirical research.

2.3. Roles and responsibilities

Clear definition of functional responsibilities within the performance team is essential for coordinated decision-making and effective implementation of evidence-informed strategies [19]. The responsibilities listed below represent typical assignments observed in elite international football; titles and structures may vary across federations and performance departments, and certain functions may be combined depending on available resources. Variability in staff titles, responsibilities, and reporting lines across elite sport organizations can create ambiguity, overlaps, and gaps in accountability, potentially undermining intervention effectiveness [20]. By explicitly defining each task or function, teams ensure coordinated practice and a unified multidisciplinary approach, enabling interventions across physiological, neurocognitive, and tactical-collective domains [21]. These functions guide accountability, facilitate translation of scientific insights into practice, and support prioritization of actions according to player readiness and team objectives. Assign clear tasks for each action to ensure accountability and coordinated implementation. They are adaptable: not all must exist as separate positions, and they can be combined depending on resources and federation structure. To support implementation across federations with varying resource availability, staffing structures may be stratified into three operational models: a minimal model (head coach, fitness coach, medical staff), a standard model (adding a performance analyst, sport scientist, sport psychologist, and dietitian/nutritionist), and an advanced model (full multidisciplinary team including a data scientist and sleep specialist). Higher-resourced federations are encouraged to implement the full complement of roles, while resource-limited environments should prioritize high-priority interventions with available personnel. Key roles and functions include:

- Head Coach: Key stakeholder for integrating monitoring feedback into tactical and match-preparation decisions.
- Assistant Coach/Technical Coach: Supports the Head Coach by providing detailed technical and tactical input and translating monitoring feedback into practical adjustments.
- Fitness Coach: Primary implementer of strength and conditioning training and recovery strategies; adjusts load based on internal and external load monitoring.
- Performance Analyst: Supports acquisition, processing, and visualization of performance data (internal and external load), as well as technical, tactical, and video data for the team.
- Sport Scientist: Responsible for collecting, analyzing, and interpreting performance and recovery data; provides actionable insights to coaches and medical staff.
- Data Scientist: Develops and maintains predictive models and data pipelines; translates complex datasets into actionable insights to support coaches, sport scientists, and performance staff.
- Medical Staff/Physiotherapist: Manages injury screening, prevention, rehabilitation, and medical clearance for training and competition; collaborates with fitness coaches and sport scientists on load adjustments; oversees injury surveillance and implements evidence-based prevention protocols.
- Sport Psychologist/Mental Performance Coach: Supports mental resilience, focus, stress management, leadership, and team cohesion; provides guidance on psychological preparation and recovery strategies.
- Dietitian/Nutritionist: Designs and monitors individualized and collective nutrition and hydration strategies across the tournament cycle, including pre-match fueling, intra-match supplementation, post-match recovery nutrition, and adaptation to travel and environmental conditions.
- Sleep Specialist: Advises on individualized sleep and circadian adaptation strategies; monitors sleep quality, duration, and recovery status during travel and tournament phases.

2.4. Logistical complexity and feasibility

When planning interventions, staff must consider the logistical requirements of each action. These comprise time available, resources, and equipment, as well as the number of players involved. Feasibility assessments help determine whether proposed strategies can be realistically implemented within the constraints of tournament schedules and training sessions, reducing the risk of overambitious plans that cannot be executed consistently. Verify resources, time, and player availability before scheduling each intervention. For medium-complexity actions, ensure that at least one dedicated staff member coordinates data collection or intervention delivery, and prioritize key or high-risk players when resources are limited. Regarding high-complexity actions, assign a designated staff member to coordinate across multiple roles, check specialized equipment availability, and consider splitting the intervention into smaller, feasible components. Always document adjustments and communicate clearly with all staff involved. If resources or personnel are insufficient, downgrade the intervention or implement an alternative, simpler action to maintain monitoring quality and safety.

2.5. Adaptive recommendations

Each table includes a column for adaptive strategies, guiding staff on how to adjust interventions in response to changing circumstances, such as limited training time, congested match schedules, individual player responses, or unforeseen disruptions. By following these adaptive strategies, teams can maintain training effectiveness, mitigate injury risk, and optimize recovery and performance even under the dynamic conditions of major tournaments [22]. The adaptive recommendations embedded within each pillar operationalize structured flexibility, allowing teams to respond to tournament volatility without compromising decision coherence. While indicative thresholds are provided to support operational decision-making, all monitoring criteria should be individualized and interpreted relative to each player's historical variability and the contextual demands of the tournament phase. Where possible, thresholds should be interpreted relative to measurement error (e.g., coefficient of variation) and the smallest worthwhile change to ensure that observed fluctuations reflect meaningful performance changes rather than normal variability [23]. Importantly, thresholds serve as guidelines for monitoring and observation rather than automatically triggering interventions and should be interpreted in the context of individual trends, player history, and tournament phase [24]. Thresholds are indicative (~) reference points rather than strict cut-offs; they should be interpreted relative to individual baseline, historical variability, trend patterns, and contextual demands of the tournament phase. While presented thresholds are broadly informed by literature, each player's specific values/data should be calibrated based on historical response, motor profile, and positional demands. Decisions should consider trends and combinations of indicators rather than single threshold breaches.

Additional interventions should be adjusted according to individual responses, and any changes should be recorded in the Adaptive Recommendations column. All thresholds should be treated as reference points rather than universal values, and individualization is critical: consider the motor profile type (speed, endurance, or mixed), positional demands, training level, microcycle context, and tournament phase. In routine daily monitoring, focus on Countermovement Jump (CMJ), Session-RPE (sRPE), body mass, hydration indices, and wellness indices; escalate to HRV, GPS-derived metrics, and blood biomarkers only when thresholds are exceeded or in high-stakes phases. Apply monitoring hierarchically: start with simple field measures and escalate to advanced tests (e.g., blood biomarkers, biochemical analyses) when indicated, always accounting for individual baseline and historical variability.

3. Legend/Tooltip for key parameters (indicative thresholds, individualized)

The following thresholds represent illustrative reference values informed by available literature. Evidence strength and measurement reliability vary across indicators, from well-validated field measures (e.g., CMJ, Session-RPE) to context-dependent or emerging metrics (e.g., HRV, salivary biomarkers). All values must be calibrated to individual baselines before operational use and should be interpreted alongside measurement error and biological variability. In practice, staff should treat isolated threshold deviations as signals for observation, not automatic intervention. Repeated deviations or converging changes across two or more indicators should prompt multidisciplinary review and may justify adjustments to training load, recovery strategy, or player availability planning.

3.1. Neuromuscular/Perceptual load

• CMJ (Countermovement Jump) – well-validated in elite football with good reliability (CV typically 1–3%) [25,26]. A $\geq$ 5% decrease in an individually selected neuromuscular KPI (e.g., RSImod, concentric impulse, peak/mean propulsive velocity, or jump height when individually sensitive) relative to the recent 3-day rolling average may indicate meaningful fatigue. KPI selection should reflect individual sensitivity and historical response patterns.

• Session-RPE (sRPE) – an RPE-based metric extensively validated across elite team sports with high practical feasibility and sensitivity to training load [27,28]. Values > 8/10 indicate high subjective session intensity; consistent administration timing/protocol and player familiarity are required to maximize reliability and minimize response bias.

• HRV (Heart Rate Variability) – moderate-to-good reliability with standardized morning resting protocols [29,30]. HRV shows higher biological variability than CMJ; $\geq$ 10% drop vs 7-day rolling average is a commonly used but population-specific threshold. Interpretation should prioritize multi-day trends over single-point readings, accounting for the player's dominant motor profile (speed, endurance, or mixed) and training level.

• Bar Velocity – good reliability with standardized protocols; sensitive to post-match neuromuscular fatigue and increasingly used in elite soccer monitoring [31]. A velocity loss of $\geq$ 10% relative to individual session baseline in a standardized exercise warrants load reduction consideration, particularly during congested match schedules. Interpretation should always reference pre-season individual baseline profiles.

3.2. External load/performance metrics

• Distance-/Speed-Based External Load Variables – good validity for quantifying locomotor demands but limited capacity to fully capture neuromechanical load [32,33]. Total distance, high-speed running, sprint distance, peak speed, and speed-zone exposure provide contextual information on running volume and intensity; upward trends or acute spikes may signal increased overload risk. Interpretation should integrate both absolute and individualized thresholds, using normalization-based approaches cautiously and in relation to positional demands, individual speed profile, match demands, and microcycle phase [34,35].

• Acceleration-/Deceleration-Based External Load Variables – moderate-to-good reliability depending on device, sampling rate, and metric definition [36,37]. Sustained increases or spikes in acceleration/deceleration counts, distance covered while accelerating/decelerating, and change-of-direction demands indicate high neuromechanical load and may warrant subsequent load reduction and/or targeted recovery. Interpretation should integrate both arbitrary absolute thresholds and individualized normalization approaches [38].

3.3. Wellness/recovery/psychological state

• Wellness/Sleep/Mood Index – brief validated questionnaires show acceptable reliability and high practical feasibility in elite football settings [39,40]. A decline of $\geq$ 1.5 standard deviations from individual baseline or $\geq$ 20% reduction in composite score across consecutive days may be used as a pragmatic flag for individualized review or intervention. Interpret relative to individual baseline and recent load history rather than normative group values.

3.4. Physiological/cardiovascular load

• HR (Heart Rate) – high reliability with standardized protocols; useful for contextualizing cardiovascular load and internal physiological responses [41,42]. Elevated relative values may reflect increased physiological strain, but interpretation should account for environmental, contextual, and individual factors, including motor profile, training status, hydration, illness, psychological stress, and heat exposure.

• Morning Resting HR/HR Recovery – reliable indicator of autonomic recovery status when measured under standardized conditions (upon awakening, lying down, before breakfast) [29,43]. A sustained elevation of $\geq$ 5–10 bpm above individual baseline across two or more consecutive mornings may indicate insufficient recovery, excessive cumulative load, illness, dehydration, travel-related stress, or changes in training status. Single-day elevations should be interpreted cautiously alongside HRV and wellness trends.

3.5. Hydration/Basic Physiological Status

• Daily Body Mass – highly reliable, low-cost field measure validated in football contexts [44,45]. A 1–2% drop from baseline reliably indicates a meaningful fluid deficit; repeat measurement under standardized conditions (same time of day, after voiding, similar clothing) is essential for valid interpretation.

• Urine Specific Gravity/Color – well-established dehydration markers in athletes with moderate ecological validity in tournament settings [46,47]. USG $\geq$ 1.020 or dark urine indicates dehydration; morning sample preferred for standardization and consistency across measurement occasions.

• Perceived Thirst/Urgency – moderate reliability as a standalone indicator; high practical feasibility [48,49]. High thirst provides a useful subjective signal of fluid deficit and should be interpreted alongside objective hydration measures rather than as a primary indicator.

3.6. Optional Advanced/Laboratory Metrics

• Blood Biomarkers (Blood Lactate, Creatine Kinase, Plasma Osmolality, Hematocrit, Serum Sodium, Salivary Immunoglobulin A) – variable reliability and ecological validity across markers. Blood lactate and creatine kinase primarily reflect acute metabolic load and muscle damage during congested competition; where available, point-of-care technologies may enable rapid field-based assessment during tournaments. Plasma osmolality and serum sodium more directly reflect hydration and fluid-electrolyte balance, with plasma osmolality considered a reference laboratory marker. Hematocrit interpretation requires caution due to exercise-induced variability [46,47,50]. Salivary immunoglobulin A is an emerging immune marker with moderate reliability and limited elite football-specific validation; use as a supplementary indicator pending further validation in elite football settings.

Interpret all markers in combination and in relation to the microcycle and tournament phase for optimal decision-making. Priority should be given to indicators with established reliability and football-specific validation, particularly CMJ, Session-RPE, body mass, hydration indices, and wellness indices, while emerging biomarkers should be interpreted as supplementary signals. Operational decisions should never rely on a single threshold breach but on converging evidence across multiple indicators. Recommendations and thresholds should always be interpreted relative to each team's context, competitive objectives, available resources, and dynamically adjusted based on match outcomes, tournament progress, and evolving player responses. With this integrative perspective in mind, we now turn to the first pillar, which lays the foundation for systematic monitoring and evidence-informed preparation across all dimensions of performance.

4. The physiological domain

4.1. Pillar I. Load management: Tailor training to physiological requirements, context and situational demands

Individualize training load and recovery based on tournament-specific demands to optimize performance, guided by monitored physiological and perceptual data.

4.1.1. Core idea

Effective training planning and management of load and recovery form the foundation of preparations for elite tournaments. Training plans need to account for match schedules, tournament situations, and the individual characteristics of the players. The key is to achieve a continuous balance between training stress and adaptation through consideration of the physiological, psychological, and cognitive loads. Ongoing monitoring of football-specific physical fitness, fatigue, readiness to train/perform, and recovery markers (including, among others, external load) is essential for elite tournament preparation [22]. This daily monitoring presents a constant challenge for coaches, who must interpret dynamic player data. They must balance training loads with individual readiness whilst accounting for both tournament constraints and each player's exposure to match-play. Notably, players' club-based fitness may not fully translate to the structure, density, and cadence of national team camps. When integrated within a broader approach of player availability, monitoring takes into account each player's readiness to train or play. It allows coaches to adjust training loads dynamically, supporting performance while contributing to injury-risk management [51].

4.1.2. Scientific rationale

The period between the end of the domestic season and the start of a tournament, often referred to as the "pre-tournament readiness phase", is critical for maintaining players' physical and cognitive preparedness [52]. During this time, the focus should be on recovery and cautious load management, rather than substantially rebuilding football-specific fitness. A short taper may be considered, while carefully managing injury risk [53–56]. During this pre-tournament readiness phase, Speed Endurance Training (SET) represents a well-researched strategy to maintain and optimize high-intensity running capacity while managing cumulative fatigue, particularly for players with high match exposure during the club season [57]. In the context of the FIFA Men's World Cup, this pre-tournament readiness phase requires individualized management across distinct player profiles [58]. Players with high match exposure should prioritize recovery and load reduction. Those returning from injury require carefully progressed reintegration protocols. Substitutes with low recent load may need targeted top-up conditioning or game-specific exposure to maintain match readiness. Players arriving from leagues with different seasonal calendars present varying levels of accumulated fatigue and fitness, necessitating rapid individual assessment upon camp arrival. Consequently, the primary challenge for performance staff is to mitigate accumulated seasonal fatigue, protect physical and cognitive readiness, and minimize injury risk rather than induce additional training adaptations. These adjustments aim to balance training demands, reducing the risk of undertraining and overload in order to enhance readiness for tournament demands.

Tournament settings add complexity: differences in available recovery equipment, staff support, and nutritional resources across team bases require adaptive strategies. Recovery interventions and monitoring approaches must be tailored to the resources accessible at each location [59]. Short recovery periods between matches may limit the time available for restoring central nervous system (CNS) function, repairing muscle microdamage, and replenishing glycogen [6,60]. These limitations can compromise neuromuscular function, impair sprint mechanics, reduce high-intensity running capacity, and slow recovery of force production. Given these logistical and recovery constraints, players' ability to tolerate short recovery windows is strongly influenced by their underlying aerobic base, developed during the club season [61]. This aerobic base supports faster phosphocreatine resynthesis, more efficient glycogen restoration, and more stable autonomic regulation, thereby reducing the relative physiological strain of repeated high-intensity actions [62]. Studies indicate that congested tournament schedules can impair sprint and high-intensity running performance, with some studies quantifying reductions in match running distance or sprint metrics [63,64], while others highlight similar trends without specifying exact magnitudes [65,66]. However, most studies report data at the team level rather than repeated measures in the same players across multiple matches, which may dilute the detection of true individual performance drops. Evidence from elite team sport cohorts suggests that individualized adjustments to training load and recovery based on monitored fatigue and readiness may be associated with reductions in injury incidence, though findings are based primarily on observational designs and populations outside football, and causal inference remains limited [67]. Current football-specific evidence regarding load monitoring and injury prediction remains inconsistent and should be interpreted with appropriate caution [68,69]. These impairments may be further amplified during 120-min matches, particularly when knockout-stage games progress to extra time [70,71]. According to FIFA's analysis of player movement and physical performance [72], the Technical Reports from the 2022 World Cup illustrate these challenges: teams had to dynamically adjust player workloads, primarily based on match playing time and in-game physical demands.

The contemporary approach to individualized load and training management integrates monitoring of both external and internal load through internal-external integration to guide individualized decisions [22,73,74]. External load refers to the work performed by the athlete and is typically quantified using Electronic Performance and Tracking Systems (EPTS). These include local positioning systems (LPS), optical tracking systems, global navigation satellite systems (GNSS), and inertial sensor-derived mechanical load metrics. These measurements capture locomotor, mechanical, and kinematic demands generated during football-specific activities, such as small-sided games (SSGs) and submaximal running protocols, which serve here as examples of monitoring contexts rather than training content recommendations per se [75,76]. Internal load reflects the individual physiological and perceptual responses to the imposed work. It is typically assessed using indicators such as heart rate, heart rate variability (HRV), perceptual ratings (e.g., rating of perceived exertion – RPE), wellness and mood state questionnaires, and neuromuscular performance tests (e.g., countermovement jump [CMJ]) [24,77–80]. Objective measurements provide valid and reliable metrics when appropriately standardized. Subjective measures capture player-reported responses and complement physiological data. Based on these measurements, adjustments in training volume, intensity, and recovery should be carefully tailored by strength and conditioning practitioners to each player's profile and the competitive context [81–84]. Together, these data guide individualized load management decisions. Metrics from both external and internal load monitoring (e.g., locomotor demands, heart rate) may provide contextual information on load variation and potential alterations in load-related injury risk, although the strength and consistency of these associations remain debated [22,85,86]. Not all variables are equally informative or valid indicators. Performance staff should prioritize a focused set of metrics that reflect football's specific demands and support actionable load-management decisions. GPS-derived data also have limitations; for

Table 1

Summary of operational strategies for load management (Physiological Domain, Recommendation I).

Priority	Evidence Certainty	Intervention / Action	Description	Key Parameters / Monitoring Criteria	Frequency / Timing	Responsible	Logistical Complexity / Feasibility	Adaptive Recommendations
High	High evidence [52,55,56]	Post-season / Pre-tournament Load	Gradually restore fitness and neuromuscular capacity to exploit adaptive plasticity while minimizing load spikes and injury risk	Primary: CMJ, RPE, HRV; Secondary: wellness index, sleep, mood	Daily, Morning + Post-training; adjust by MD−3 → MD + 1	Primary: Fitness Coach; Supporting: Head Coach	Moderate – requires monitoring tools and access to training space; feasible at team base	If selected CMJ-derived KPI drops ~5% vs baseline → consider reducing session intensity; if RPE > 8 → consider adding recovery support; record adjustments with reference to historical response patterns and player context
High	High evidence [77,78,90]	Continuous Load Monitoring	Track individual load combining GPS-derived metrics, accelerometry, HRV, CMJ, and subjective wellness to detect fatigue and inform training	Primary: external load, CMJ, RPE; Secondary: HRV, wellness index, sleep quality	Daily, Post-session; review trends over microcycle	Primary: Sport Scientist, Fitness Coach; Supporting: Physiologist, Performance Analyst	Moderate – requires devices and data interpretation; feasible if protocol pre-established	If high load trend persists > 2 days → consider modifying next session; prioritize recovery for high-risk players; log adjustments per player, taking into account individual response patterns and tournament context
Medium	High evidence [74,75,93]	Microcycle Variation / Pre-Match Activation	Implement short, varied sessions within the microcycle to maintain neuromuscular readiness and prepare players for specific match demands; vary intensity, movement patterns, and stimulus type	Primary: CMJ, RPE; Secondary: HRV, wellness index, perceived readiness	Daily or pre-match, adjusted per match schedule	Primary: Fitness Coach; Supporting: Sport Scientist, Head Coach	Moderate – requires coordination and space for multiple session types; feasible at team base with standard equipment	If a player responds poorly to a session → modify stimulus type or intensity; monitor CMJ/RPE and adjust microcycle load to individual readiness and tournament context
Medium	High evidence [6,51,91]	Dynamic Recovery Response	Adjust training and recovery dynamically using short-term physiological and neuromuscular data; “Top-Up” sessions for substitutes	Primary: HR, HRV, CMJ, RPE; Secondary: wellness, subjective fatigue	Daily, throughout microcycle; pre/post session checks	Primary: Fitness Coach, Head Coach; Supporting: Medical Staff	Moderate – requires real-time monitoring; feasible with coordinated staff	If HRV decreases > 10% or selected CMJ-derived KPI drops > 5% → consider reducing load or applying additional recovery; top-up sessions for bench players as appropriate, taking into account individual baseline, historical response, and tournament context
Medium	Expert-informed [19–21,94]	Staff Coordination	Coordinate daily staff communication on load, recovery, and injury risk; align interventions with player characteristics	Daily staff meeting completion; load report dissemination; flagged player issues resolved within 24 h	Ongoing; brief daily meeting or digital report	Primary: All team members	Low – relies on scheduled communication; feasible	If urgent issues arise → use standardized communication template and flag for immediate action; consider player status, context, and operational feasibility

Note: Epistemic classification of operational recommendations: High = empirical sport science evidence; Moderate = applied/consensus-based evidence; Expert-informed = practitioner-derived operational heuristics.

example, they may not fully capture true neuromechanical demands, which currently cannot be assessed more accurately with available technology [68,87,88]. Alternative approaches for managing training load and injuries in football also exist, including advanced statistical modelling of acute and chronic training load interactions, but these approaches may be limited by data quality, model assumptions, and context-specific generalizability [89]. Nevertheless, the use of internal and external load parameters is intended to support the balance between stress and adaptation while preserving both physiological and cognitive readiness, though the direct relationship between load monitoring and injury prevention remains debated in the literature [90,91]. Effective load management is continuous and context-dependent, requiring that data be interpreted collectively by the performance staff and adjusted based on individual physical and physiological responses. Players may exhibit different internal physiological responses to the same external load, including differences in lactate levels and heart rate [92]. This principle, optimizing training and recovery through individualized load management, underpins all other recommendations for player preparation and performance.

4.2. Pillar II. Recovery for performance: Structure regeneration and sleep optimization

Optimize recovery, regeneration, and sleep through individualized protocols to sustain performance.

4.2.1. Core idea

Effective recovery is the foundation for sustaining performance during high-intensity tournaments. It can help preserve physical capacity, cognitive readiness, and decision-making during congested schedules. The design of training microcycles should account for players' individual needs, including sleep routines, nutritional support, and recovery strategies. Particular attention should be given to habits developed at the club level, as these influence readiness at the national team camp. Ideally, intervention modalities must be tailored to the player's current physiological, psychological, and cognitive status. However, individual variability in responses presents an ongoing demand for coaches, who must continuously adapt recovery strategies to each player under tournament constraints [118]. In tournament settings, the scheduling of naps and recovery sessions is often constrained by logistical factors such as recovery-facility availability, mealtimes at the team base camp, travel, and stadium training schedules [95].

4.2.2. Scientific rationale

Match-play leads to muscle glycogen depletion, muscle microdamage, inflammation, oxidative stress and central nervous system fatigue [53,119–122]. A central component of post-match recovery is the restoration of muscle glycogen (also influenced by nutrition and sleep). This process is critical for repeated high-intensity efforts and neuromuscular function during congested match schedules [60,71,123,124]. Recovery habits developed at the club level play a critical role in shaping players' physiological, cognitive, and psychological readiness upon arrival at the national team camp. In this context, the cumulative effects of match-induced metabolic, muscular, inflammatory, and central fatigue can reduce players' ensuing capacity to perform subsequent efforts or make accurate decisions, with their magnitude depending on the specific demands of each game [6,60,70,125]. Systematic reviews confirm that insufficient post-match recovery delays restoration of key performance markers, highlighting the need for targeted recovery interventions [118]. Recent systematic evidence published by Vatne and colleagues [100] provides support for the use of specific post-exercise recovery strategies to enhance both physical and perceptual restoration.

Building on these physiological mechanisms, practical interventions have been tested to accelerate recovery and restore performance. Practical recovery interventions differ in their primary targets and mechanisms. Glycogen restoration is primarily supported through targeted nutritional strategies; sleep and circadian recovery through sleep extension and napping protocols; soreness and inflammation through selected nutritional strategies such as curcumin, omega−3, and tart cherry supplementation; neuromuscular recovery may be supported by modalities such as cold-water immersion and contrast therapy when appropriate; and cognitive recovery through sleep quality optimization and mental reset strategies [121,126]. Specifically, cold-water immersion (CWI) after simulated football match play reduces central and peripheral neuromuscular fatigue compared with thermoneutral immersion. Fatigue parameters returned to baseline within ~24 h post CWI, whereas in controls they remained impaired 48–72 h, and 20-m sprint performance was better preserved [102]. Contrast water therapy (alternating warm and cold immersion) has been shown in systematic reviews and meta-analyses to accelerate recovery, reduce muscle soreness, and improve perceptual readiness compared with passive rest, supporting its value as a thermal contrast recovery strategy in team sport contexts [103]. However, not all interventions (e.g., pneumatic compression, massage) demonstrate consistent evidence [100]. This highlights the need to tailor multifactorial recovery plans to individual athletes' needs, preferences, and competition demands. Furthermore, brief, individualized active recovery sessions of 10–15 min after match-play or intense training, including light running, mobility drills, hydrotherapy, or stretching, may support metabolic clearance and promote faster autonomic and neuromuscular restoration [98]. It should be noted that blood lactate represents a measurable metabolic marker rather than a direct proxy of overall fatigue or readiness to perform – lactate clearance does not necessarily reflect restoration of neuromuscular function, glycogen stores, muscle damage, or inflammation [81,99]. Short "reset" interventions such as controlled cryotherapy sessions, lymphatic drainage, neuromuscular recovery modalities, as well as breathing and relaxation techniques, further support the regeneration process [101]. A holistic and individualized approach is essential, as recovery is a multifactorial bio-psychophysiological process, an aspect strongly emphasized in the international consensus statement on recovery and performance in sport [56,127]. The intensity, duration, and type of each recovery intervention should be individualized according to the player's specific needs, style of play, load performed, and current fatigue level, ensuring optimal regeneration without compromising subsequent performance. Evidence from athlete populations, primarily basketball players and non-football athletes, suggests that extending sleep by ~60–90 min and incorporating a 20–30-minute nap may improve next-day sprint performance and reduce subjective fatigue [95-97,128,129]. Direct evidence from elite footballers remains limited, and tournament-specific validation is currently absent. Findings should therefore be interpreted cautiously and applied with appropriate contextual judgment. Beyond physical restoration, sleep duration and quality also critically influence cognitive functions essential for elite football performance, including reaction time, decision-making accuracy, and perceptual–cognitive processing under fatigue [130,131].

During international tournaments, teams often need to adapt recovery protocols to logistical constraints. This may include adjusting nap times, modifying cryotherapy access, or reorganizing mobility sessions at the team base. Such adaptations help maintain recovery quality and performance readiness, supporting physiological and neuromuscular restoration. Importantly, recovery-related challenges may already emerge in the pre-competition phase, particularly during rapid east–west travel from club environments to national team camps, where sleep disruption and circadian misalignment can substantially increase fatigue accumulation and injury risk before the first match is played [132]. Tournament preparation requires monitoring players' accumulated load over 2–3 months, using club-provided data, and discussing perceived fatigue and readiness with the player and relevant performance staff. Indeed, high accumulated match and training exposure is linked to performance decrements and injury risk [69,104,133]. This approach allows for more precise adjustments of training microcycles

Table 2
Summary of operational strategies for recovery and sleep optimization (Physiological Domain, Recommendation II).

Priority	Evidence Certainty	Intervention / Action	Description	Key Parameters / Monitoring Criteria	Frequency / Timing	Responsible	Logistical Complexity / Feasibility	Adaptive Recommendations
High	High evidence [95-97]	Sleep Optimization	Extend nightly sleep by ~60–90 min, schedule short naps, and control sleep environment to support recovery and readiness	Primary: Sleep duration and quality; Secondary: HRV, wellness index	Daily, Night + post-training nap; adjust per match/travel schedule	Primary: Sleep Specialist; Supporting: Fitness Coach	Moderate – requires monitoring tools and controlled environment; feasible at hotel or training base	If nap or sleep extension not possible → prioritize key sleep periods (night) and apply light exposure strategies to support circadian adaptation, considering individual chronotype and tournament schedule
High	High evidence [81,98,99]	Individualized Recovery Protocols	Implement active recovery, hydrotherapy, stretching, and mobility drills tailored to player profile and match/training demands to support recovery and contribute to injury-risk management	Primary: CMJ, RPE, wellness index; Secondary: HRV, subjective fatigue	Daily, Post-training / Post-match; adjust per match intensity	Primary: Fitness Coach; Supporting: Medical Staff	Moderate – requires access to recovery facilities and equipment; feasible at team base	If selected CMJ-derived KPI drops > 5% or RPE > 8 → consider extending recovery duration or adding additional modalities; adjust exercises according to individual tolerance and historical response patterns
Medium	Moderate evidence [98,100, 101]	Dynamic Match-Day Recovery Sequence	Structure match-day recovery using pre-activation, micro-naps, mobility, and hydrotherapy to support physiological and cognitive restoration	Primary: CMJ, RPE, wellness index; Secondary: HRV, subjective fatigue	Match-day: pre-training warm-up → post-match interventions; adjust per player status	Primary: Fitness Coach; Supporting: Medical Staff	Moderate – requires coordination and access to facilities; feasible with pre-planned schedule	If player shows delayed recovery → adjust sequence timing or duration; prioritize key modalities based on individual response and logistical constraints
Medium	Moderate evidence [102,103]	Contrast Thermal Exposure (Heat + Cold Water Immersion)	Apply sequential heat and cold exposure (e.g., hot bath or thermal modality followed by cold-water immersion) to accelerate neuromuscular and autonomic recovery, support metabolic clearance and perceptual restoration	Primary: CMJ, RPE, wellness index; Secondary: HRV, core temperature	Post-training / Post-match; 10–20 min each exposure; adjust per player tolerance	Primary: Fitness Coach; Supporting: Medical Staff	Moderate – requires sauna and cold-water access; feasible at well-equipped team base	If player experiences discomfort or intolerance → modify exposure duration or sequence; monitor perceptual and neuromuscular response to guide future sessions
Medium	Moderate evidence [98,100]	Targeted Reset Interventions	Apply short post-match or post-intense session strategies (cryotherapy, lymphatic drainage, neuromuscular drills) to accelerate recovery and minimize fatigue	Primary: CMJ, RPE, wellness index; Secondary: HRV, muscle soreness scores	Post-match or post-high-intensity session (within 30 min); adjust by player response	Primary: Medical Staff; Supporting: Fitness Coach	Moderate – requires specialized equipment and trained staff; feasible with pre-planned schedule	If immediate post-match interventions are unavailable → prioritize accessible modalities (e.g., light cycling, foam rolling); consider individual player preferences and tolerance; record adaptations in the recovery log
Medium	High evidence [67,96,104]	Continuous Load & Fatigue Monitoring	Track objective and subjective load to guide individualized recovery and readiness decisions, including passive or low-burden monitoring methods	Primary: external load, CMJ, HR, HRV, RPE; Secondary: wellness, mood	Daily, Post-session; interpret trends per microcycle	Primary: Performance Analyst, Fitness Coach; Supporting: Sport Scientist	Moderate – requires devices, data interpretation, and communication; feasible if protocol pre-established	If full monitoring is not possible → prioritize high-risk players; use simplified measures (RPE, wellness) to guide individualized load and recovery adjustments

Note: Epistemic classification of operational recommendations: High = empirical sport science evidence; Moderate = applied/consensus-based evidence; Expert-informed = practitioner-derived operational heuristics.

and recovery strategies [67,96]. These strategies should operate within a continuous monitor–decide–adjust cycle, rather than following fixed recovery routines. The expected benefits include maintaining sprint and high-intensity performance and reducing next-day fatigue, thereby supporting consistent performance throughout the tournament. Individual adaptation of recovery plans based on rapid fatigue and readiness indicators may help performance staff limit subsequent performance decrements, reduce overload risk, and support the maintenance of readiness throughout the tournament [67].

4.3. Pillar III. Fuel the engine: Optimize nutrition and hydration strategies

Periodize energy intake and hydration to match training cycles and competitive demands.

4.3.1. Core idea

Nutrition and hydration are essential for sustaining physical performance and cognitive readiness during high-intensity tournaments. Foundational strategies should be implemented months in advance in coordination with the player's club. Attempting them only at the start of tournaments is "too little, too late." Strategies should ideally be individually tailored to each player, the type of effort, training microcycle, and tournament demands. Contextual factors such as recovery time, training load, opponent playing style and quality, temperature, humidity, altitude, time of day for training or matches, and logistical constraints determine meal and fluid timing, composition, and quality. Elite teams adapt nutrition by reorganizing schedules, using locally available products when safety and quality can be assured, and adapting supplementation according to accessibility and anti-doping considerations [105]. Adapting nutrition and hydration strategies to each player's unique needs in the face of fluctuating tournament conditions is a critical challenge for coaching and support staff. Effectiveness can be evaluated through monitoring player energy availability, hydration status, performance metrics, and cognitive readiness during both training and matches.

4.3.2. Scientific rationale

Intensive training sessions and matches deplete muscle glycogen stores, cause dehydration, and disrupt electrolyte balance [6,53,66,70,123,134–138]. These effects limit endurance, sprint performance, and decision-making efficiency, and increase the risk of low energy availability. Well-planned nutrition and hydration strategies form the cornerstone of optimal physical and mental performance [106]. Adequate hydration is essential to maintain cognitive function, reaction speed, and decision-making precision [44]. Studies show that dehydration is a challenge even in football at national team level [138] and requires careful attention. These strategies support recovery, mental readiness, concentration, and situational awareness, and help players stay prepared and perform at a high level [114,115].

Studies indicate that targeted pre-match carbohydrate intake of 1–1.2 g/kg body mass 30–60 min before kick-off may support sprint performance and help delay early fatigue during the initial phases of high-intensity matches [106,139,140]. In situations where carbohydrate intake is limited, such as immediately before a match, at halftime, or during referee-mandated breaks, carbohydrate mouth rinsing may support sprint performance and maintain central drive without affecting glycogen stores [112,113]. Recent soccer-specific evidence supports its efficacy in both intermittent and continuous small-sided games in adolescent players [107]. Provision of carbohydrate prior to extended play (e.g., extra-time) may help maintain sprint performance and technical execution, reinforcing the importance of targeted fueling strategies when matches exceed 90 min. The UEFA Expert Group Statement recommended that targeted protein-based supplementation supporting post-match recovery in football players may contribute to performance and recovery when diet alone does not meet daily requirements [105]. Others (e.g., creatine, beta-alanine, omega−3 fatty acids) require longer-term, periodized intake to improve anaerobic or aerobic capacity and support overall health [141]. Therefore, supplementation strategies must be individualized and context-specific to maximize benefits and avoid misuse [106,110,142]. Importantly, supplements should never take precedence over a well-balanced and varied diet, which remains the foundation of optimal health and performance. Current recommendations emphasize individualized hydration strategies that account for substantial inter-individual variability in sweat rate among elite football players, ranging from 0.9 L/h in cool conditions to over 1.7 L/h in hot environments, which is further amplified by exercise intensity and environmental heat stress during tournaments [143]. Pre- and post-session body mass measurements and urine specific gravity serve as practical field tools to guide individualized fluid replacement, ensuring that hydration supports both physiological performance and cognitive readiness [144]. Even mild dehydration of 1–2% body mass has been associated with significant impairments in high-intensity running performance and passing decision-making accuracy in football players, with effects amplified under heat stress and congested match schedules [145–147]. Therefore, athletes, in collaboration with support staff, should monitor fluid intake before, during, and after training or competition, ensuring that hydration supports both physiological performance and cognitive readiness. Although it is anecdotally believed that consuming soft drinks or beer (1–2 servings) after a match may alleviate mental fatigue, current evidence indicates that even moderate alcohol intake is detrimental to both physical and cognitive recovery. Moderate alcohol consumption (e.g., 1–2 standard drinks) after exercise has been associated with impaired glycogen resynthesis, exacerbated dehydration, reduced neuromuscular performance, and potentially delayed cognitive recovery processes [116,148]. A growing body of evidence from systematic reviews and meta-analyses further demonstrates that acute alcohol intake negatively affects psychomotor function, including reaction time, attention, and executive functions such as inhibitory control and decision-making, all of which are critical for high-performance football contexts [149,150]. Acute alcohol intake has also been shown in experimental and systematic review evidence to impair neuromuscular performance, including reductions in power output and repeated sprint performance, with potential implications for high-intensity running demands in team sports [116,151]. Therefore, alcohol consumption in recovery contexts is not recommended.

Plan meals and supplementation before, during, and after matches, including rapid energy sources and performance-supporting supplements such as caffeine, beta-alanine, creatine, and omega-3 fatty acids. Use these supplements in an evidence-based, context-specific manner to support focus, reaction time, anaerobic or aerobic capacity, and overall recovery [106,110]. Recommended protein intake includes 0.25–0.4 g/kg per feeding, cumulatively targeting ~1.6–2.2 g/kg body mass per day, with higher intake potentially beneficial during congested schedules. Supplementation should be periodized and tailored to individual needs, training phases, and performance goals to ensure efficacy and safety [111]. Some supplements, such as caffeine, may exert acute ergogenic effects, whereas others, including beta-alanine, require chronic loading over several weeks to increase muscle carnosine levels and should not be used as acute match-day interventions [110]. All supplements should undergo third-party batch testing to minimize contamination and prohibited-substance risk; medical oversight, gastrointestinal tolerance assessment, and player-specific trialing well in advance of competition are essential prerequisites for any supplementation strategy in elite international tournament contexts [141]. During matches and breaks, players can use rapid carbohydrate sources and isotonic drinks to maintain focus, hydration, and high-intensity performance. In high-temperature conditions, these breaks can also be used to strategically rehydrate with electrolyte solutions and perform brief cooling interventions, such as applying cold towels to the neck or face, to maintain core temperature and sustain high-intensity running [108,109,152,153]. Additionally, these pauses can be used for short mental resets, allowing players to refocus, reinforce tactical cues, and optimize

Table 3

Summary of operational strategies for nutrition and hydration optimization (Physiological Domain, Recommendation III).

Priority	Evidence Certainty	Intervention / Action	Description	Key Parameters / Monitoring Criteria	Frequency / Timing	Responsible	Logistical Complexity / Feasibility	Adaptive Recommendations
High	High evidence [105-107]	Individualized Macronutrient Periodization	Tailor macronutrient intake to each player considering training phase, logistical constraints, and sleep patterns to optimize performance, support recovery, and enable carbohydrate supercompensation	Primary: Daily energy intake, macronutrient distribution (carbohydrates, protein, fat); Secondary: body mass, subjective energy, sleep quality	Daily, aligned with microcycle (MD−1, MD, MD+1); adjust per travel/logistics	Primary: Dietitian; Supporting: Fitness Coach	Moderate – requires individualized meal prep and tracking; feasible with team kitchen & monitoring tools	If full individualization is not possible → consider prioritizing key meals around match day; use portable snacks to support carbohydrate/ protein targets, adjusting where possible to individual preferences and tolerance
Medium	High evidence [44,108, 109]	Hydration & Cooling Strategies	Synchronize fluid and electrolyte intake, plus brief cooling interventions, to limit body mass loss to < 2% and optimize physical and cognitive performance	Primary: Body mass changes, urine color/ osmolality; Secondary: subjective thirst, perceived exertion	Daily, Pre-, During-, Post-training/ match; adjust by ambient temperature and match intensity	Primary: Fitness Coach; Supporting: Dietitian	Moderate – requires hydration testing equipment, fluids, and cooling tools; feasible at team base	If hydration testing is unavailable → apply general guidelines (200–300 ml/15 min, electrolyte balance) and cooling towels/fans, adjusting to individual tolerance and environmental conditions where possible
Medium	Moderate evidence [106,110, 111]	Meal & Supplement Planning	Plan pre-, intra-, and post-match meals and evidence-based supplementation to support energy, recovery, and performance	Primary: Macronutrient intake, meal timing; Secondary: post-match protein intake, caffeine dose, supplement tolerance	Daily, aligned with training/match schedule; adjust by player preference & travel	Primary: Dietitian; Supporting: Fitness Coach	Moderate – requires coordinated meal prep and supplement availability; feasible if kitchen & staff organized	If individualization is prioritized → coordinate with hotels/local hosts; adjust timing, composition, and options to player tolerance/ preferences
Medium	Moderate evidence [107,112, 113]	Strategic caffeine and carbohydrate use	Targeted pre-match and intra-match use of caffeine and carbohydrate strategies to support sprint performance, perceived energy, and cognitive focus in high-minute players	Subjective tolerance, HR response, sprint metrics, reaction time, GI comfort	Pre-match 30–60 min, intra-match breaks as feasible	Primary: Dietitian, Sport Scientist; Supporting: Head Coach, Fitness Coach	Moderate – requires individualized preparation and tracking, feasible with team support	If used pre-/intra-match → adjust dose and timing according to player tolerance, match load, environment, and prior testing
Medium	Moderate evidence [106,110, 111]	Short-cycle regenerative supplementation	Short periods of selected recovery-support supplements to support muscle recovery, manage inflammation, and maintain perceived readiness during congested tournament schedules	Primary: Post-match soreness, perceived fatigue; Secondary: Cognitive tests, HR variability	1–3 days post-match or micro-cycle aligned with tournament schedule	Primary: Dietitian, Sport Scientist	Moderate – requires pre-preparation and cycle planning; feasible with kitchen/staff coordination	Apply only when indicated → based on match congestion, recovery metrics, and individual tolerance
Medium	Moderate evidence [105,114, 115]	Monitoring & Adjustment	Track responses to nutrition and hydration strategies using subjective reports and observable performance; dynamically adapt plans	Primary: Subjective energy, fatigue, well-being; Secondary: match performance indicators, adherence to meal plan	Daily, Post-training/match; trend analysis over microcycle	Primary: Dietitian, Sport Scientist; Supporting: Fitness Coach	Moderate – requires reporting system and staff coordination; feasible with standard monitoring	If monitoring limited → use player self-reports and coach observations to adjust intake, considering individual tolerance and contextual factors; log key deviations
Supporting	Expert-informed [116,117]	Lifestyle Guidance – Alcohol Avoidance	Implement a team policy to avoid alcohol in order to support recovery, hydration, and cognitive readiness	Compliance with alcohol policy; Secondary: post-training wellness	Ongoing during tournament; brief reminders daily	Primary: Head Coach; Supporting: Dietitian	Low – relies on education and communication; feasible	If players breach policy → provide alternative recovery strategies (hydration, sleep, nutrition), considering individual tolerance and contextual constraints; reinforce education and log deviations

Note: Epistemic classification of operational recommendations: High = empirical sport science evidence; Moderate = applied/consensus-based evidence; Expert-informed = practitioner-derived operational heuristics.

decision-making for the next phase of play. Nutrition and hydration should be continuously calibrated to each player's load, fatigue, and tournament demands to ensure optimal performance and recovery. Particular attention should be given to extra-time periods, where prolonged high-intensity activity further challenges glycogen availability, hydration status, and cognitive performance [6].

4.4. Pillar IV. Adapt or Fade: Manage travel, climate, and environmental stress

Prepare for environmental transitions through strategic acclimatization and time-zone planning.

4.4.1. Core idea

Long-distance travel, time-zone shifts, and unfamiliar environmental conditions are sometimes underestimated yet critical factors influencing tournament performance and the risk of illness and/or injury. Poor management of circadian rhythm, jet lag, and climatic or micro-environmental stress can impair physical capacity, concentration, reaction time, and technical precision. Effective preparation requires strategic acclimatization, including gradual adjustments to sleep timing, meal timing, and training schedules. Coaching and support staff must navigate the difficulty of adapting these strategies to the variable responses of each player under differing environmental conditions. Individual responses vary, so monitoring each player's adaptation to match demands and recovery strategies is essential to optimize performance and maintain readiness throughout the tournament [96].

4.4.2. Scientific rationale

Crossing time zones disrupts circadian synchronization, leading to sleep disturbances, reduced alertness, and lower neuromuscular performance [154]. Given that many players will arrive from intercontinental travel shortly before the tournament, the limited window for recovery and circadian adaptation may constrain the effectiveness of acclimatization strategies and require pragmatic micro-adjustments in training, sleep, and hydration. In international football, these effects have been confirmed by Zacharko and colleagues [132], who analyzed national team performance during the 2018 World Cup qualifiers and the build-up to EURO 2020. Circadian misalignment primarily impairs alertness, reaction time, and hormonal regulation [155]. In elite soccer players, sleep duration decreased substantially in the first days after arrival following long-haul eastward travel (>5 time zones), highlighting the potential benefit of extending sleep before departure [96]. If accumulated sleep debt occurs, this disproportionately affects cognitive processing, emotional regulation, and recovery capacity [156]. The study revealed that eastward travel, going "against" the body's natural rhythm, caused more pronounced performance declines than westward travel, especially when crossing more than five time zones. Even minor delays in circadian adaptation can reduce cognitive readiness and endurance capacity during tournament play.

Elevated temperatures are expected during the FIFA World Cup 2026 and may substantially affect player performance and health [108,157,158]. Ambient temperatures above 25°C have been associated with 5–8% reductions in total distance covered and high-intensity running, while high humidity has been associated with 4–6% decreases in technical efficiency [159–161]. However, these effects are modulated by match context, pacing strategies, scoreline, team tactics, acclimatization status, and measurement methodology. Situational variables, such as match status or opponent level, can interact with heat or altitude stress to further influence sprinting and technical performance [162–164]. For example, during the 2014 FIFA World Cup, players adapted their activity patterns in hot and humid conditions, performing less high-intensity running but more low-intensity running and successful passes, without changes in total distance or peak running speed [165]. Additionally, even moderate altitude (~1500–2000 m) can reduce high-intensity running distance by ~5% and impair recovery between repeated sprints [166]. This is particularly relevant for the FIFA Men's World Cup 2026, as Mexico City's Estadio Azteca, host of the opening match, sits at ~2240 m above sea level, making it one of the highest-elevation venues in the tournament. Beyond altitude, the FIFA Men's World Cup 2026 presents unprecedented environmental variability across host cities. These range from high heat-stress venues in Atlanta, Dallas, Houston, Kansas City, Miami, and Monterrey, identified by FIFPRO as posing extremely high heat-stress risk, to milder conditions in Vancouver and Toronto. Indoor retractable-roof venues in several US cities may provide partial climate control. Travel distances between host cities across three countries further compound circadian and fatigue challenges. Data from the 2010 FIFA World Cup showed a 3.1% lower total distance covered by teams during the matches played at 1200–1400 and 1401–1753 m compared with sea level [167]. Frequent relocation between cities with markedly different altitudes poses an additional challenge. Short adaptation windows limit full physiological acclimatization, necessitating pragmatic micro-adjustments in load, recovery, pacing, and substitution strategies rather than complete altitude adaptation [166,168]. Evidence suggests that these micro-adjustments, even when applied pragmatically, may provide measurable benefits for thermoregulation, circadian alignment, and neuromuscular readiness in elite athletes [96,169,170].

Where feasible, proactive but pragmatic adaptation to environmental stressors may help protect players from excessive physiological strain and support physical and cognitive efficiency during competition. Strategic planning of team base locations, travel logistics, and structured staff meetings can improve workflow, support clear communication, and contribute to both individual and collective performance under tournament conditions. Another potential strategy is sleep banking, where players extend their sleep duration in the days prior to travel to create a "reserve" of rest [156]. This approach has been shown to reduce accumulated sleep debt and mitigate the negative effects of long-haul eastward travel across multiple time zones. Additionally, controlling the hotel microclimate (temperature, lighting, noise) and aligning training sessions with the local daylight pattern helps support circadian synchronization and significantly improves readiness for match performance [171]. Recommended mitigation strategies include: (1) timed exposure to natural and artificial light, (2) carefully planned meal timing, and (3) melatonin supplementation. These interventions may support circadian adaptation, though the reported magnitude of approximately 30–40% acceleration should be interpreted cautiously given methodological variability across studies and individual response differences [128,170,172]. Melatonin use in particular should be medically supervised, individually dosed, and compliant with team medical policy and anti-doping regulations before being implemented in tournament settings. Equally important, coaching and performance staff must actively monitor meteorological and environmental data: temperature, humidity, altitude, and air quality to adjust training loads, hydration strategies, and match tactics accordingly. To mitigate these risks, teams should implement strategies across all match phases, including pre-match preparation, half-time breaks, cooling interventions, and post-match recovery measures. Where extreme heat is expected, low-cost cooling interventions can help reduce thermal strain and support player performance [108,157,169]. For teams with sufficient resources and planning time, longer-term heat-acclimation strategies can be implemented prior to arrival to further enhance thermoregulatory capacity and match performance under extreme heat. These interventions include wearing cooling vests before or during training and matches, as well as short cold-water immersion sessions after training, which help maintain high-intensity running capacity and accelerate recovery. In addition to heat and circadian stress, exercise performance at mild-to-moderate altitude shows substantial inter-individual variability. Therefore, monitoring individual responses to hypoxic exposure is essential. Teams with players who acclimatize more rapidly may gain a competitive advantage under such conditions. Protocols for recognizing exertional heat illness and altitude sickness, as

Table 4
Summary of operational strategies for managing travel, climate, and environmental stress (Physiological Domain, Recommendation IV).

Priority	Evidence Certainty	Intervention / Action	Description	Key Parameters / Monitoring Criteria	Frequency / Timing	Responsible	Logistical Complexity / Feasibility	Adaptive Recommendations
High	High evidence [96,132, 156]	Critical Travel Preparation	Gradually adjust sleep timing pre-travel to align with destination and monitor adaptations to guide load adjustments, maintaining readiness and minimizing jet-lag impact	Primary: Sleep duration & timing, RPE, HRV, wellness indices, CMJ; Secondary: subjective fatigue, mood	Daily, 3–5 days pre-travel + post-travel monitoring (MD−3 → MD+1)	Primary: Sleep Specialist, Fitness Coach; Supporting: Sport Scientist	Moderate – requires individual sleep planning, monitoring devices, and coordination with travel schedules; feasible with dedicated staff	If pre-travel adjustment limited → prioritize post-arrival naps, hydration, and recovery; adjust training load based on observed adaptation and individual tolerance; log interventions
Medium	Moderate evidence [128,170, 172]	Circadian & Sleep Optimization – Light Exposure	Manage light exposure to support circadian adaptation, sleep quality, and performance at destination	Primary: Timing of light exposure, sleep onset/ offset; Secondary: subjective alertness, sleep quality	Daily, 3–5 days pre-travel + post-arrival	Primary: Sleep Specialist; Supporting: Fitness Coach	Moderate – requires light exposure tools or natural light access; feasible with player cooperation	If light exposure control limited → use scheduled naps and gradual adaptation over first 1–2 days post-travel; adjust based on individual tolerance and observed sleep patterns; record adaptations
Medium	Moderate evidence [95,96,156]	Circadian & Sleep Optimization – Sleep Banking	Extend nightly sleep by 60–90 min for 3–4 days pre-travel to reduce post-arrival sleep deficit; include short naps post-travel	Primary: Sleep duration, sleep quality, subjective alertness; Secondary: HRV, RPE	Nightly pre-travel + short naps MD–MD + 1	Primary: Sleep Specialist; Supporting: Fitness Coach	Moderate – requires schedule adjustment and player compliance; feasible with team coordination	If extending sleep not feasible → prioritize naps and minimize early-morning training; adjust intensity of first 1–2 sessions based on individual response and observed sleep quality; record adaptations
Medium	High evidence [96,169, 170]	Environmental & Situational Adaptation	Adjust workload, hydration, and recovery according to climate, air quality, and microclimate to support performance and manage fatigue	Primary: Temperature, humidity, WBGT (Wet Bulb Globe Temperature), air quality, player hydration, workload; Secondary: perceived exertion, fatigue	Daily, aligned with training/match times; continuous monitoring	Primary: Fitness Coach, Medical Staff; Supporting: Sport Scientist	Moderate – requires environmental monitoring tools and staff to adjust load; feasible with preparation	If monitoring limited → follow conservative load and hydration guidelines; implement basic cooling strategies (ice packs, vests); adjust based on individual tolerance and observed responses; log adaptations
Medium	Moderate evidence [108,157, 169]	Active Heat Acclimatization – Pre-Tournament	Structured heat exposure via controlled sessions (sauna, heat chambers, climate simulation), tailored to positional subgroups and individual heat tolerance to support thermoregulation and high-intensity performance	Primary: Core temperature, HR response, sprint/high-intensity metrics; Secondary: RPE, perceived fatigue	Daily sessions, 5–10 days pre-tournament; adjust by player position and tolerance	Primary: Fitness Coach / Sport Scientist; Supporting: Medical Staff	Moderate–High – requires access to heat chambers/ saunas and monitoring devices; feasible with early planning	Adjust intensity and duration → according to position, fitness level, heat tolerance, and observed physiological responses
Medium	Moderate evidence [166–168]	Altitude-Specific Strategies	Implement targeted acclimatization or fly-in/fly-out strategies for moderate altitude matches to preserve neuromuscular and cognitive performance	Primary: Oxygen saturation, RPE, HRV, CMJ; Secondary: sleep quality, perceived fatigue	Pre-match: 2–5 days for acclimatization if possible; match day planning	Primary: Fitness Coach, Medical Staff; Supporting: Head Coach, Sport Scientist	High – requires careful planning, travel logistics, and monitoring; feasible with early coordination	If acclimatization not possible → minimize hypoxic exposure, increase hydration, reduce workload, and prioritize post-match recovery; adjust based on individual responses and tolerance; document adaptations

Note: Epistemic classification of operational recommendations: High = empirical sport science evidence; Moderate = applied/consensus-based evidence; Expert-informed = practitioner-derived operational heuristics.

well as monitoring environmental stressors such as air quality and allergen exposure, should be considered to protect player health and optimize performance under varying tournament conditions. These include low-cost strategies for thermal stress (e.g., cooling vests, short cold-water immersion), circadian adaptation (sleep and light exposure management), hydration protocols, training-time adjustments, and early in-camp exposure [173,174].

5. The neurocognitive domain

5.1. Pillar V. Unlock the brain: Train around the psychomotor fatigue threshold

Understand the psychomotor fatigue threshold to enhance decision efficiency under fatigue.

5.1.1. Core idea

Decision-making efficiency, perception, and anticipation during tournaments depend on both physical fitness and the ability to maintain cognitive function under fatigue. Effective Psychomotor Fatigue Threshold (PFT) management begins by assessing each player's baseline through coordinated Club–Country monitoring. This cognitive–neuromotor state determines how effectively players perceive, select, and execute actions in high-pressure contexts. The concept of the PFT provides a framework for understanding the exercise intensity and tolerance to fatigue at which central nervous system (CNS) function and decision-making appear to be optimally maintained [10,11]. However, its direct validation and operational standardization in elite football match-play contexts remain limited, and current applications should be considered exploratory. Within this, the PFT is used as an applied construct to operationalize the interaction between mental fatigue and motor performance in tournaments as well as other training and match situations. In practice, coaching staff face the challenge of determining each player's individual PFT given limited time, methodological and technological constraints, and adjusting training accordingly under congested tournament schedules. Effectiveness can be evaluated through monitoring decision accuracy, reaction times, and neuromotor readiness during training and matches.

5.1.2. Scientific rationale

It has traditionally been assumed that optimal decision-making, perception, and anticipation occur around the anaerobic threshold during high-intensity tasks [65,175]. However, emerging evidence suggests that fatigue–performance relationships are more complex and may be better described by multifactorial threshold-based responses influencing both cognitive and neuromotor output under high-load conditions [11]. It is important to distinguish mental load from mental fatigue in this context. Mental load refers to the cognitive and emotional demands imposed during training and competition, whereas mental fatigue reflects the psychobiological state resulting from sustained exposure to such demands [176–178]. More recent experimental studies and controlled laboratory assessments suggest that players may reach peak psychomotor performance at intensities slightly above the anaerobic threshold, with some reports indicating approximately 5–6% above this threshold [10,179]. The Psychomotor Fatigue Threshold represents the proposed exercise intensity slightly above the anaerobic threshold at which central nervous system (CNS) function and psychomotor performance may be optimally maintained under controlled conditions. Under experimental and laboratory conditions, the PFT has been associated with faster reaction times, improved discrimination of task-relevant stimuli, greater attentional mobilization and concentration, and more efficient perception, anticipation, and decision execution [180]. Exceeding this threshold may be accompanied by a decline in cognitive and neuromotor efficiency, potentially reflecting the accumulation of central and peripheral fatigue [10]. The intensity range between the anaerobic threshold and the PFT is referred to as the "psychomotor comfort zone", within which the CNS may function more efficiently, selecting relevant cues and executing motor actions with greater speed and accuracy under controlled task conditions [179].

Empirical observations show that the PFT occurs at faster running speeds than the lactate threshold, typically ~15.0 km/h compared with ~13.0 km/h, confirming that psychomotor peak performance emerges at intensities above the lactate threshold [181]. In another study, Konefał and colleagues [182] showed that at the psychomotor fatigue threshold, trained football players often operate at approximately 84% of maximal running speed, around 91% of HRmax, ~84% of VO_2max. Together, these physiological markers may help delineate the intensity range in which CNS efficiency appears to be optimized under controlled testing conditions. This range may vary by player position and role, reflecting specific perceptual-cognitive and neuromotor demands. This provides an evidence-based reference for calibrating training stimuli and interpreting match-play demands, while accounting for inter-individual variability in fitness and adaptation [90,183]. During matches, the aim is to operate, where possible, within the estimated psychomotor comfort zone, acknowledging situational and tactical constraints. Empirical observations highlight the "preparatory dilemma", where staff must carefully balance high-intensity cognitive–perceptual training with tactical instruction during limited preparatory sessions (e.g., Match Day −2/−1) to avoid overloading players before matches. Complementary to short high-intensity CNS activations, Brain Endurance Training (BET) consists of prolonged submaximal cognitive or combined physical–cognitive efforts. It may enhance central fatigue resistance, helping sustain decision-making speed and perceptual accuracy over extended tournament periods [176,184,185]. Brief lower-intensity periods allow partial recovery and help prevent excessive fatigue [186]. In tournaments, accumulated mental fatigue, resulting from congested schedules, emotional pressure, and repeated high-stakes decision-making, increases the risk of crossing this threshold [187,188]. Crossing it may slow perception, impair anticipation, and reduce decision accuracy, potentially affecting match outcomes [187, 189].

To develop resilience and elevate the PFT, regular exposure to high-intensity stimuli slightly above the anaerobic threshold is recommended [179]. Even brief efforts (~3–5 s), such as accelerations, short sprints, or starts from various positions, can effectively activate the CNS. When repeated with accurate rest intervals, these actions enhance neural efficiency and decision-making. Very short, explosive movements of a few seconds, including accelerations, jumps, and changes of direction, can transiently enhance CNS activation and decision-making without inducing fatigue. Experimental evidence indicates that short bouts of high-intensity interval training (HIIT) can acutely influence performance in specific cognitive tasks, although findings are heterogeneous and depend on task type, timing, and participant characteristics [190, 191]. These findings suggest that targeted high-intensity stimuli can acutely influence performance in specific cognitive tasks under controlled conditions. They support the use of such stimuli within training microcycles, although their direct translation to match decision-making performance remains uncertain. Translating this to applied settings, elite footballers performing short priming sessions on match day (e.g., morning mobility, core, and reactive drills) demonstrate enhanced subsequent high-intensity performance without technical decline [192,193]. These brief, targeted high-intensity actions may allow players to operate near the estimated PFT while supporting cognitive responsiveness without inducing excessive fatigue. When combined with rapid decision-making or perceptual tasks, these efforts may enhance cognitive engagement without imposing excessive load when appropriately dosed [10]. Such interventions can be integrated into pre-match warm-ups, training microcycles, or cognitive priming sessions, preparing players to achieve high psychomotor readiness from the first minutes of official matches [193]. Where resources and scheduling allow, the PFT can be explored during the pre-tournament preparation camp using controlled progressive exercise tests with

Table 5
Summary of operational strategies for psychomotor fatigue management (Neurocognitive Domain, Recommendation V).

Priority	Evidence Certainty	Intervention / Action	Description	Key Parameters / Monitoring Criteria	Frequency / Timing	Responsible	Logistical Complexity / Feasibility	Adaptive Recommendations
High	Moderate evidence [10,11,177]	Cognitive Monitoring & CNS Readiness	Track cognitive responses and CNS readiness using reaction time, B-PVT, accuracy; prepare players for high-intensity decision-making and maintain performance under fatigue	Primary: Choice reaction time, variability, accuracy, B-PVT; Secondary: subjective mental fatigue, perceived alertness	Pre/post session or match; daily monitoring during microcycles; adjust by match proximity	Primary: Performance Analyst, Sport Psychologist; Supporting: Fitness Coach	Moderate – requires mobile/tablet-based cognitive tools and data analysis; feasible with dedicated staff	If monitoring tools unavailable → use subjective mental readiness scales; apply pre-session cognitive priming heuristically; adjust based on individual responses and document adaptations
High	Moderate evidence [10,190, 192]	High-Intensity Cognitive Bouts	Train short high-intensity efforts (~3–5 s) integrating perceptual-cognitive tasks to support CNS activation and resilience	Primary: Task accuracy under fatigue, decision-making speed; Secondary: HR, RPE, CNS readiness markers	Multiple times per session; pre-match, half-time, or pre-substitution; adjust by microcycle and fatigue	Primary: Fitness Coach, Head Coach	Moderate – requires planning and supervision to avoid overloading; feasible with structured session design	If schedule limited → prioritize pre-match or bench-entry bouts; reduce repetitions or duration to manage fatigue; adjust based on player response and log adaptations
Medium	Moderate evidence [176,184, 185]	BET Sessions (Brain Endurance Training)	Prolonged cognitive efforts combined with moderate physical intensity (~70–80% HRmax) to enhance resistance to central fatigue and sustain decision-making under extended tournament conditions	Primary: Choice reaction time, decision-making accuracy, error rate; Secondary: subjective mental fatigue, HR, RPE	1–2x per microcycle; ideally on recovery days or preparatory sessions before matches	Primary: Fitness Coach, Performance Analyst; Supporting: Sport Psychologist	Moderate – requires planning, monitoring tools for cognitive load and HR; feasible with structured sessions	If limited time → prioritize shorter cognitive endurance bouts; adjust intensity or duration based on mental fatigue, match proximity, and individual response; log adaptations
Medium	Expert-informed [179,182]	Cognitive Pacing & Match Application	Optimize time in the psychomotor comfort zone by pacing high- and low-intensity periods to maintain CNS and neuromotor performance	Primary: Time in target intensity zone, perceptual-motor accuracy; Secondary: match load, fatigue indices	Training sessions & matches; adjust dynamically based on match stage, accumulated fatigue, recovery status	Primary: Head Coach, Fitness Coach; Supporting: Assistant Coach	Moderate – requires integration into training plans and real-time monitoring; feasible with clear coaching guidance	If fatigue limits pacing control → extend low-intensity periods; adjust tactical rotations or substitutions based on observed player response; log interventions
Supporting	Expert-informed [10,186]	CNS Recovery & Cognitive Readiness	Support CNS recovery with active recovery, hydration, brief power naps, recovery nutrition, and cognitive priming to sustain concentration without increasing physical load	Primary: Cognitive task performance post-recovery; Secondary: HRV, RPE, subjective alertness, sleep quality	Daily post-training or microcycle recovery windows; optional during match breaks	Primary: Fitness Coach, Medical Staff; Supporting: Sport Psychologist	Moderate – requires individualized recovery planning and monitoring; feasible if recovery resources allocated	If limited recovery time → prioritize hydration, light active recovery, and micro-cognitive drills; avoid additional physical load; adjust based on player response and document interventions

Note: Epistemic classification of operational recommendations: High = empirical sport science evidence; Moderate = applied/consensus-based evidence; Expert-informed = practitioner-derived operational heuristics.

simultaneous monitoring of heart rate, blood lactate, and choice-reaction time tasks. In tournament practice, however, simpler field-based indicators such as B-PVT, reaction-time tasks, perceived cognitive fatigue, and longitudinal wearable-device data may provide more feasible proxies for monitoring CNS function and individualizing training stimuli [175]. These field-based assessments can provide repeated, low-burden indicators of CNS function, supporting early-warning signals and proactive adjustment of workloads and recovery strategies [24,187,194,195].

5.2. Pillar VI. Think Fast, Decide Smart: Cognitive Load and Decision-Making

Develop perceptual-cognitive skills and manage mental load for optimal tactical responses.

5.2.1. Core Idea

Rapid and accurate tactical decisions rely on players' perceptual-cognitive skills and effective mental load management. During elite tournaments, sustained decision quality increasingly depends on the integration of perception, anticipation, and situational awareness under conditions of controlled but accumulating physical effort and fatigue. Building on the Psychomotor Fatigue Threshold (Pillar V), this pillar emphasizes applying it to decision-making contexts to maintain accuracy and reaction speed under cumulative physical and mental fatigue. For coaching staff, the challenge lies in addressing accumulated mental fatigue and emotional stress while preserving focus and tactical clarity across repeated matches and compressed preparation windows. Monitoring mental readiness can be conducted using indicators such as decision accuracy, reaction speed, and cognitive load metrics, thereby offering evidence-informed guidance for preparation and intervention [176]. In this context, cognitive load-related constructs are operationally distinguished as: (i) mental load (task- and context-dependent demands), (ii) mental fatigue (accumulated psychobiological state), and (iii) cognitive performance outputs (decision accuracy, reaction time, and error rate), which serve as primary field-relevant indicators in elite tournament environments.

5.2.2. Scientific Rationale

The fluctuating physical and mental intensity during tournaments affects players' ability to process information accurately and make decisions, with recent evidence syntheses indicating that fatigue–performance relationships are characterized by multifactorial threshold-based responses that extend to cognitive decision-making processes under high-load competitive conditions [11,210]. Beyond fatigue accumulation, players' performance is influenced by mental load, defined as the combined cognitive and emotional demands imposed by high-pressure tournament contexts [203]. Mental load is conceptually distinct from mental fatigue, reflecting the immediate cognitive and emotional demands, rather than accumulated exhaustion [176,204]. In elite international tournaments, these demands are further amplified by competitive pressure, media exposure, and role uncertainty, which can modulate decision-making efficiency under fatigue. Mental fatigue has been shown to negatively impact physical, technical, and tactical performance in soccer [205], including a reduction in high- and low-intensity running actions due to increased perceived exertion [211]. Systematic reviews in team sports confirm that decision-making efficiency under fatigue is highly individual and can be enhanced by repeated exposure to variable, time-pressured scenarios [206], emphasizing the need for personalized perceptual-cognitive load management.

Integrating task constraints such as time pressure, scoring systems, or scenario-based rules can help manage mental load during training and support decision-making efficiency under tournament conditions. Research shows that small-sided games (SSGs) and situational drills, which require rapid identification of relevant cues and anticipatory responses to opponents' movements, improve perception and decision-making speed and accuracy under tournament-like time pressure [196–198]. Evidence indicates that small-sided games (SSGs) of various formats (e.g., 3–5 players per side, 4–6-minute bouts with 2–3-minute active rest) can enhance perceptual-cognitive engagement. Improvements in decision-making accuracy of approximately 10–15% have been reported in controlled small-sided game intervention studies, although effect magnitudes are highly variable and dependent on task constraints, intervention duration, and participant characteristics [196,197]. Although evidence from SSG interventions is primarily derived from longer-term training studies (4–6 weeks), these findings are interpreted here as supportive of acute, constrained application strategies during tournament phases, aimed at maintaining rather than developing perceptual-cognitive capacities. These smaller formats increase player involvement with the ball and frequency of decision-making opportunities, though they may underload certain physical, technical, and tactical aspects of full 11-a-side match play [212,213]. A match-representative SSG typically involves a larger playing area, providing a more realistic physical and tactical stimulus while maintaining high perceptual-cognitive engagement. A recent systematic review and meta-analysis found that perceptual-cognitive training interventions in team sports significantly improve athletes' anticipation and decision-making skills, with medium effect sizes observed for transfer to real-game performance [199]. These findings support the use of perceptual and cognitive drills within training microcycles to develop tactical responsiveness and decision efficiency under time pressure. Appropriate modulation of cognitive load during drills may help prevent CNS overload and support cognitive adaptation [209]. Integrating sensory information, tactical decisions, and emotion regulation during SSGs promotes effective decision-making in decisive moments of tournament matches. Periodic augmented feedback can support short-term decision performance, but should be strategically faded to promote long-term learning, independent decision-making, and adaptive perceptual-cognitive skills [207,208]. Utilizing short, high-intensity mental stimuli in training, such as rapid decision-making tasks requiring quick choices between passing, dribbling, or shooting, may enhance players' mental readiness while maintaining overall physical training volume [214]. Elite players may benefit from carefully controlled exposure near the estimated psychomotor fatigue threshold to support decision-making capacity in critical match phases, but careful monitoring of intensity, rest, and recovery is essential to prevent overloading and injury [10,181]. Conceptually, neurophysiological indicators such as EEG-derived metrics or HRV cognitive indices [215] offer objective insights into players' mental readiness and decision-making capacity under fatigue. While their practical implementation in tournament settings may be constrained by logistics, these measures provide a scientifically grounded framework to link cognitive load, mental fatigue, and performance outcomes. Importantly, a clear distinction is made between long-term perceptual-cognitive development interventions (typically 4–6 weeks in duration) and acute tournament-phase micro-dosing strategies, which are constrained by compressed schedules and prioritize maintenance rather than adaptation.

Critically, during key moments of a match, players may face situations where a single rapid decision (e.g., a through ball, an unexpected shot, or creative involvement in the attack) can dramatically influence the outcome. To maintain decision-making efficiency under cumulative mental load, prolonged moderate cognitive or combined physical–cognitive tasks (Brain Endurance Training, BET; ~70–80% HRmax) can be applied. These sessions focus on sustaining reaction speed, perceptual accuracy, and minimizing decision errors during congested tournament schedules [176,184,195]. Short, controlled exposures (10–20 min) embedded in recovery or preparatory sessions help players retain tactical sharpness without inducing additional physical fatigue. BET may therefore serve as a practical strategy for preserving cognitive efficiency under cumulative mental load [195,202]. From a performance-analysis perspective, these moments involve reduced

Table 6
Summary of operational strategies for cognitive load and decision-making (Neurocognitive Domain, Recommendation VI).

Priority	Evidence Certainty	Intervention / Action	Description	Key Parameters / Monitoring Criteria	Frequency / Timing	Responsible	Logistical Complexity / Feasibility	Adaptive Recommendations
High	High evidence [196–199]	Small-Sided Games & Situational Drills	Replicate high-pressure match situations to train perception–action coupling and time-constrained decision-making	Primary: Decision accuracy, reaction time, successful execution under pressure; Secondary: RPE, subjective stress	Multiple sessions per week; integrate within technical–tactical sessions; adjust by match schedule	Primary: Head Coach, Fitness Coach; Supporting: Assistant Coach	Moderate – requires planning and suitable space; feasible within normal training sessions	If time limited → prioritize most match-critical scenarios; consider shortening drill duration or reducing player numbers while maintaining cognitive load; log player responses for future adjustments
High	Moderate evidence [198,200, 201]	Critical Match Moment Simulation	Simulate scenarios where a single decision can influence outcome; train optimal choices under time pressure and emotional stress	Primary: Decision accuracy under time pressure; Secondary: composure rating, physiological stress markers	Integrated into SSGs or situational drills 1–2x per microcycle; adjust to match proximity	Primary: Head Coach, Fitness Coach; Supporting: Assistant Coach	Moderate – requires scenario design and supervision; feasible if drills embedded in training	If session time constrained → select 1–2 high-impact scenarios; consider rotating players to ensure exposure and maintain cognitive load; note performance outcomes for subsequent sessions
Medium	Moderate evidence [176,184, 202]	BET Sessions – Sustained Cognitive Load	Prolonged cognitive or combined physical–cognitive efforts (~70–80% HRmax) to maintain reaction speed, decision accuracy, and perceptual sharpness under cumulative mental fatigue	Primary: Choice reaction time, decision-making accuracy, error rate; Secondary: subjective mental fatigue, HR, RPE	1–2x per microcycle; embedded in recovery or preparatory sessions before matches	Primary: Fitness Coach, Performance Analyst; Supporting: Sport Psychologist	Moderate – requires structured sessions, cognitive load monitoring, and HR tracking; feasible with planning	If time limited → shorten sessions to 10–15 min; consider reducing intensity or integrate with tactical drills; monitor player fatigue and decision accuracy to adjust future sessions
Medium	Expert-informed [203–205]	Cognitive Load Management	Regulate complexity, timing, and delivery of tactical instructions to prevent cognitive overload while stimulating decision-making	Primary: Player comprehension, error rate; Secondary: subjective fatigue, mood, attention lapses	During training sessions; monitor continuously; adjust per session	Primary: Head Coach, Fitness Coach	Low–Moderate – depends on communication clarity; feasible with structured instructions	If multiple tasks overwhelm players → simplify instructions, focus on core tactical points; consider reducing session density; track errors to guide adjustments
Medium	Expert-informed [206-208]	Feedback & Reflection	Structured debriefs and guided self-assessment to consolidate perceptual-cognitive skills and improve decision-making	Primary: Quality of reflections, skill transfer to next session; Secondary: observed improvements in decision-making under pressure	Post-training sessions; after SSGs or critical scenario drills	Primary: Head Coach, Fitness Coach; Supporting: Assistant Coach	Low – relies on time allocation for feedback; feasible	If time limited → provide written or brief video feedback; consider highlighting key learning points only; log outcomes for follow-up
Supporting	Expert-informed [10,181, 209]	Short, Intense Mental Stimuli	Rapid cognitive drills or simulated decision-making under temporal pressure to support perception and concentration with minimal additional physical load	Primary: Accuracy and speed of cognitive tasks; Secondary: RPE, attention focus	Integrated into warm-ups or technical drills daily or as micro-doses; adjust by training intensity	Primary: Fitness Coach; Supporting: Performance Analyst, Sport Psychologist	Low–Moderate – can be embedded in existing drills; feasible with minimal extra resources	If time-constrained → shorten drill duration; consider prioritizing highest-impact cognitive tasks; monitor accuracy and adjust micro-doses for individual players

Note: Epistemic classification of operational recommendations: High = empirical sport science evidence; Moderate = applied/consensus-based evidence; Expert-informed = practitioner-derived operational heuristics.

decision time, high uncertainty, and cognitive and emotional stress. Training should target measurable indicators such as decision latency, option selection quality, and error rate under fatigue to ensure cognitive sharpness in decisive situations. Observational analyses of elite matches indicate that decisions made under high time pressure in the final third, such as playing a through ball or taking a spontaneous shot, have been associated with increased scoring opportunities and match-winning potential [198,210]. Maintaining high cognitive and decision-making capacities, particularly in the final stages of the second half, is critical, as research shows most goals are scored or conceded during this period [200]. This highlights the importance of focused perceptual-cognitive interventions to sustain tactical sharpness under fatigue. Conditioning and performance staff should therefore aim to maintain cognitive capacities as effectively as possible even under cumulative fatigue, with drills and situational exercises designed to maintain decision-making efficiency despite mounting physical demands [201]. Recent reviews highlight that monitoring cognitive states, for example via mental RPE or validated attention tasks, allows staff to tailor interventions and prevent decision-making decline under cumulative fatigue [204].

5.3. Pillar VII. Turn data into decisions: Leverage analytics for performance and load management

Integrate real-time data and predictive models into decision-making during matches.

5.3.1. Core idea

During congested international tournaments, rapidly transforming performance and load data into actionable insights is crucial for training and in-match decision support. Real-time monitoring of CNS, cognitive, and physical metrics can support coaching staff decision-making by tracking performance, managing player loads, and informing tactical adjustments during evolving match situations. These data should be interpreted through trend-based analytics and context-specific decision-support tools, with predictive or AI-assisted approaches used only where sufficient longitudinal data are available. Success depends on prioritizing relevant information, filtering out noise, and translating complex metrics into clear, collectively interpreted guidance for the Head Coach under time pressure and evolving match demands. Outcomes can be assessed by integrating cognitive, emotional, and physical data within the Psychomotor Fatigue Threshold framework, ensuring players maintain near-optimal neuromotor and cognitive readiness and supporting evidence-informed preparation, load management, and tactical decisions [78].

5.3.2. Scientific rationale

Modern data analysis systems include Electronic Performance Tracking Systems (EPTS) such as the official FIFA EPTS used in World Cup tournaments, heart rate monitoring, fatigue indicators, and wearable technologies (e.g., IMUs, HR/HRV monitors, sleep tracking) [22,78]. These tools can support detailed assessment of physical load, player readiness, and potential injury-risk indicators [216,217]. Where sufficient longitudinal and contextualized data are available, predictive models and AI-enhanced analytics may help forecast specific performance-related outcomes, such as high-intensity running output or external load indicators, with reported classification accuracy of approximately 80–85% in retrospective and cross-validated datasets [218]. However, these models are primarily trained and validated on historical and observational datasets rather than prospective elite tournament data [219,220]. Recent studies indicate that such models, when supported by adequate physiological, tactical, and cognitive data, may provide early indicators of impending declines in high-intensity performance and decision-making within the final phases of match periods [221,222]. Accordingly, effective performance analytics should not begin only weeks before a tournament, but ideally from the start of the World Cup cycle, including the appointment of skilled analysts, identification of relevant questions, curation of longitudinal datasets, and gradual development of decision-support models to inform coaching decisions [223]. Integrating predictive insights with expert coaching judgment may improve practical utility while mitigating the risk of over-reliance on automated models. Empirical evidence from elite tournament settings and match simulations demonstrates that rapid prioritization and visualization of key load and performance indicators significantly improve the timeliness and accuracy of substitutions and tactical decisions [224]. This reflects a broader trend of AI applications and wearable technologies advancing sports analytics across multiple disciplines and data types, enhancing both predictive accuracy and real-time interpretability [218]. It should be noted that the accuracy of these models can be reduced in dynamic tournament settings, especially when accounting for contextual variables, player fatigue, and unanticipated tactical changes [225,226]. However, when using tracking data, it is essential to acknowledge that these external load markers are only surrogates for underlying physiological systems. Therefore, the use of tracking parameters that accurately reflect key physiological variables relevant to performance is recommended [6,60,227]. The implementation of AI-driven and data-informed decision systems also requires consideration of data governance, including player consent, data ownership, privacy protection, algorithmic transparency, and accountability for decisions informed by predictive outputs.

When integrated data streams are prioritized, visualized, and interpreted by the coaching and performance staff, they may enable timely interventions such as substitutions and tactical adjustments during matches, as well as training-intensity modification during preparation [91,228]. Analysis of tactical data, including activity zones, pressing patterns, and passing efficiency, provides insights that support strategic decision-making in real time [229]. Studies show that rotation of key players often occurs in the third group-stage match for teams that have already secured qualification, helping maintain high activity levels and readiness for subsequent knockout matches [230]. Effective integration of physiological data, tactical data, predictive outputs, and AI-generated insights can aid coaching staff in balancing stress, adaptation, and injury risk. By translating complex analytics into actionable interventions, coaching staff can support players in approaching high cognitive and neuromotor readiness while managing fatigue and injury risk [78,230]. The challenge lies not in the sheer volume of data, but in prioritizing and interpreting information within the context of the team’s tactical objectives, opponent characteristics, evolving match conditions, and established decision-making processes [231]. Real-time monitoring combined with predictive and AI-assisted insights may support more proactive decision-making by enhancing situational awareness and informing load-management decisions in high-stakes tournaments [232]. Furthermore, structured communication of critical metrics (e.g., physical load, fatigue, tactical indicators) to the Head Coach helps ensure that actionable insights are translated into decisions on player rotation, substitution timing, and tactical adaptations. Although large amounts of data are collected, only a subset is transformed into meaningful solutions that directly inform coaching decisions. Emphasizing this translation process is therefore critical for maximizing the practical value of performance monitoring [217].

This integrated, data-informed approach may support team performance and individual player readiness throughout the tournament cycle, provided that outputs are interpreted within the tactical context and combined with expert coaching judgment. Recent approaches involve integrating AI and machine learning for tactical forecasting. They highlight the need for close collaboration between computer scientists and sport scientists to optimize predictive accuracy and guide future research directions [223]. In addition to physiological and tactical metrics, integrating cognitive and psychological indicators, such as decision-making speed, attentional focus, and perceived readiness, can further enhance player-specific interventions and tactical planning [233]. Leveraging individual player profiles allows coaching staff to tailor load management, rotation strategies, and recovery protocols,

Table 7
Summary of operational strategies for analytics-driven performance and load management (Neurocognitive Domain, Recommendation VII).

Priority	Evidence Certainty	Intervention / Action	Description	Key Parameters / Monitoring Criteria	Frequency / Timing	Responsible	Logistical Complexity / Feasibility	Adaptive Recommendations
High	High evidence [22,78,230,254]	Real-Time Monitoring for Player Management	Adjust rotations, substitutions, and workload dynamically using real-time data to support team performance and manage injury risk	Primary: Workload trends, HRV deviation, RPE, high-speed running and sprint load; Secondary: cognitive load, CMJ, wellness	Continuous during matches and training; adjust microcycle according to match density	Primary: Head Coach, Fitness Coach, Performance Analyst; Supporting: Sport Scientist, Medical Staff	High – requires integrated monitoring systems, trained staff; feasible with prior setup	If technology limited → consider prioritizing key players or critical match periods; focus on core metrics (HRV, workload, cognitive load) and log decisions for future adjustments
Medium	Moderate evidence [216,217,221]	Multi-Source Data Integration	Combine GPS-derived metrics, heart rate, fatigue indices, recovery, sleep, tactical, and cognitive data into a coherent framework to inform tactical decisions and substitutions	Primary: Integrated load and fatigue score; Secondary: match scenario performance, cognitive alertness	Daily review and pre/post-match; update per microcycle	Primary: Fitness Coach, Assistant Coach, Sport Scientist; Supporting: Performance Analyst	Moderate – requires coordination of multiple data streams; feasible if workflow pre-defined	If integration constrained → consider focusing on highest-priority metrics (workload, recovery, key tactical indicators); document adaptations and review effectiveness post-session
Supporting	Moderate evidence [22,218,227]	Validated Devices & Real-Time Visualization	Use scientifically validated wearables and dashboards to provide clear actionable indicators for coaching staff, ensuring valid and reliable data	Primary: Device accuracy, HR/HRV, GPS-derived metrics reliability; Secondary: sleep monitoring, mobility	Continuous data acquisition during sessions; update dashboards pre/post training/match	Primary: Performance Analyst; Supporting: Sport Scientist	Moderate – requires devices, software dashboards, and trained staff; feasible with pre-deployment	If devices limited → consider rotating monitoring among players; emphasize validated indicators (HRV, CMJ) and note responses to guide subsequent sessions
Supporting	Moderate evidence [218,219,223]	Predictive & AI-Assisted Models	Apply validated predictive models, where data allow, to flag performance declines, fatigue patterns, and tactical vulnerabilities	Primary: Fatigue forecasts, performance decline probabilities; Secondary: predicted tactical vulnerabilities; track tactical patterns from WC cycle start	Daily/weekly trend analysis; adjust per microcycle and match schedule	Primary: Data Scientist, Performance Analyst, Fitness Coach; Supporting: Sport Scientist	High – requires data modeling expertise, validated predictive tools; feasible with structured workflow	If predictive tools unavailable → consider using historical trends and subjective monitoring to inform proactive decisions; log outcomes to refine future model use and support evidence-based adjustments

Note: Epistemic classification of operational recommendations: High = empirical sport science evidence; Moderate = applied/consensus-based evidence; Expert-informed = practitioner-derived operational heuristics.

supporting performance and injury-risk management [234]. Maintaining a feedback loop by regularly evaluating outcomes against model predictions helps ensure that interventions remain contextually valid and that staff can dynamically adjust strategies for each player and match situation [223].

6. The tactical-collective domain

6.1. Pillar VIII. Tactical efficiency: Manage substitutions, energy, and match rhythm

Use substitutions strategically to sustain intensity and exploit tactical flexibility.

6.1.1. Core idea

In football tournaments, success depends not only on the squad's rotation and the chosen "starting eleven," but also on the team's ability to adapt tactically and physically. Optimal use of substitutions and management of game rhythm maintain high intensity, player freshness, and tactical advantage in tournaments with a dense schedule [235,236]. Slowing the match down when needed, accelerating during attacking phases, or using substitutions to change momentum is an essential part of tactical adaptability. Player rotation and flexibility in game structure reflect strategic adaptability and conscious resource management. A key challenge for coaching staff is balancing player deployment to manage cognitive load, maintain attention, and sustain decision-making quality under match pressure [237]. Effectiveness can be evaluated through player load, substitution patterns, and tactical outcomes to support sustained intensity and focus.

6.1.2. Scientific rationale

Research shows that in tournaments with matches every 3–5 days, fatigue accumulates unevenly and can increase disproportionately over successive matches [66,238–240]. This heightened fatigue can lead to declines in effort intensity and decision-making quality. Physiologically, muscle glycogen depletion and neuromuscular fatigue reduce sprint capacity and high-intensity running, while central fatigue slows reaction times and impairs executive function [70,189,241]. Psychologically, sustained high-intensity exposure increases mental strain and reduces attentional focus, compromising tactical decisions in critical match phases [237]. Strategic substitutions and careful management of match rhythm help mitigate these effects, primarily preserving physical output and team structure while indirectly influencing tactical dimensions by maintaining pacing and game control. Monitoring players' physiological, tactical, and observable behavioral indicators during matches, complemented by periodic cognitive assessments, may help coaching staff identify fatigue-related trends and inform substitution decisions, supporting physical output and tactical performance during congested tournament schedules [242,243].

Offensive substitutions enhance space control in the attacking third and increase goal-scoring opportunities, while defensive substitutions improve team compactness and defensive effectiveness [244]. Substitute players maintain collective high-intensity sprint output and pressing, which in turn helps preserve team compactness and tactical execution during decisive phases of the match. Considering the specific playing position and tactical role of players is crucial to maintain overall team effectiveness. Studies indicate that substitutions made at appropriate moments during a match can maintain sprint dynamics, pressing quality, and rapid decision-making ability in the second half, potentially supporting improved match outcomes [245–247]. Substitutions have also been shown to influence match pace [125]. They help teams sustain high-intensity running and disrupt opponent momentum in the final 15 min of matches [248]. In addition to physical effects, timely substitutions can boost player motivation and collective focus by reducing psychological strain on key players through fresh teammates and planned rotations [249]. Strategic substitutions may influence collective pacing and workload distribution, potentially helping teams maintain attentional focus and effective pressing, and counter-pressing during high-intensity phases. In congested tournament schedules, deliberate rotation strategies through substitutions allow coaching staff to micro-manage cumulative load. This approach balances physical output and cognitive readiness across successive matches, reflecting findings on rotation management by Lorenzo-Martínez et al. [244]. Overloading players without rotation increases the risk of intensity reductions, technical errors, and injuries [22,65].

The five-substitution rule has become particularly important in managing player load in high-intensity tournaments. Following its introduction, the average number of substitutions increased by approximately 48%, resulting in more even distribution of effort and reduced declines in performance during the final stages of matches [235]. Further research by the same authors [236] showed that substitute players covered greater distances and high-intensity running per minute of play compared with the players they replaced, reflecting higher relative output during their shorter playing time. This effect was most pronounced in the last 15 min of matches and even more evident in knockout games, particularly during extra time. Muscle glycogen is depleted by an additional 10–12% in these situations [70], highlighting that strategic substitutions and tactical adjustments are crucial for maintaining running performance [250]. Beyond supporting physical output, these effects directly influence the rhythm of late-game phases, enhancing tactical flexibility. Analyses by Kołodziejczyk et al. [251] on players from the top four teams at the 2018 FIFA Men's World Cup suggested that lower rotation across successive matches was associated with declines in selected running-performance indicators. Specifically, total running distance and sprint counts decreased in subsequent knockout-stage matches. Similarly, Chmura et al. [230] found that teams in the top eight of the 2018 FIFA Men's World Cup in Russia, using more frequent rotations of key players across successive matches, maintained higher running intensity and offensive effectiveness in later stages. Rotation was greater in group-stage matches for top-ranked teams, especially after winning early games, while knockout rounds required more selective rotation to protect key players. These findings suggest that thoughtful squad rotation may help maintain physical output and is associated with more stable performance indicators under high-pressure conditions, preserving tactical consistency. For example, research comparing matches before and after the introduction of the five-substitution rule in Spain's LaLiga showed that teams covered greater running distances at high speeds ($\geq$ 21.0 km/h and $\geq$ 24.0 km/h) after the increase in substitutions. This indicates improved running performance and the ability to maintain match intensity during the final phases under congested conditions [252]. Overall, careful squad rotation and effective use of substitutions may help sustain performance and tactical flexibility in top-tier tournaments. Gabrys and colleagues [253] analyzed UEFA EURO 2024 and reported that substitutions introduced between the 60th and 85th minute were more frequently associated with favorable changes in match dynamics than substitutions made earlier in the second half. However, these observations should be interpreted within the specific tactical, contextual, and competitive conditions of each match. Collectively, these findings suggest that observational tournament data may inform substitution decision-making principles, but do not support the identification of universally optimal substitution windows across teams, tactical systems, or match situations.

Table 8
Summary of operational strategies for tactical efficiency, substitution, and match rhythm management (Tactical-Collective Domain, Recommendation VIII).

Priority	Evidence Certainty	Intervention / Action	Description	Key Parameters / Monitoring Criteria	Frequency / Timing	Responsible	Logistical Complexity / Feasibility	Adaptive Recommendations
High	High evidence [70,235, 253]	Strategic Use of Five-Substitution Rule	Apply substitutions to manage fatigue, sustain pressing intensity, and stabilize match rhythm; extra substitution in extra time helps maintain freshness or prepare key players for penalties	Primary: Player load (GPS-derived metrics, RPE), pressing intensity; Secondary: heart rate, CMJ	During matches, adjust by match context and accumulated load	Primary: Head Coach Supporting: Assistant Coach, Performance Analyst	Moderate – requires real-time monitoring and coordination; feasible if substitution plan pre-established	If match context changes → consider adjusting substitutions based on accumulated load and tactical priorities; document decisions to inform subsequent rotations
High	Moderate evidence [230,251, 252]	Rotation of Key Players in Group Stage	Protect high-workload players and maintain energy reserves for knockout rounds; may reduce fatigue-related errors and supports consistent physical and cognitive performance	Primary: Player cumulative workload, match minutes; Secondary: neuromuscular status, wellness scores	Daily monitoring; adjust rotation plan per match cycle	Primary: Head Coach, Fitness Coach Supporting: Assistant Coach	Moderate – requires tracking workload and planning rotations; feasible with established data logs	If roster depth limited → consider rotating only highest-risk players; prioritize maintaining physical and cognitive freshness for knockout stages
High	Expert-informed [244,246, 249]	Integrate Substitutes through Tactical Microcycles	Assign substitutes specific tactical roles in scenario-based drills to ensure readiness, tactical understanding, and seamless integration	Primary: Drill performance, tactical accuracy, decision-making under time constraints; Secondary: movement efficiency, neuromuscular readiness	Short sessions (≈15–20 min), multiple times per microcycle; before key matches	Primary: Head Coach; Supporting: Assistant Coach	Moderate – requires scenario design and coordination; feasible with structured sessions	If time-constrained → consider focusing on substitutes most likely to play; condense scenarios while preserving role-specific decision-making and tactical engagement
Medium	Moderate evidence [70,241, 242]	Readiness Monitoring	Track physical readiness and recovery to inform selection and rotation decisions, including optional wellness/mental load checks	Primary: GPS-derived load metrics, RPE, neuromuscular tests (CMJ, HRV); Secondary: subjective wellness, mood	Daily, Morning + Post-training; review trends across microcycle	Primary: Fitness Coach, Medical Staff	Moderate – requires devices and daily reporting; feasible with pre-defined workflow	If monitoring limited → consider prioritizing key players; use brief CMJ or wellness checks to guide immediate selection and rotation decisions

Note: Epistemic classification of operational recommendations: High = empirical sport science evidence; Moderate = applied/consensus-based evidence; Expert-informed = practitioner-derived operational heuristics.

6.2. *Pillar IX. Collective Focus: Minimize distractions and mental fatigue*

Protect mental readiness through controlled screen time, mindfulness practices, and cognitive recovery.

6.2.1. *Core Idea*

In football tournaments, maintaining collective and individual mental readiness is as important as sustaining physical intensity [255]. Mental readiness is expressed through the team's ability to sustain focus, regulate attention, and preserve composure during tactical execution. High mental load can reduce neural efficiency, slowing reaction times and impairing decision-making. Early tournament excitement can temporarily mask accumulating mental fatigue, so apparent alertness may be misleading. Constant stimuli, screen exposure, and accumulated mental load further threaten tactical cohesion. Effective teams deliberately protect attentional resources through agreed digital-use routines, structured mindfulness practices, and planned psychological recovery. Sustaining mental focus and minimizing distractions is critical for preserving attention, decision accuracy, and composure during intense tournament periods. Outcomes can be assessed via attention metrics, decision accuracy, and response times to ensure ongoing mental readiness.

6.2.2. *Scientific rationale*

Players with less efficient executive functions are particularly vulnerable under high mental loads, excessive information, or uncontrolled screen time, showing reduced attention and impaired decision-making [255,256,280]. Neuroimaging studies show that mental fatigue reduces prefrontal cortex efficiency and increases neural noise, impairing inhibitory control and attentional regulation [176,237]. These neural changes manifest as slower reaction times, reduced accuracy in tactical decisions, and diminished anticipatory processing under cumulative cognitive load in tournaments. Evidence from soccer-specific research shows that players with greater working memory capacity make faster and more accurate tactical decisions, even under auditory distraction, indicating that stronger executive functions translate into measurable performance advantages in real game-like conditions [180,281]. Structured micro-interventions, such as brief mindfulness, guided visualization, and controlled cognitive breaks, can be integrated into training and match-day routines to support attention and decision-making without adding substantial fatigue [282]. Early declines in inhibitory control, a core component of executive function, serve as a sensitive indicator of mental fatigue and can compromise tactical performance under pressure [263,283]. Recent football-specific evidence suggests that 30 min of pre-exercise social media use may increase perceived mental fatigue and negatively affect mood and communication patterns during small-sided games, although the evidence is currently limited and population-specific [257]. In football tournaments, such effects could plausibly disrupt communication and coordination between players, supporting the use of agreed phone-free periods and brief cognitive recovery routines to preserve both individual focus and team cohesion. However, early-match alertness may mask these deficits, which often become apparent only in later matches, emphasizing the need for proactive mental recovery strategies [210]. Even brief but repeated episodes of mental overload can impair anticipation speed and tactical execution, whereas maintaining focused attention protects players from distracting stimuli and supports tactical decision-making under high-pressure conditions [283,284].

Mindfulness practices, breathing techniques, and short mental breaks enhance alertness, reduce stress, and accelerate the recovery of cognitive functions [258,285]. While evidence from elite football is emerging, much of the current support for these interventions is derived from broader sport and performance psychology literature, with acute effects primarily observed in attentional regulation, perceived stress reduction, and short-term cognitive recovery during congested competition periods [259,286]. Meta-analytic evidence shows that

Table 9
Summary of operational strategies for maintaining focus and minimizing mental fatigue (Tactical-Collective Domain, Recommendation IX).

Priority	Evidence Certainty	Intervention / Action	Description	Key Parameters / Monitoring Criteria	Frequency / Timing	Responsible	Logistical Complexity / Feasibility	Adaptive Recommendations
High	Moderate evidence [255-257]	Manage Digital Exposure	Promote agreed digital-use routines and reduce excessive screen, social media, and information exposure to preserve focus, maintain mental readiness, and support tactical decision-making under pressure	Primary: Adherence to agreed digital routines; Secondary: subjective focus, reported distractions	Daily, throughout tournament; reinforce pre-training and pre-match	Primary: Head Coach, Sport Psychologist; Supporting: Assistant Coach	Low – relies on team rules and monitoring; feasible	If adherence is difficult → prioritize critical periods; use reminders, digital curfew alerts, and brief team check-ins to reinforce shared routines
High	High evidence [258-260]	Short Mindfulness & Breathing Routines	Use 2–5 min mindfulness, body-scan, or controlled breathing before training/matches to support concentration, emotional regulation, and mental readiness	Primary: Session completion; Secondary: pre/post focus or stress ratings	Daily, pre-training or pre-match	Primary: Sport Psychologist; Supporting: Assistant Coach	Low – requires minimal time and space; feasible	If time-constrained → integrate into warm-up or immediately before substitutions; focus on highest-risk players and consider combining with short cueing prompts to maximize attention benefits
Medium	Expert-informed [210,261, 262]	Structured Mental Breaks & Recovery Blocks	Integrate planned mental rest to reduce overload, restore attention, and maintain consistent decision-making under congested schedules	Primary: Scheduled recovery blocks; Secondary: perceived mental fatigue, RPE	Daily, microcycle-dependent; adjust by match intensity	Primary: Head Coach; Supporting: Assistant Coach	Moderate – requires schedule planning and staff adherence; feasible	If schedule tight → shorten break duration or combine with low-intensity physical recovery periods; consider maintaining minimal cognitive restoration for highest-risk players
Medium	Expert-informed [176,237, 263]	Monitor Mental Fatigue	Detect early signs of mental decline using self-reports and simple vigilance/reaction-time tests; adjust mental load accordingly	Primary: Reaction-time scores, vigilance tests; Secondary: subjective fatigue, sleep quality (including wearable-derived metrics)	Daily, pre/post-training or post-match; review trends	Primary: Sport Psychologist; Supporting: Sport Scientist	Moderate – requires short assessments and recording; feasible	If testing limited → prioritize high-demand players or post-congested matches; use brief self-report scales or simplified vigilance cues for rapid assessment

Note: Epistemic classification of operational recommendations: High = empirical sport science evidence; Moderate = applied/consensus-based evidence; Expert-informed = practitioner-derived operational heuristics.

mindfulness-based interventions improve critical psychological states (flow, attentional control) and competitive performance outcomes in athletes, supporting their use as a reliable cognitive recovery strategy in high-pressure contexts [259]. Practical methods include brief 2–5-minute body-scan or guided mindfulness sessions before training. Short 2–3-minute breathing breaks during exercise and brief visualizations of key match situations can enhance attentional control and reduce mental fatigue [260]. Even brief rest breaks or structured micro-interventions during periods of high cognitive load can reduce perceived mental fatigue. Consequently, this supports attentional restoration, facilitating better decision-making and tactical execution in high-pressure tournament conditions [261]. In tournaments with matches played every few days, managing mental fatigue becomes crucial for maintaining tactical efficiency, as players must perform under combined physical and psychological strain [210,237]. Appropriate management of free time and the introduction of mental routines can support focus, enable faster reactions in critical moments, and help sustain team cohesion throughout the tournament. Designing the team hotel as a holistic ‘safe space’ can further enhance recovery, supporting not only rest but also social and emotional restoration. From an applied perspective, mental recovery should be understood as an active process, not merely the absence of cognitive demands. Strategies that facilitate attentional restoration, such as reducing information density, limiting exposure to emotionally charged stimuli, and providing periods of cognitive disengagement, may help restore executive functioning and stabilize performance [262].

Research has also shown that mental fatigue depletes executive-control resources and slows perceptual processing, which means that even low-level but continuous cognitive stressors can accumulate and affect performance consistency [256,283]. Therefore, teams may consider structured periods of reduced digital exposure, where appropriate and consent-based, as well as structured mindfulness or meditation sessions to restore attentional control and emotional balance [287]. These brief psychological recovery strategies, combined with adequate sleep and relaxation time, reduce neural noise and improve prefrontal efficiency, supporting better anticipation, focus, and tactical execution under pressure [130,285,288]. Integrating subjective monitoring (self-reports) with cognitive-focused vigilance or reaction-time tests, such as the Brief-Psychomotor Vigilance Test (B-PVT), allows staff to detect early signs of mental fatigue, distinguishing it from purely physical readiness [237]. However, introducing unfamiliar tests can itself become a cognitive stressor, so assessments should only be used when their informational value outweighs the potential mental cost to players. For example, guided meditation, short naps, or regulated breathing routines can be implemented proactively to help preserve match-critical mental readiness [289]. Current literature reviews highlight the need for more ecologically valid studies on mental fatigue in football, while also supporting the cautious implementation of practical strategies to preserve players’ executive functions, concentration, and decision-making during tournaments [189,290]. Collectively, these findings suggest that structured cognitive recovery strategies may help maintain mental readiness and tactical performance across congested tournament schedules, although further ecologically valid evidence in elite football is needed.

6.3. Pillar X. Collective resilience and team cohesion: Build one mind, one team

Foster mental strength, leadership, and team spirit to thrive under tournament pressure.

6.3.1. Core Idea

Success in high-intensity tournaments relies on teams’ psychological resilience and cohesion, helping players stay focused, manage pressure, and execute tactics effectively [264]. Players with higher mental fortitude sustain attention, regulate stress, and make accurate decisions, while collective processes enable teams to absorb adversity, adapt, and stay coordinated under pressure. Cohesive teams with a strong shared identity communicate effectively, coordinate actions seamlessly, and provide mutual support in critical moments. Cultivating a "one mind, one team" mindset supports clarity, emotional stability, and tactical execution, especially during key moments such as conceding a goal or facing setbacks. A central challenge for coaching staff is fostering collective resilience while maintaining cohesion and communication under the pressure of high-intensity matches. Progress can be monitored via team communication metrics, shared decision-making quality, observed adaptability during match situations, and players' coping responses under pressure [267].

6.3.2. Scientific rationale

Psychological resilience and team cohesion are core psychosocial mechanisms that support sustained performance under stress. They buffer teams from high-pressure effects and enable adaptive responses to collective challenges [273]. Importantly, these psychosocial resources do not merely promote wellbeing; they may contribute to effective tactical execution by supporting attentional focus, decision-making quality, and team coordination during critical match phases. High cohesion and collective resilience have been empirically linked with superior communication and coordination under pressure [268,291]. Team resilience is a dynamic psychosocial process that helps teams adapt positively under collective stress [276]. The role of psychological resilience can vary across players' experience levels; younger athletes often rely on structured support and explicit resilience training, while experienced players draw upon prior exposure to competitive stress [267]. Research indicates that team leaders play a crucial role in shaping shared values, motivation, and team cohesion within the squad [269]. This adaptation to pressure is further shaped by team culture and shared norms, which guide communication, mutual support, and coordinated problem-solving under stress [292]. Psychological resilience also engages neurocognitive mechanisms, supporting selective attention, emotional regulation, and adaptive decision-making under pressure. Furthermore, resilience helps protect players from mental fatigue during multi-stage tournaments, sustaining cognitive and emotional performance across successive matches [277]. Leaders with high emotional competencies can redirect individual player ambitions toward team goals, minimizing conflicts and reinforcing the "one for all, all for one" principle.

Teams with strong shared leadership have been reported to exhibit higher morale, greater emotional stability, and faster recovery in key performance indicators, although magnitude estimates vary depending on study design, population, and measurement approach [268]. Recent evidence also shows that structured team-building practices consistently enhance task cohesion across sports, supporting effective coordination and collective resilience [274]. Complementing this, evidence from talented athletes shows that higher team cohesion profiles enhance mental skills and stress management, supporting improved performance under challenging competitive conditions [275]. It is also important to assemble a team with complementary personality traits; a squad composed exclusively of natural leaders may struggle with coordination and decision-making. Empirical evidence in team sports shows that group cohesion (task and social) and collective efficacy are robust antecedents of team resilience. Vulnerability under pressure is reduced when teams display strong shared beliefs and interpersonal bonds [276]. A recent large-scale analysis of football matches found that shared experience and the quality of successful interactions between player pairs significantly predicted pass success and effective coordination, with higher interaction quality associated with more successful tactical exchanges and on-ball outcomes, highlighting how team cohesion and shared experience translate into measurable performance advantages on the field [291]. There is an additional need for staff to proactively manage players who receive limited or no match minutes, ensuring they remain engaged, motivated, and ready to contribute when called upon. Practical strategies help maintain cognitive readiness and mental resilience throughout tournaments [265,270,293]. Examples include pre-match rituals, guided visualization, joint mindfulness sessions, brief focus breaks, and controlled motivational cues, such as team symbols, music, or slogans. These strategies may help modulate attentional focus and pre-performance emotional states, while stress-regulation effects are more consistently supported for mindfulness- and breathing-based interventions, particularly under high-pressure competitive conditions [294]. Structured coping strategies can enhance tactical performance under pressure, reduce errors after setbacks, and support faster recovery of team morale during tournaments [266,271,295]. Problem-focused strategies help players tackle challenging in-game scenarios directly. Task-oriented approaches maintain focus on immediate tactical objectives. Emotion-regulation techniques reduce frustration or anxiety after setbacks. Together, these strategies may contribute to fewer decision errors, faster morale recovery, and more consistent execution of team tactics during congested tournament schedules. They can be applied through scenario-based drills, short mental resets, and shared team rituals. This allows coaching staff to maintain both individual and collective resilience under cumulative physical and psychological load. These exercises prepare them for the psychological demands of tournament play [272]. Structured reflection sessions, where players review individual and team performance, reinforce shared understanding, trust, and adaptive problem-solving under pressure [296,297].

Importantly, collective efficacy mediates the relationship between cohesion and resilience, highlighting its central role in sustaining team functioning under stress [276]. Finally, fostering open communication channels and peer support enhances social cohesion, mitigates negative effects of fatigue and stress, and ensures tactical instructions are executed effectively during critical match moments [278,297]. Integration of these elements into daily routines and training microcycles allows teams to sustain high mental performance, maintain focus under stress, and optimize decision-making during decisive phases of tournaments. From a self-determination perspective, cohesive team environments support more autonomous forms of motivation, which are associated with greater resilience, engagement, and sustained performance in high-pressure tournament contexts [279]. Even in teams of highly skilled athletes, research shows that shared cohesion, mutual respect, and a common sense of purpose are essential for achieving success in elite competitive settings [266]. This approach also helps protect players from cumulative mental fatigue during multi-stage tournaments, sustaining cognitive and emotional performance [277]. Importantly, a distinction should be maintained between proposed psychosocial and neurocognitive mechanisms (e.g., attention regulation, shared efficacy, motivation) and empirically observed tournament outcomes, as not all proposed pathways have been directly validated under elite competitive conditions.

Table 10
Summary of operational strategies for resilience and team cohesion (Tactical-Collective Domain, Recommendation X).

Priority	Evidence Certainty	Intervention / Action	Description	Key Parameters / Monitoring Criteria	Frequency / Timing	Responsible	Logistical Complexity / Feasibility	Adaptive Recommendations
High	High evidence [264-266]	Pre-Match Rituals & Mindfulness	Use structured rituals, visualization, and mindfulness to support focus, resilience, and stress coping; embed in technical–tactical tasks to improve cohesion without extra cognitive load	Primary: Completion of pre-match routines; Secondary: subjective readiness, focus scores	Daily, pre-match (approx. 15–30 min)	Primary: Sport Psychologist, Fitness Coach; Supporting: Assistant Coach	Low – minimal equipment, feasible in locker room or on pitch	If time-limited → focus on highest-impact players or shorten session to 5–10 min; integrate into warm-up; consider cueing prompts to maximize attention benefits
High	Expert-informed [267-269]	Shared Leadership Development	Engage formal and informal leaders to strengthen team cohesion, motivation, and adaptive responses under stress	Primary: Observed leadership behaviors, player feedback; Secondary: team cohesion rating	Ongoing, reinforced pre-match and during training	Primary: Head Coach; Supporting: Sport Psychologist	Moderate – requires monitoring and mentoring; feasible with planned interventions	If staff time limited → prioritize key leaders and rotate mentoring responsibilities; encourage peer-to-peer reinforcement; consider brief check-ins to sustain impact
High	Moderate evidence [270-272]	Coping Strategy Training	Structured coping strategies including problem-focused, task-oriented, and emotion-regulation approaches to enhance tactical execution under pressure, reduce errors, and accelerate morale recovery	Primary: Observed coping behaviors during drills/ match scenarios; Secondary: post-stress decision accuracy, morale recovery time	Scenario-based drills 1–2 times per microcycle; short mental resets pre/ post training or match	Primary: Sport Psychologist; Supporting: Head Coach, Assistant Coach	Low – can be integrated into existing drills or pre/ post-match routines	If time-limited → prioritize key players or critical match scenarios; combine with pre-match rituals or scenario drills; reinforce via shared team rituals; consider short, scenario-specific mental resets for efficiency
Medium	Expert-informed [273-275]	Team-Building & Integration	Targeted activities to reinforce trust, cooperation, and communication, supporting tactical coordination under competitive stress	Primary: Participation and engagement; Secondary: team cohesion surveys	1–2 × per microcycle; integrate pre-tournament or between matches	Primary: Sport Psychologist, Fitness Coach; Supporting: Assistant Coach	Moderate – requires planning and scheduling; feasible	If schedule congested → shorten sessions or combine with recovery/ warm-up activities; consider micro-activities that maintain trust and communication
Medium	Expert-informed [276,277]	Mental State & Cognitive Load Monitoring	Assess mood, perceived stress, and psychological readiness to detect mental fatigue or overload; adjust training and recovery accordingly	Primary: Self-report scales, brief questionnaires; Secondary: coach observations	Daily or post-training; adjust by match proximity	Primary: Sport Psychologist, Fitness Coach; Supporting: Assistant Coach	Low – quick assessments; feasible	If full assessment not possible → prioritize high-risk players or post-congested sessions; use abbreviated tools or brief self-report scales
Supporting	Expert-informed [266,278, 279]	Autonomy-Supportive Leadership	Encourage player ownership, shared decision-making, and clear role definition to enhance engagement, responsibility, and collective resilience	Primary: Observed autonomous behaviors, feedback; Secondary: team engagement metrics	Ongoing, throughout tournament	Primary: Head Coach, Sport Psychologist; Supporting: Assistant Coach	Moderate – requires observation and reinforcement; feasible	If limited staff → focus on key leaders and influential players; use structured reminders during practice and meetings; consider pairing with micro-debriefs to reinforce autonomy

Note: Epistemic classification of operational recommendations: High = empirical sport science evidence; Moderate = applied/consensus-based evidence; Expert-informed = practitioner-derived operational heuristics.

6.4. Addendum – The Transition Principle: Protect Performance Through Critical Transition Phases

Ensure performance and resilience through critical transition phases with a guiding principle of seamless transitioning "one team to another".

6.4.1. Core Idea

The Transition Principle functions as a cross-system integration framework designed to support continuity of performance adaptations between club, national team, and tournament environments. The process of ensuring performance readiness in elite football begins before players arrive at the national team camp. Seamless transitions from club to national team, supported by trust, clear communication, and aligned load management, are essential to maintain physical condition, cognitive readiness, and psychological resilience [298]. These transitions should be structured within a Recovery Individual Development Plan (IDP) to support continuity of training adaptations and player preparation. Effective implementation of transition frameworks requires structured data-sharing agreements, informed player consent, respect for medical confidentiality, and alignment on minimum viable datasets between clubs and national federations to ensure both ethical compliance and operational feasibility. Properly managed transitions can support continuity of training adaptations, limit fatigue accumulation, contribute to injury-risk management, and support tactical integration. This enables players to perform consistently at the highest level across congested tournament schedules. Even well-prepared players may show diminished performance when transitions lack continuity, trust, or coordination. This highlights the need for integrated performance systems between clubs and national teams. Effectiveness can be monitored through player fitness, recovery metrics, cognitive readiness, and integration into national team tactical plans.

6.4.2. Scientific rationale

Transitions between club and national team environments represent critical yet often underestimated phases in elite football performance management. Poorly coordinated handovers can disrupt physiological adaptation, increase cumulative fatigue, and elevate the risk of injury [299,300]. Transition phases also impose cognitive and psychological demands, as changes in tactical frameworks, staff practices and expectations, and social environment may increase mental load and transient stress responses. These demands potentially affect decision-making quality and perceived recovery status, particularly because elite athletes navigating career transitions face complex psychosocial stressors and adjustment demands that can challenge mental health and adaptive functioning [301]. It should be noted that monitoring frameworks often differ between clubs and national teams, which can complicate handovers and require pragmatic adaptation of monitoring strategies. Differences in monitoring technologies and data standards across clubs present a substantial obstacle to precise load management and informed training adjustments. Without standardized or translatable data, national team staff face challenges in making fully informed decisions on training load and recovery strategies [24]. A standardized pre-transition report including physiological (GPS-derived metrics, HRV, training load), tactical, and psychological metrics allows national team staff to tailor individualized integration strategies and maintain continuity of training adaptations [298]. Contemporary research highlights that cumulative load exposure and abrupt changes in high-intensity demands interact to influence short-term performance and injury probability [300,302]. Disrupted data continuity between environments may therefore impair accurate load recalibration during transition phases.

Oliva-Lozano and colleagues [303] proposed five practical transition phases for international soccer players: 1) preparation at their club, 2) travel to the national team, 3) integration into the national team camp, 4) match participation, and 5) return to the club. During the travel phase, efficient planning and minimization of transit stress support physiological and cognitive readiness upon arrival, reducing early adaptation challenges [304]. These phases include specific evidence-based strategies such as building trust between staff groups, sharing load and wellness data, managing jet lag and travel fatigue, and conducting structured entry and exit assessments [96,305]. During the first 48–72 h after arrival from club to national team camp or from camp to tournament, players frequently experience fluctuations in wellness, sleep efficiency, and neuromuscular performance as they adapt to new environmental and recovery conditions [31,306]. Such early adaptation challenges can reduce external load outputs and impair decision-making metrics; therefore, initial training sessions should prioritize controlled intensity, individualized rotation, and targeted recovery interventions guided by wellness scores, neuromuscular readiness, and sleep efficiency. Limited access to standardized recovery modalities and inconsistent monitoring protocols can slow adaptation, increase subjective fatigue and temporarily reduce both physical output and cognitive decision-making in early sessions or matches [307]. Structured onboarding and socialization efforts, including tactical briefings, individual psychological check-ins, and team-building exercises, support athletes' adaptation to national team systems and are associated with stronger team cohesion and clearer role understanding [308]. Empirical evidence shows that effective transition management preserves performance consistency across congested schedules while supporting players' confidence, tactical compliance, and psychological readiness [302]. Marked changes observed in elite football, such as marked reductions in autonomic markers (HRV) and decrements in neuromuscular performance (e.g., CMJ), can provide actionable indicators of early adaptation challenges and emerging fatigue, as HRV reflects autonomic regulation and recovery status and neuromuscular declines correlate with increased training intensity and perceived fatigue in professional soccer settings [42,309,310]. In practice, when logistical constraints such as limited recovery access, travel schedules, or equipment variability are present, staff must interpret these signals flexibly, prioritizing load and recovery adjustments to maintain overall adaptation without prescribing rigid interventions.

Transparent and timely communication between club-based staff and national team staff supports faster adaptation to different coaching approaches and optimizes load distribution. It also mitigates the negative effects of travel and environmental stress on recovery [304]. When both environments operate as an integrated system, they form a cohesive performance ecosystem that protects physical, cognitive, and psychological resources across competitive calendars. As Oliva-Lozano and colleagues [303] emphasize, "the handover process is not administrative – it is a performance-critical intervention." Post-tournament exit debriefs should be shared with both players and their clubs. These include detailed load data, wellness assessments, and recovery recommendations. Such debriefs support continuity, reduce the risk of overload, and enhance long-term resilience through evidence-based feedback [303,311]. Poorly managed transitions can compromise tournament preparation, making it difficult to achieve optimal readiness, as athletes may experience increased training load and adaptive challenges when moving from club to national team contexts [22,311]. This principle underscores one of the most relevant organizational challenges for national teams: coordinating high-performance processes across independent systems while safeguarding athlete continuity, health, and resilience. Measurable proxies of adaptation and resilience can be tracked to evaluate the effectiveness of transition management, supporting evidence-based decisions without prescribing operational specifics. Early trends in HRV, neuromuscular readiness indices, sleep efficiency, and wellness scores provide sensitive indicators of adaptation progress and emerging fatigue, enabling staff to interpret individual responses without prescribing specific interventions [310].

Table 11
Summary of operational strategies for managing critical transition phases (Addendum: The Transition Principle).

Priority	Evidence Certainty	Intervention / Action	Description	Key Parameters / Monitoring Criteria	Frequency / Timing	Responsible	Logistical Complexity / Feasibility	Adaptive Recommendations
High	High evidence [302,304, 309]	Entry & Exit Assessments	Evaluate player readiness, physical condition, and cognitive state at camp start/end to detect deviations and plan targeted interventions	Primary: CMJ, RPE, HRV, subjective wellness; Secondary: sleep quality, mood, cognitive test scores	Start and end of camp; additional mid-camp if indicated	Primary: Fitness Coach; Supporting: Medical Staff, Sport Scientist	Moderate – requires access to testing equipment and staff; feasible with pre-scheduled assessments	If time/staff limited → prioritize high-risk players or key starters; consider using abbreviated test battery to capture essential metrics without overloading staff
High	Moderate evidence [42,298, 303]	Individualized Development Plans (IDPs)	Develop personalized plans combining physical load, recovery, tactical integration, and psychological support to ensure smooth transition from club to national team and optimize early adaptation	Primary: adherence to individual plan, CMJ, HRV, RPE, wellness scores; Secondary: tactical compliance, cognitive readiness	Developed pre-camp and implemented continuously during first 5–7 days; adjusted based on monitoring	Primary: Sport Scientist / Fitness Coach; Supporting: Head Coach, Sport Psychologist, Medical Staff	Moderate – requires coordination across staff and access to player data; feasible with pre-camp planning	If staff/time limited → prioritize high-risk or key players; combine with Entry & Exit Assessments; consider tailoring interventions based on initial wellness and neuromuscular readiness
High	Moderate evidence [31,304, 306]	Travel & Recovery Management	Implement individualized strategies to mitigate jet lag, reduce travel fatigue, and support rapid adaptation, preserving cognitive readiness	Primary: Sleep duration/ quality, HRV, RPE post-travel; Secondary: subjective fatigue, alertness	Arrival + first 48 h post-travel; adjust per player response	Primary: Fitness Coach; Supporting: Sleep Specialist, Medical Staff	Moderate – requires coordination with travel schedule; feasible with planning	If travel schedule tight → prioritize key interventions (sleep timing, hydration, light exposure) for high-priority players; consider customizing strategies for players most affected by transit or jet lag
Medium	Expert-informed [298,303, 305]	Club-to-National Data Handover	Ensure smooth transfer of load, readiness, and performance data between club and national staff to maintain preparation continuity	Primary: Key load metrics (GPS-derived metrics, HRV, CMJ), injury reports; Secondary: wellness, training logs	Pre-camp, during camp as needed	Primary: Performance Analyst; Supporting: Fitness Coach	Low – depends on data access and standardization; feasible with structured templates	If data incomplete → focus on most recent 1–2 weeks and key performance indicators; consider which metrics are most critical to inform load adjustments
Medium	Expert-informed [303,308, 311]	Staff Communication & Trust	Maintain continuous dialogue between club and national staff regarding workload, injury risk, and training expectations to avoid conflicting instructions	Primary: Meeting notes, digital reports, confirmation of aligned decisions; Secondary: staff feedback	Ongoing; brief daily/ twice-daily digital updates or weekly meetings	Primary: Head Coach; Supporting: Performance Analyst	Low – relies on scheduled communication; feasible	If time-limited → use concise digital reporting or delegate communication to key staff members; consider who is best placed to ensure aligned decisions and maintain trust

Note: Epistemic classification of operational recommendations: High = empirical sport science evidence; Moderate = applied/consensus-based evidence; Expert-informed = practitioner-derived operational heuristics.

7. Limitations and critical considerations

This framework is based on a non-systematic narrative synthesis of the literature combined with a structured expert consensus process [312]. As such, it does not follow a formal systematic review methodology or preregistered protocol, and conclusions should be interpreted accordingly. While systematic monitoring and data-driven decision--making form a cornerstone of this framework, it is important to acknowledge that greater monitoring volume does not inherently translate into better decisions. Coaching staff operating under tournament time pressure face a genuine risk of data overload and information paralysis, whereby an excess of metrics may obscure rather than clarify the most actionable signals. This framework is therefore intentionally designed to guide prioritization – helping coaches and performance staff distinguish what matters most from what is merely measurable, while preserving expert judgment as the final arbiter of all performance decisions.

Furthermore, monitoring systems are not infallible – false positives, measurement error, and limited ecological validity of laboratory-derived thresholds must be acknowledged when translating metrics into field-based decisions. The reproducibility of certain recommendations across different competitive contexts, squad compositions, and resource levels remains an open empirical question. Applied decision-making under tournament conditions inherently involves uncertainty, and this framework should be understood as a structured guide to inform, rather than replace, the contextual judgment of experienced practitioners. In addition, some conceptual constructs and applied interventions included in this framework, including the Psychomotor Fatigue Threshold (PFT), related neurocognitive markers, and Brain Endurance Training (BET), remain incompletely validated in elite international tournament environments. Evidence supporting these constructs is therefore partly indirect and extrapolated from laboratory, training, or domestic competition contexts. Furthermore, implementation feasibility may vary substantially across national team environments due to heterogeneity in staffing structures, technological resources, data infrastructure, and monitoring capabilities across football federations. This variability may influence both the precision and consistency of applied recommendations. Although some principles may be relevant to elite women's international football, the present statement primarily reflects evidence and practitioner experience from men's elite football. Future work should examine whether and how this framework can be adapted and refined for women's international tournaments.

8. Summary. The "Ten Performance Pillars" as a Compass for Modern Preparation for International Tournaments

The Ten Performance Pillars are not intended as dogma, but as a practical guide for coaches, analysts, and performance staff preparing squads for the biggest football tournaments such as the FIFA Men's World Cup, as well as for other major international tournaments (Fig. 2). Fig. 2 operationalizes the proposed framework by illustrating how multidimensional monitoring inputs are translated into interdisciplinary interpretation, targeted interventions, and tournament performance outcomes, while the Ten Performance Pillars and the Transition Principle operate across all layers under contextual constraints. The present statement represents the expert interpretation and recommendations of the authors, informed by the current literature and expert practice. The principles are grounded in available scientific evidence, applied practitioner knowledge, structured expert interpretation, analyses of global football, and the experience of practitioners working at the front line of professional football. These guidelines were agreed upon by the authors based on a review of scientific literature and extensive practical experience with elite international tournaments. In addition, the Transition

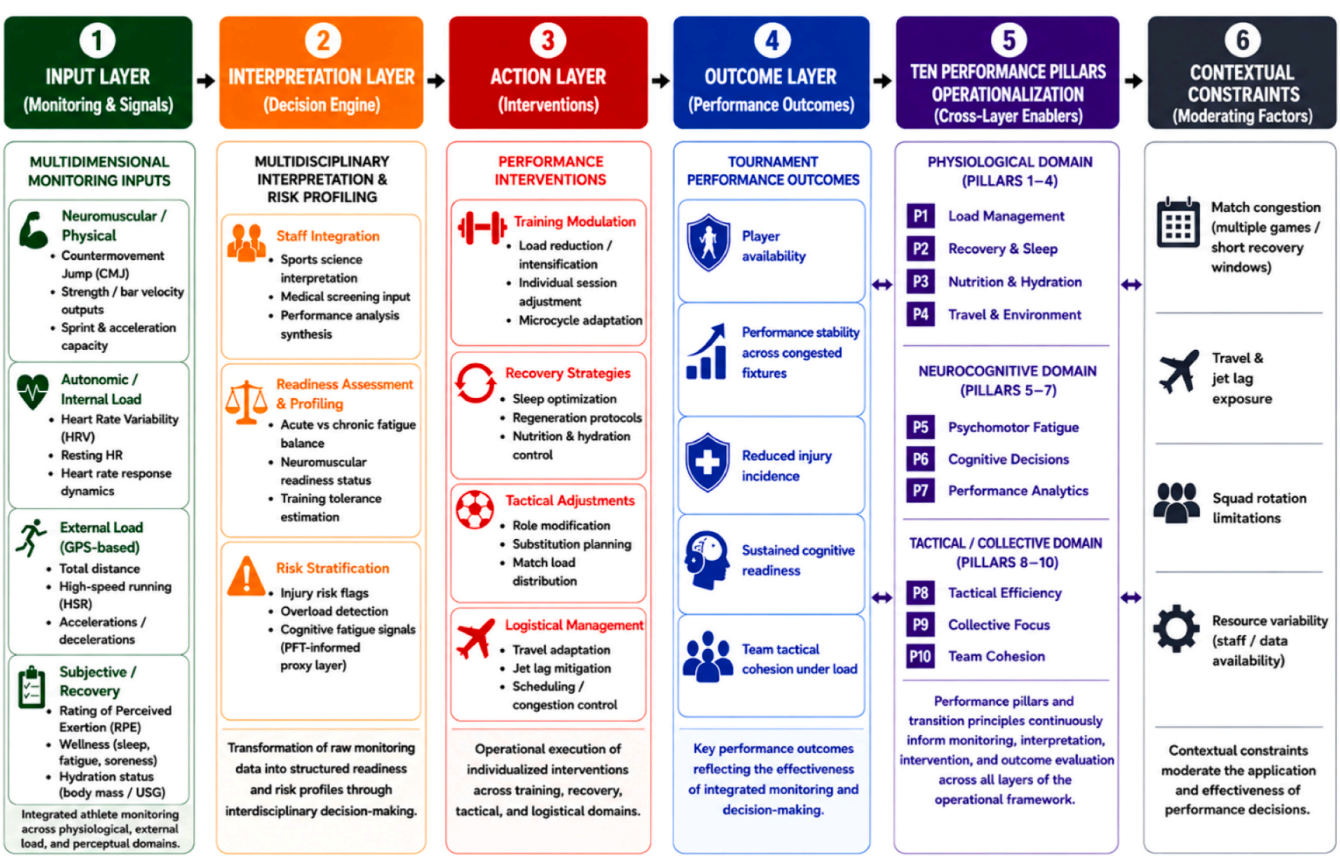

Fig. 2. Operational translation of the ten performance pillars under tournament-specific conditions.

Principle emphasizes the importance of protecting performance during critical transition phases before, during, and after tournament competition. Each pillar highlights a different dimension of effective tournament preparation, ranging from load management, recovery, nutrition, and environmental adaptation to cognitive performance, analytics-driven decision-making, tactical efficiency, collective focus, and team cohesion.

In contemporary football, the real competitive edge belongs to teams that can integrate data-driven insights with intuition and empathy, applying rigorous science and the human dimensions of leadership in each specific context. International tournaments may involve teams playing up to eight high-intensity matches, including multiple 120-minute challenges, over a typical FIFA World Cup period of about 30–35 days. These tournaments are not only a test of physical endurance but, above all, the resilience of systems, relationships, and structures. For this reason, each pillar is intended to encourage reflection, interdepartmental collaboration, and the cultivation of a culture open to knowledge and innovation.

Across all pillars, the repeated emphasis on monitoring reflects the reality that modern tournament performance emerges from continuous feedback loops between load, recovery, cognition, and decision-making. Advances in wearable technologies, integrated data platforms, and AI-supported analytics now allow staff to capture these dynamics with greater precision and timeliness, even under the constraints of congested international tournaments. Integrating data-driven frameworks, including structured PFT and BET assessments, can support individualized decisions on load management, recovery, and tactical interventions, while preserving the central role of coaching expertise. In this context, systematic monitoring does not replace coaching expertise, but augments it by enabling informed, individualized adjustments that support player availability and performance throughout the tournament.

The Ten Performance Pillars are intended to serve as a starting point for further discussion, the exchange of experiences, and the joint development of the coaching environment. This evidence-informed framework supports a conscious and interdisciplinary approach to tournament preparation in the spirit of the motto "science meets performance." The pillars offer clear guidance while allowing adaptation to the team context and individual player characteristics. This ensures their relevance across different competitive environments. Ultimately, excellence in the world's most important tournaments depends not only on the players but also on the entire support team behind them. The effectiveness of each pillar can be monitored through context-specific indicators such as HRV trends, neuromuscular readiness, wellness scores, tactical outputs, and cognitive metrics. Interpreted collectively, these data can help staff adapt load, recovery, and tactical interventions while preserving expert judgment as the central decision-making authority.

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Declaration of Generative AI and AI-assisted technologies in the writing process

Artificial intelligence (AI)-assisted tools were used for the preparation of figures, schematic illustrations, and language refinement of the manuscript. All scientific content, interpretations, and conclusions were developed and critically verified solely by the authors, who take full responsibility for the final version of the manuscript.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Data availability

No data was used for the research described in the article.

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