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REVIEW

Translating physical training theoretical framework to soccer practice: a narrative review

Carlo Simonelli[1,2] · Damiano Formenti[1] · Athos Trecroci[3] · Alessio Rossi[4]

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Abstract

Background In contemporary soccer, effective athlete monitoring is essential for optimizing training and enhancing performance.

Aim This narrative review applies Jeffries et al.'s conceptual framework of physical training to the context of soccer, aiming to assess its external validity and identify redundancies and gaps within current literature.

Methods Highly cited and conceptually relevant studies were prioritized from PubMed, Web of Science, SPORTDiscus, and Google Scholar to populate the framework, which outlines a structured training process in which external training load (ETL), internal training load (ITL), and training effects—categorized as acute/chronic and positive/negative—interact within a system influenced by individual and contextual factors.

Results and Conclusions Findings show an evident alignment between the framework's components and soccer-specific research. Numerous studies validate the ETL–ITL distinction and highlight the relevance of contextual elements (e.g., match congestion, opposition level) and individual characteristics (e.g., playing position, psychophysiological status). Additionally, subjective wellness metrics and psychometrically sound monitoring tools play a role in evaluating adaptation, recovery, and fatigue, particularly in high-demand environments. It further supports the classification of training effects and sport performance outcomes into distinct yet interconnected constructs. This narrative review serves as a foundational reference for advancing knowledge in soccer training, offering insights into refining monitoring practices to optimize player performance.

Keywords Training monitoring systems · Training variables · Training effect · Performance outcomes · Individual and contextual factors · Football

Introduction

Soccer is one of the most extensively researched intermittent team sports [1]. Indeed, scientific work in soccer has contributed knowledge to the natural and physical sciences, medicine and social sciences [1].

✉ Athos Trecroci
athos.trecroci@unimi.it

1 Department of Biotechnology and Life Sciences, University of Insubria, Varese, Italy

2 Sport Science Department, Vero Volley, Monza, Italy

3 Department of Biomedical Sciences for Health, University of Milan, Milan, Italy

4 Department of Research and Development, Feel Good Plus S.R.L. - MyPowerSet, Rome, Italy

Given the breadth of research on soccer training, conceptual frameworks are useful to synthesize evidence, clarify the phenomenon under study, inform future research, and guide practice. Within the scientific process, such frameworks allow more precise hypothesis formulation, even when primary theories are refined following failed predictions [2].

The need for individualized workloads means that monitoring should be rigorous, integrated, continuous, and multifaceted, combining GPS-derived data with subjective wellness scales and biochemical markers to capture a holistic profile. Similar challenges are shared with other team sports. Large volume of monitoring data is now routinely collected. However, these variables are often used or combined without a clear theoretical foundation, generating complex analyses based on poorly defined constructs. This may introduce bias and error, ultimately affecting decision-making. Therefore, a conceptual and effective monitoring strategy should

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integrate the latest developments and innovations in sport science.

Several theoretical frameworks have been developed and are currently used in the field, often guiding the research for practical solutions to issues in training individualization and load management. Recently, Jeffries et al. [2] proposed an intriguing and comprehensive model of physical training, introducing several expanded concepts. In this framework, the training prescription provided by coaches results in an external training load (ETL), defined as the quantification of an athlete's activity during the training session [2]. The physiological and psychological responses to this activity are collectively referred to as internal training load (ITL), which can be assessed through subjective or objective measures. For a given prescription leading to the same ETL in two or more subjects, ITL can differ between each one of them due to individual (e.g. characteristics of the individual athlete such as genetics, psychological traits and states, training background, etc.) and/or contextual (e.g. environmental, social, cultural) factors.

All outcomes resulting from single or multiple training sessions are referred to as the training effect. These occur at different levels and can be classified as acute and chronic, and as positive or negative adaptations, yielding four interconnected elements of the construct. The resulting adaptation, again mediated by individual and contextual factors, leads to sport performance outcomes, which can improve, decline, or remain unchanged. Classifying training and monitoring methodologies improves knowledge sharing and verifies scientific validity. This would help practitioners to make more informed decisions. Furthermore, a practical framework can highlight gaps and redundancies in the international literature on soccer.

The aim of this narrative review is to apply this conceptual framework to soccer, illustrating the relationships between imposed stimuli (e.g. ETL), the perceptions they generate (e.g. ITL), the subsequent adaptations (e.g. training effects), and their impact on sport performance outcomes [2].

Search methodology

Given the narrative nature of this review, a structured but non-systematic approach was adopted to identify relevant literature. We searched the electronic databases PubMed, Web of Science and SPORTDiscus as primary sources, and from Google Scholar as a secondary source, for peer-reviewed English-language articles published before 2023. We excluded articles that focused primarily on: (i) injury epidemiology or prevention without explicit links to training load or monitoring; (ii) talent identification or long-term career development; (iii) isolated video-match or notational analyses with no direct implications for the training process; and (iv) case reports, editorials or conference abstracts. Overall, approximately 150 potentially pertinent records were screened, from which we prioritized highly cited and conceptually relevant studies to populate the framework.

Training process framework overview

Exercise prescriptions

In the conceptual framework by Jeffries et al. [2], training prescriptions can be described as short (single training session) to long (multiannual periodization) plans that define the nature and organization of the exercises/training sessions intended to target factors causally (directly or indirectly) related to sport performance. The training prescription is influenced and adapted based on performance models, contextual and individual factors, training effects, previous training load experienced by the athletes, and coach experience [2]. Hence, exercise prescriptions represent the practical implementation of the training concepts, translating them into actionable practice (Fig. 1).

External training load

The term ETL implicitly refers to the physical work performed by an athlete during a training session, as prescribed in the training plan [2]. Accordingly, the term external load encompasses both quantification and prescription in various ways, allowing for a diverse range of measures and metrics. Some common quantification methods include variables such as speed, accelerations, decelerations, accelerometer load, impacts [3–9], and level of resistance [3, 10, 11] during training or matches. In soccer, the training activities include

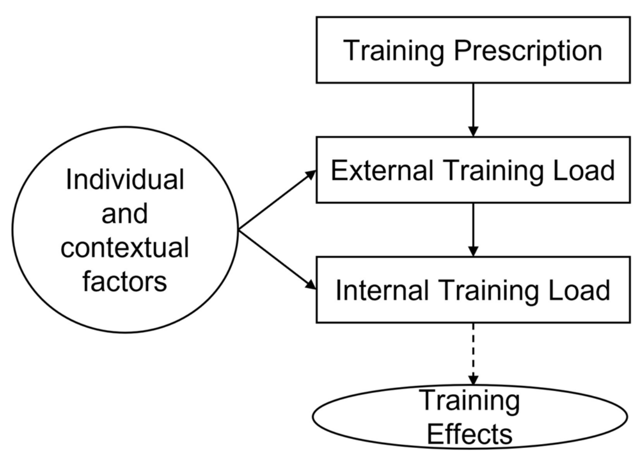

Fig. 1 Visual overview adapted from the Jeffries et al.'s framework including training prescription, external and internal training load, and training effects, mediated by individual and contextual factors

technical drills, conditioning stimuli, and small-sided games (SSG). Different SSG formats and constraints have been described by Bujalance-Moreno et al. [7]. However, when Casamichana et al. [12] and Dellal et al. [13–15] compared SSGs with friendly matches, they found that high-intensity demands were greater in the latter. Nevertheless, global workload indicators (work-rest ratio, player workload, and exertion index) and distance covered per minute were higher in SSGs compared with friendly matches. Regarding SSG formats, Aguiar et al. [16] reported that the smallest format (2 vs. 2) elicited total distance and fewer sprints than larger formats (3-,4- and 5-a-side). Indeed, Casamichana et al. [17], Cihan [18] and Aasgaard and Kilding [19] showed that imposing tactical rules (e.g., man-marking and double-man pressure) increases total distance and high-intensity running during SSGs. Moreover, Castellano et al. [20] found that total distance covered, player load, and the work-rest ratio decreased when goals and goalkeepers were included. However, these games elicited a higher number of accelerations. Arslan et al. [21] reported greater high-intensity running distance in SSGs with active rest than passive rest. Regarding coach feedback, Brandes and Elvers [22] found no differences in time-motion characteristics between feedback types, suggesting that verbal encouragement may only indirectly affect players' behaviour during SSGs. Finally, Gimenez et al. [23] observed that during SSGs, players reached their highest exercise intensity (acceleration of > 4 m/s^2) when constrained to one-touch play.

Internal training load

ITL typically refers to the body responses experienced by an athlete during an exercise or a training session. Both physiological (e.g. heart rate, EMG, salivary, blood, and muscle samples) and psychological (e.g. rating of perceived exertion—RPE) variables are representative measures of internal responses during exercise. Some physiological markers, although accurate, require invasive or impractical collection methods: blood or saliva samples and muscle biopsies are time-consuming and unsuitable for routine use, while heart rate monitoring may be uncomfortable (chest straps) and can be affected by technical artefacts and environmental conditions, especially in high-intensity intermittent efforts. Differently, RPE is one of the most widely used time-efficient tools to estimate ITL, as it is reliable, non-invasive and low-cost. Moreover, previous studies have demonstrated its association with physiological variables such as heart rate, oxygen consumption, respiratory rate, ventilation, and blood lactate concentrations [24–27]. Impellizzeri et al. [28] compared the Borg RPE scale [25] as adapted by Foster [27] with Bannister's training impulse, describing the RPE-based method as simpler, cheaper, and less invasive, while providing comparable information on training dose. However, RPE may be subject to limitations, including potential bias related to players' motivation, scale compliance, match result or coaching staff-player relationship. Moreover, diverse definitions, scales, instructions, and application strategies may concur to affect measurement validity of RPE [29].

A combination of an external measure of duration (volume) of a specific exercise or session with an internal measure of intensity (e.g. the RPE of the session, sRPE), has been used to estimate the subjective players' TL [26] (TL = sRPE × training time). Moreover, in many different team sports such as soccer, where the unpredictable nature of the game makes the TL management complex and competition occurs at least on a weekly basis, this specific subjective approach is simple, quick and inexpensive [30–32]. Hence, as players are required to peak with limited recovery between matches, monitoring internal TL is critical for practitioners for assessing the psychophysiological responses of their athletes to the external training workload stimulus performed during the scheduled training programme [33].

Training effects

Training effects can be described as the outcomes occurring after a single or multiple training sessions. In soccer, as in most team sports, all stimuli elicit both acute and chronic responses during physical, technical and tactical soccer training. The ability to manage long-term adaptations throughout the competitive season is crucial for enhancing soccer performance. Specifically, if adaptation to these stimuli lasts more than one training session but less than a week, it is considered acute. Conversely, if the recovery extends beyond a week or a microcycle, the resulting effect is classified as chronic.

Training effects can also be categorized as either positive or negative. Identifying whether training effects are beneficial or detrimental is essential for recognizing expected outcomes and optimizing training strategies. In this framework, these training effects reflect physiological and perceptual adaptations, whereas sport performance outcomes refer to how such adaptations are expressed in competition.

The Fitness-Fatigue Model explains that performance results from the balance between fitness (which enhances performance) and fatigue (which temporarily impairs it). Managing this balance is crucial in soccer, where high training loads develop fitness, but excessive accumulation can lead to overtraining. Using validated metrics to monitor fatigue and adaptation helps optimize performance during a congested competitive season [34]. Therefore, establishing clear processes to quantify training effects is essential both for validating monitoring metrics and for interpreting training variables over time.

Daily monitoring

In professional soccer, as in other high-performance sports, balancing the fatigue from matches or training sessions with adequate rest is crucial to ensure that players can train and compete effectively the upcoming day. An improper balance between exercise prescription, subsequent fatigue, and recovery can lead to an accumulation of fatigue, increasing the risk of overreaching or overtraining. Conversely, an excessive reduction in training stimuli can result in detraining. Both conditions are detrimental to performance [32]. Hence, many non-invasive monitoring tools have been developed in recent years to serve as valid and reliable indicators of fatigue and recovery status in athletes. In a real-world professional soccer scenario, those tools should be simple, quick, inexpensive, easy to administer and sensitive to a specific training effect determined by acute and/or chronic adaptations of daily training load [32].

Furthermore, in team sports such as soccer, monitoring assessments should be conducted frequently over the long and congested competitive period, starting from the preseason onward. During the competitive season, soccer players compete at least on a quasi-weekly basis, and in some instances, two to three times within a seven-day span. This scheduling highlights the need for daily monitoring tools to assess physical and psychological conditions, track changes in ITL, and evaluate both acute and or chronic training effects.

Subjective wellness scales

Subjective wellness questionnaires, comprising four or more single-item scales, have been widely used to assess athletes' day-to-day responses to training and competition [30, 35–39]. Saw et al. [40–42] reported that these subjective measures can be more sensitive to fatigue and to both acute and chronic training load compared to objective measures.

In recent years, non-invasive and psychometrically validated tools, such as the Profile of Mood States [43], Daily Analyses of Life Demands for Athletes [24], Total Quality Recovery [44], and Recovery-Stress Questionnaire for Athletes [45], have become common methods for assessing athletes' subjective status. However, these instruments are designed for weekly or monthly assessments and are therefore more suited to individual sports preparing for long-term events. In professional team sports, where matches may be played up to three times per week, their practicability is limited by the high number of items and the time required for completion. Brief validated tools such as the Acute Recovery and Stress Scale and the Short-Recovery and Stress Scale offer more feasible options for daily monitoring in team sport environments such as soccer, due to their reduced number of items and shorter completion time.

As a result, customized daily wellness questionnaires have become widely adopted in team-sports because they are quick, easy to administer, and have good face validity, even though most have not been formally validated. In Australian Football League, custom subjective questionnaires have shown sensitivity to daily, within-week, and seasonal changes in training load [35, 46]. During the pre-season, daily training load has been significantly correlated with fatigue, sleep quality, stress, mood and muscle soreness [46], while in-season, subjective ratings of nine items (i.e. fatigue, general muscle, hamstring, quadriceps, pain/stiffness, power, sleep quality, stress, well-being) have been sensitive to weekly training manipulations, unloading periods, and individual player characteristics [35]. However, caution is required when interpreting data from such custom wellness tools, as concerns have been raised about their psychometric properties and potential biases according to COnsensus-based Standards for the selection of health Measurement INstruments [2].

In soccer players, subjective ratings of fatigue, muscle soreness, sleep quality and stress have been extensively used for post-match monitoring [47–49]. In professional players, large negative correlations have been reported between fatigue and sRPE [49] and small to very large negative correlations between sleep quality, fatigue, muscle soreness, and various ITL and ETL variables [49].

These relationships highlight the importance of understanding how training stimuli shape athlete's responses and their subsequent adaptation over time. Distinguishing between acute and chronic effects, and their cumulative impact on adaption and performance, is essential for researchers and practitioners aiming to optimize training strategies in high-performance settings. In line with the proposed framework, four possible permutations of training effects can be identified: acute positive, acute negative, chronic positive, and chronic negative training effects (Fig. 2).

Acute positive effects

Responses that directly improve the sport performance outcome, induced by one or a few training sessions and requiring only a relatively short time to occur and return to baseline once training has stopped, can be described as acute positive effects. Dello Iacono and Seitz [50] showed the acute positive effects of two post-activation potentiation hip thrust-based protocols on subsequent sprint performance. Guerra Jr. et al. [51] observed that acute plyometric and sled towing stimuli enhanced jump performance in male soccer players. Their protocol also revealed a significant difference in CMJ height across conditions, with caffeine ingestion (60 min pre-test) eliciting a greater response. Morcillo et al. [52], assessed changes in metabolic and mechanical

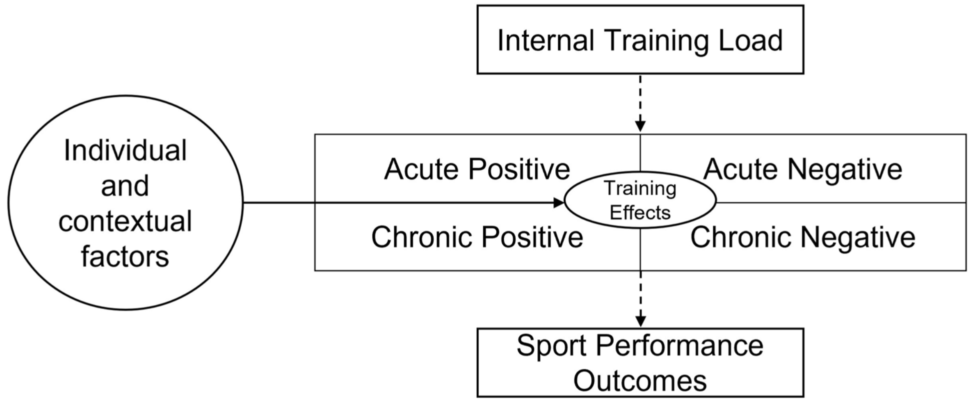

Fig. 2 Visual overview adapted from the Jeffries et al.'s framework classifying four training effects (acute/chronic × positive/negative) of the internal training load on sport performance outcomes, mediated by individual and contextual factors

responses to a specific repeated sprint ability (RSA) test. A nearly perfect correlation was found between CMJ height loss and the lactate concentration. Additionally, a moderate correlation was observed between speed loss and post-RSA ammonia concentration at the end of the RSA [52].

Acute negative effects

Responses that directly reduce sport performance outcomes, induced by one or a few training sessions and requiring only a relatively short time to occur and return to baseline once training has stopped, can be described as acute negative effects. Acute negative effects have been observed when comparing acute inflammatory responses, muscle damage and hormonal variations following eccentric training in soccer professional athletes with different ACTN3 genetic profiles (XX, RX and RR) [53]. Additionally, recovery kinetics, assessed through performance, muscle damage, and neuromuscular fatigue, after speed-endurance training have been found to induce short-term neuromuscular fatigue lasting between 24 and 72 h [54].

Extensive research on acute effect of hormonal, psychophysiological, anthropometric and contextual variables during matches has not been included in the training effects as part of sport performance outcomes [47, 55–57].

Chronic positive effects

Responses that directly improve the sport performance outcome, induced by multiple micro-cycles of training (cumulative effects over weeks, months, years) and requiring a longer time to occur and return to baseline once training is stopped, can be described as chronic positive effects. Wong et al. [58] in a concurrent muscular strength and high-intensity interval training intervention, observed improvements in strength, jump height, 10-m and 30-m sprint times, distances covered in the Yo-Yo Intermittent Recovery Test and maximal aerobic speed [58]. Askling et al. showed that the addition of specific pre-season eccentric strength training for hamstrings benefits both injury prevention and performance enhancement in elite soccer players [59]. Dupont et al. [60] highlighted improvements in maximal aerobic speed and a reduction in 40-m sprint time due to high-intensity interval training. Rønnestad et al. [61] found that one weekly strength maintenance session during the first 12 weeks of the season allowed professional soccer players to maintain the strength, sprint and jump performance gains achieved during a preceding 10-week preparatory period. Bujalance et al. [7] showed that SSGs can lead to improvements in sprint speed, RSA and change of direction, along with muscular and physiological adaptations.

Chronic negative effects

Responses that directly reduce the sport performance outcome, induced by multiple micro-cycles of training (cumulative effects over weeks, months, years), and requiring a longer time to occur and return to baseline once training is stopped, can be described as chronic negative effects. These effects may unintentionally emerge due to contextual elements (e.g. congested fixture schedules and inadequate recovery strategies) or methodological issues (e.g., poorly structured periodization and lack of individualization), potentially impacting both physical and psychological readiness. A long-term negative effect of training is not usually induced voluntarily during a pre-season or a season but can hypothetically happen in a contextual and methodological way of speaking. Casajus et al. [62] examined the seasonal variations in physiological parameters in professional soccer players and found no significant changes in mean VO_2 max between the first (65.5 ml kg^{-1} min^{-1}) and the second (66.4 ml kg^{-1} min^{-1}) test. Additionally, no significant differences in maximal heart rate or treadmill speed at VO_2 max were revealed.

Given that training effects include subjective and perceptual measures, it is reasonable considering factors such as psychological strain playing a role in chronically reducing the training effects themselves. Brink et al. [63] confirmed that chronic negative training effects extend beyond common measures (e.g., performance and physiological) and also aligning with the biopsychological model, where physical load, individual psychology, and social-contextual dynamics are seen as interacting variables that influence adaptation and performance. Unfortunately, limited information is available on this topic, and additional research is needed to expand the existing evidence within the literature. Acknowledging this interplay would enable a deeper interpretation of monitoring data and training response.

Individual and contextual factors

In many widely recognized training models, such as the IR Banister and PerPot models, any additional element related to the primary performance variable is described as an individual or contextual factor [64–66]. Unlike the IR Banister model, which primarily considers dose–response, the framework by Jeffries and colleagues incorporates contextual and individual factors in a more integrated manner. Jeffries et al. [2] defined contextual factors as those not included in the main training process (physical training), such as environmental, social and cultural influences, which can affect the training process and its outcomes (training effect and sport performance). These factors interact with all components of the conceptual framework, involving bidirectionality with training effects.

Conversely, characteristics of the individual athlete, such as training background, genetics, psychological traits and states that can influence the training process or its outcomes should be classified as individual factors [2]. These factors also show integrated and bidirectional relationships with all components of the framework. In practice, psychological state (e.g., mental fatigue) can modify physiological responses to a given external load, highlighting the interaction between psychological and physiological domains. Rampinini et al. [8] found that total distance, high-intensity running and very high-intensity running distance were influenced by the activity profile of opponent teams. They also showed that players' physical activity is influenced by their playing position. Barrett et al. [57] analyzed the relationship between sRPE and playing position, finding that fullbacks experienced higher sRPE compared to all other positions. Additionally, they examined how sRPE varied based on the quality of the opponent. Their analysis distinguished between general sRPE and its link to technical/cognitive exertion (sRPE-T), a measure capturing the mental and technical demands placed on players. Their findings indicated that sRPE-T was significantly higher in matches against top-ranked teams compared to bottom- and mid-ranked teams, likely reflecting the increased tactical complexity and cognitive (i.e., decision-making tasks) in high-level competition.

Beyond the tactical and perceptual elements, physiological responses to environmental conditions also play a crucial role in performance outcomes. Mohr et al. [67] identified the relationship between quadriceps muscle temperature and sprint performance during soccer matches. A major finding of the study was that both muscle and core temperature decreased markedly during the half-time period when players recovered passively. The lower body temperatures prior to the beginning of the second half were associated with a significant impairment in sprint performance. Conversely, when players performed a period of moderate-intensity exercise prior to the second half, body temperatures were maintained and sprint performance did not deteriorate.

Sport performance outcomes

Following the framework description, the results of the whole training process arising from the balance between the positive and negative training effects, together with the influence of contextual and individual factors (e.g., genetics, environment and psychological states) can be described as sport performance outcomes (Fig. 3). Soccer-specific outcomes can be measured in various ways using absolute (e.g. distance at different speeds, etc.), relative (e.g., metrics per minute), or aggregate measures (e.g. winning/losing, etc.). Additionally, measures of tactical behaviour can serve as lower-level (causal) dimensions or proxies. However, the validity and sensitivity of these indicators as markers of training-induced change are constrained by match-to-match variability, opponent quality, and potential measurement error that may reflect noise rather than true adaptations. Therefore, when considering only variables sensitive to training, it is important to identify which aspects of the training process affect performance.

Helgerud et al. [68], studied the effects of aerobic training on performance during soccer matches and soccer-specific tests. Their results showed that improvements in players' aerobic endurance changed soccer performance by

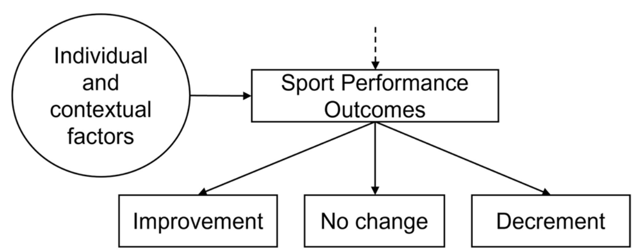

Fig. 3 Visual overview adapted from the Jeffries et al.'s framework including the three possible sport performance outcomes following the training process

increasing distance covered, number of sprints, work intensity and ball interactions during a match.

While aerobic profile performance represents a fundamental determinant of soccer-related performance, it is important to acknowledge other performance determinants. For example, technical and cognitive demands play a significant role in match performance, where sRPE-T remains elevated when facing top-tier opponents, reflecting the influence of tactical complexity and psychological strain [57].

Discussion

In this narrative review, Jeffries et al.'s theoretical framework on physical training was applied to soccer with the attempt to analyse and classify training and monitoring practices. The primary aim of this review was to evaluate the external validity of Jeffries et al.'s revised training framework by applying it to soccer contexts, and secondarily, to use it as a lens for identifying redundancies and gaps within the current literature on soccer training. We assumed that the framework would show strong external validity, indicating that its findings, conclusions and principles could extend beyond the original context and apply in wider practical soccer contexts. External validity here refers to the extent to which results from a specific model or study can be generalized across different contexts, populations, or settings beyond those initially examined.

Each aspect of this framework found relevant support within the soccer literature, with associated studies corresponding to its various constructs. Comprehensively, the external validity of the framework aligns with well-documented interactions between ETL and ITL in soccer [8, 57]. For instance, this differentiation is widely supported in the soccer literature, as observed by Rampinini et al. [8], who reported how positional and match-related variations impacted ETL metrics, such as total distance covered and high-speed running. Likewise, Barrett et al. [57], supported the influence of opponent activity and positional demands significantly affect ITL response, resulting in notable sRPE variations across playing positions and match contexts. Moreover, studies examining training effects reported that neuromuscular enhancements, such as post-activation potentiation [50] and plyometric training protocols [51], can immediately improve sprint and jump performance in soccer players. Whereas, acute metabolic responses, such as lactate accumulation and neuromuscular fatigue, can impact sprint capacity during RSA performance [52]. Altogether, these training-related conditions reinforce the framework's categorization of acute positive and negative training effects. This also extends to chronic training effects, as described by Jeffries et al. [2], also in the specific case of soccer-related studies. For example, Wong et al. [58] and Dupont et al. [60] found that high-intensity interval training and concurrent strength training protocol resulted in long-term improvements in aerobic capacity, maximal sprint speed, and RSA.

Nevertheless, not all chronic adaptations lead to positive effects. Casajus et al. [62] failed to observe significant changes in aerobic performance after a long-term training program, while Brink et al. [63] have highlighted the role of psychobiological factors in inducing negative training effects over time. However, the current literature is far from providing comprehensive insights into the chronic negative effects of these factors preceding potential decrement in the sport performance outcome. This leaves open an important area for future research in the attempt to corroborate the external validity of the framework on that specific topic.

A limitation of this review lies in its narrative approach, rather than systematic. Although narrative reviews are less rigorous and more interpretive than systematic reviews, they offer flexibility and are valuable for synthesizing complex knowledge or introducing fresh perspectives in a research field. Notably, this review highlights the contribution of soccer literature in identifying crucial individual and contextual elements that shape the coaching process. This framework innovatively broadens the understanding of these elements, showing they impact not only internal training loads but also all components within the entire training process. However, we acknowledge that applying this framework in daily practice should be done by considering several factors (e.g., interchangeability of GPS-derived metrics between providers and the variability and potential biases of subjective wellness ratings), which require specialized staff expertise and data-management resources.

Practical application

This narrative review serves as an entry point for both researchers and practitioners aiming to expand their understanding of soccer and its training methodologies. Coaches and sport scientists may also benefit from this framework to integrate GPS-derived external load, internal load measures and single-item wellness scale into their decision-making processes for better managing the weekly training load, planning recovery and reducing the risk of overreaching. The current framework provides a clear and concise overview of the operational dynamics involved in training monitoring and physical preparation. Applying the training process to soccer has resulted in a more nuanced interpretation of the original Jeffries et al.'s concepts by integrating them into a context-specific framework. Notably, all fundamental components essential for soccer training are encompassed within the framework, further reinforcing its strong external validity.

Future directions should aim to define core elements for a minimal, effective monitoring system in elite soccer, including simple tools that integrate training load, injury occurrence and basic indicators of individual load tolerance. This would enable coaches and sport scientists to evaluate a team's operational level based on the monitoring methods employed, while highlighting areas where additional or more refined monitoring could further enhance performance and reduce injury risk. The framework can be processed to enhance specificity, accuracy, and decision-making support in real-time [69].

Beyond training load monitoring, the framework could be extended to assess training tolerance and performance readiness, even though it does not encompass the entire training process. For instance, classifications proposed by Impellizzeri et al. [10], which categorize training based on organizational quality and quantity, are not included. Additionally, the framework lacks explicit considerations on injury variables, which can significantly impact performance outcomes. Overtraining and excessive exertion may result in injuries that could temporarily exclude athletes, with the extent of withdrawal depending on the injury's severity or the athlete's conditioning level.

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Author contributions C.S. conceived the review. C.S. and A.R. led the analysis of the studies and the writing of the manuscript. A.T. and D.F. provided critical feedback and helped shape the manuscript. All authors reviewed the manuscript.

Data availability No datasets were generated or analysed during the current study.

Declarations

Conflict of interest The authors declare no competing interests.

Ethical approval Not applicable, as no primary data were collected and no interventions involving human participants/animals were performed.

Informed consent Not applicable.

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