The 11 Evidence-Informed and Inferred Principles of Microcycle Periodization in Elite Football

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Periodization | Recovery | High-Speed Running | Strength Training | Load Management | Tapering | Priming Sessions | Chaos Management

Headline

In the dynamic and constantly evolving world of elite football, understanding and optimizing the microcycle periodization remains a subject of paramount importance. Prior to this review, the knowledge base primarily revolved around prevailing trends observed in practice, insights drawn from anecdotal evidence, or the perspectives of individual authors such as Verheijen (2014), Delgado Bordonau & Mendez Villanueva (2018), Campos Vázquez (2019) or Owen (2023) for example. While these contributions are valuable and well thought out, they often represent a singular viewpoint, needing more breadth and depth of collective evidence.

The comprehensive review by Silva et al. (2023), compiling GPS data from 16 studies, could be seen as a significant advancement, shifting towards a more collective and integrative understanding of the field's dynamics. However, the exclusive focus on locomotor loads (i.e., GPS metrics), albeit crucial, provides only a partial view of the multifaceted nature of a microcycle's load and contents. This gap in comprehensive data, especially regarding the relationship between these practices and match performance and injury rates, underscored the necessity for a review such as ours.

To set the foundation for our present review paper, we (i.e., Buchheit 2021a and Douchet 2022) conducted extensive surveys involving 100 and 50 top practitioners, respectively. These surveys provided initial insights into potential 'ideal' or 'optimal' patterns regarding loading, recovery days, and training content programming. However, they encountered the same limitation of not being able to establish a direct connection between these practices and performance or injury outcomes, which are pivotal aspects of football training and performance. Injuries are not just a health concern but a strategic imperative in elite football. Their management directly influences team performance and ranking, as evidenced by the negative relationship between days lost due to injuries and team success (Eliakim 2020, Hägglund 2013).

In an effort to infuse more objectivity into these programming practices, our present work meticulously scrutinizes available data and research on periodization, providing essential insights into the efficacy of diverse programming approaches in the elite football domain. We critically examine the intersection of injuries and team performance, advocating for robust injury management strategies. We employ injury data as a prism through which to evaluate training and recovery periodization, addressing the challenge of correlating programming practices with match performance, a task complicated by the lack of definitive KPIs and the complex nature of defining match outcomes (Settembre 2023).

Finally, it is worth noting that while this review brings to light key principles intersecting injuries and team performance, there are undoubtedly numerous other training principles worthy of discussion. However, in the absence of robust evidence and research, we've chosen to concentrate exclusively on those principles supported by clear data and research, leaving unexplored territories for future investigation as the science and understanding of sports training evolve.

Aim

Our review adopts a structured approach, inspired by the seminal work of Raymond Verheijen (2014), to present key evidence-informed principles of microcycle periodization in elite football. While not directly adopting Verheijen's principles, this method echoes his approach by establishing a set of clear, objective guidelines as a foundation amidst the inherent unpredictability of competition and the multifaceted nature of football. This structured analysis allows for a comprehensive, empirical understanding of each principle before integrating them into a cohesive strategy, aiming to optimize performance and manage injuries effectively.

The present work addresses a critical gap in the existing literature by offering an in-depth investigation into training practices within elite football, their direct impact on injury rates, and, consequently, their implications for team performance. Given the scarcity of direct performance data as dependent variables, we employ injury rates as a proxy, understanding that they often serve as surrogate indicators of team performance (Eliakim 2020, Hägglund 2013). Our goal extends beyond academic enrichment; we aspire to empower practitioners with evidence-informed strategies to optimize player well-being and enhance team success.

To accomplish this, we embark on a chronological journey through the microcycle, meticulously examining each of the 11 key principles identified. Our exploration begins on the day following a match and progresses methodically toward the next game. The focal points of our investigation encompass:

1. Overall Load Dynamics and Content Periodization
2. Mapping Rest Days
3. Managing Post-Match Recovery and Compensation
   - 3.1 Integrating Lower Limb Recovery and Upper Body Training
   - 3.2 Compensation Training For Substitutes

4. Weekly Training Loads and High-Speed Running Management
5. Optimal Training Sequencing
6. Maximum Speed Exposures
7. Mastering Strength Training
8. Strategic Tapering Leading to the Match
9. Match Day Morning Priming Sessions

Following the presentation of these 9 evidence-informed key principles of microcycle periodization in elite football, we introduce a set of "Inferred Principles". These principles, while not directly substantiated by the same level of research, are deduced from a blend of logical reasoning, practical experience, and the theoretical foundations that underpin our understanding of elite football training and performance. They serve to bridge the gap between evidence-informed practices and the nuanced realities of implementing these strategies in the dynamic environment of professional football.

10. Running as an Intrinsic Aspect of Football
11. Embracing the Chaos

Methods

In this review, our primary focus lies on an array of studies, with the majority featuring significant contributions from the first author, though not exclusively. This selective approach lends itself to a narrative-style review, transparently acknowledging the potential bias that may arise due to our direct involvement in much of the discussed research. Nevertheless, we hold confidence in the value this paper delivers to practitioners. It amalgamates a synthesis of these recent studies with fresh and exclusive content, including some unpublished or unlikely to appear elsewhere. This unique compilation offers innovative and exclusive insights, positioning this manuscript as a source of novelty and exclusivity in the world of elite football.

Our examination of each of these topics forms the basis of the 9 key evidence-informed principles, derived from the insights gained through the scrutiny of 1 to 3 studies for each principle. These principles collectively contribute to the overarching goal of minimizing injury risks and optimizing player performance, providing a comprehensive perspective on microcycle structuring in elite football.

Principle 1. Mastering the Microcycle: Load Dynamics and Content Periodization in Elite Football. This principle delves into the comprehensive load dynamics and content periodization practices in elite football, drawing on the study "Loading Patterns and Programming Practices in Elite Football: Insights from 100 Elite Practitioners" by Buchheit et al (2021a). The study provides a detailed analysis of the weekly load dynamics, revealing a three-phase structure within the microcycle: recovery, acquisition, and tapering phases. It highlights the first couple of days post-match as dedicated to recovery, followed by acquisition days marked by a heavy load, typically lasting two days, and then a couple of days with lower intensity and volume, allowing players to recover and taper before the next match (Figure 1).

One of the key insights from the study is the fluid nature of the microcycle in response to the interval between matches. In scenarios where the microcycle is shortened, such as when there are only five days between matches, the first session to be eliminated is typically one of the mid-cycle high-intensity sessions. When the gap narrows further to four days, there is no opportunity for any high-intensity sessions, underscoring the essential balance between rigorous training and necessary recovery. This finding illustrates that the length of the microcycle, determined by the number of days between matches, is a critical factor in shaping the load and content of the training program (Figure 1).

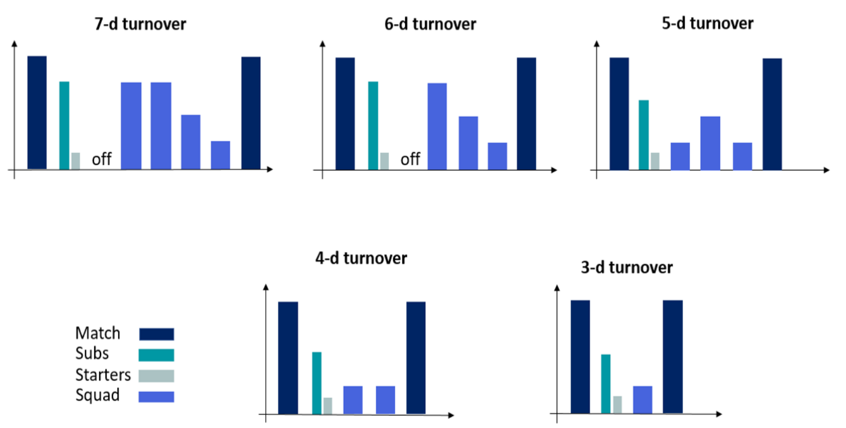

Fig. 1. Typical load periodization in relation to match turnovers. The suggested loading patterns reflect the greatest percentage of responders' preferences on each day (Buchheit 2021a).

Moreover, the study sheds light on the periodization of content within the microcycle, suggesting that some content is generally implemented consistently at specific times (e.g., High-Speed Running mainly mid-week, M-4 and M-3; strength -4), while other content, like mobility, is implemented on various day (Table 1 and Figure 2). This principle sets the stage for subsequent ones that dive deeper into the data supporting or challenging these practices, demonstrating the intricate interplay between load dynamics, content periodization, and match schedules in elite football.

Table 1. Programming preferences of selected training contents in relation to match turnovers (Buchheit 2021a).

	Days from last Match	Gym strength	Gym power	Gym hypertrophy	Pitch strength	Pitch power	Aerobic power	Endurance	High-speed running	Max speed	Resisted speed	Speed repeats	Acceleration	Agility (COD)	Unplanned agility and reaction	Prevention (structural)	Prevention (mobility, control, etc.)
7-d Turnover	D+1	23%	5%	21%	3%	3%	5%	10%	13%	4%	3%	6%	1%	1%	0%	36%	40%
	D+2	25%	9%	16%	8%	5%	12%	17%	6%	3%	4%	5%	8%	9%	8%	30%	35%
	D+3	73%	45%	26%	48%	29%	30%	23%	30%	19%	34%	30%	58%	55%	19%	65%	51%
	D+4	23%	31%	12%	13%	26%	42%	39%	64%	55%	22%	29%	27%	29%	14%	49%	45%
	D+5	19%	26%	8%	4%	16%	1%	3%	18%	25%	3%	9%	16%	25%	14%	43%	51%
	D+6	1%	13%	1%	1%	10%	1%	1%	4%	6%	1%	4%	23%	25%	38%	18%	29%
6-d Turnover	D+1	16%	4%	14%	4%	3%	4%	4%	4%	3%	0%	4%	3%	3%	0%	26%	32%
	D+2	30%	13%	16%	16%	4%	5%	14%	10%	5%	3%	6%	14%	14%	4%	29%	30%
	D+3	39%	31%	13%	27%	27%	43%	36%	52%	44%	26%	25%	36%	31%	13%	43%	32%
	D+4	8%	14%	9%	3%	8%	1%	3%	18%	19%	4%	3%	14%	13%	13%	23%	42%
	D+5	0%	4%	0%	0%	5%	0%	0%	0%	4%	0%	1%	19%	18%	30%	10%	25%
5-d Turnover	D+1	16%	4%	14%	3%	0%	5%	5%	8%	3%	3%	3%	5%	4%	1%	27%	31%
	D+2	21%	6%	6%	8%	0%	8%	9%	14%	8%	3%	4%	9%	10%	4%	31%	19%
	D+3	12%	14%	6%	5%	0%	5%	5%	18%	16%	4%	10%	21%	21%	14%	27%	34%
	D+4	0%	4%	0%	0%	0%	1%	0%	0%	4%	0%	0%	14%	9%	22%	10%	18%
4d Turnover	D+1	17%	9%	8%	8%	6%	6%	6%	12%	8%	3%	5%	8%	8%	1%	26%	26%
	D+2	6%	10%	3%	3%	6%	4%	8%	8%	1%	3%	5%	10%	13%	10%	30%	44%
	D+3	0%	4%	0%	0%	6%	3%	0%	4%	6%	0%	3%	19%	17%	26%	14%	23%
3-d Turnover	D+1	6%	6%	1%	3%	1%	4%	5%	4%	3%	1%	1%	6%	5%	5%	19%	42%
	D+2	0%	0%	0%	0%	1%	0%	0%	0%	1%	0%	1%	10%	14%	18%	16%	31%

	7-d	6-d	5-d	4-d	3-d
D-6	Prev / Gym Strength / Hypertrophy				
D-5	Prev / Gym Strength	Prev			
D-4	Prev / Gym + Pitch Strength / Acc + Agility	Prev / Gym Strength	Prev		
D-3	Prev / HSR / Aerobic Power / Max Speed	Prev Gym Strength / Acc + Agility / HSR / Aerobic Power / Max Speed	Prev / Gym Strength	Prev	
D-2	Prev / Gym power / Max Speed	Prev / HSR / Max Speed	Prev Gym power / Acc + Agility	Prev	Prev
D-1	Prev / Unplanned Agility	Prev / Unplanned Agility	Prev / Unplanned Agility	Prev / Acc / Unplanned Agility	Prev / Unplanned Agility

Fig. 2. Programming of the main training contents in relation to match turnovers. The suggested training contents reflect the greatest percentage of responders' preferences on each day (Buchheit 2021a).

Principle 2. Mapping Rest Days: A Data-Driven Approach to Scheduling Recovery Days. In the first segment of our rest day principle, we use some data from a top 5 team in one of the top 5 European leagues to examine the relationship between the number of consecutive training days and injury occurrence (unpublished data: courtesy of Kitman Labs). In Figure 3 we see a clear trend: injury rates are lower than the usual when that team limited consecutive training sessions to a span of 5-6 days. Conversely, when the training sequence extended beyond this duration, the likelihood of injuries increased. This pattern, albeit from a single team's data, tentatively supports the incorporation of at least one rest day per week to potentially mitigate injury risks. However, while these results provide helpful initial insights, it's important to note that they only reveal associations and do not establish causation. Moreover, these findings, although valuable, do not specify the optimal timing for a rest day within the training microcycle.

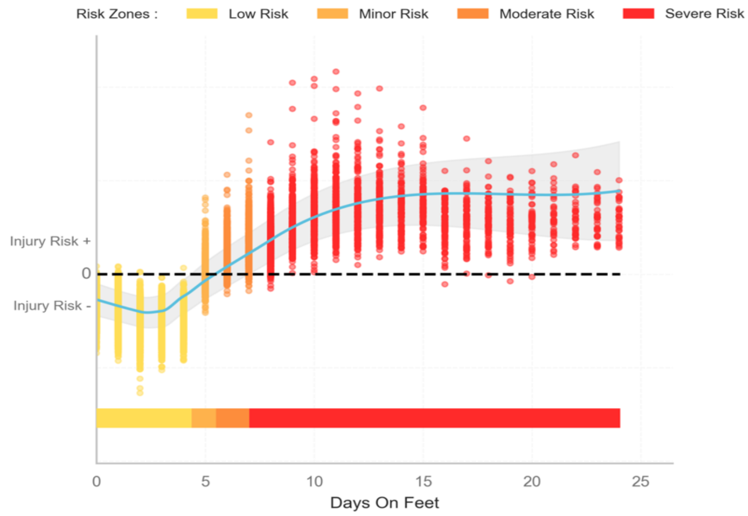

Fig. 3. SHAP feature dependence plots for injury risk vs. accumulated days on feet over 3 consecutive seasons in a top 5 European league team (110 non-contact injury occurrences).. Injury (+/-) is quantified as the magnitude of the SHAP contribution. Data source: courtesy of Kitman Labs.

This leads us to the second part of our principle, which examines the study "Planning the Microcycle in Elite Football: To Rest or Not to Rest?" by Buchheit et al (2023a). This subsequent analysis addresses the critical question left unanswered by the previous case study (Figure 3): when should the rest day be scheduled for maximum benefit? The study retrospectively analyzes data covering 56 team seasons from 18 elite teams in top leagues from January 2018 to December 2021 (total of 1578 players, 2865 injuries, 2859 non-international matches and 12939 training session days). It explores the link between rest day scheduling ('days off feet,' where players abstain from on-field training) and noncontact injury rates within microcycles of varying lengths, from 3 to 8 days.

A noteworthy revelation of the study is the significant reduction in non contact injuries when a rest day, specifically a 'day off feet,' is scheduled at D + 2 (the second day post-match), particularly within 3- and 7-day microcycles (Figure 4). The injury rates observed were 2 to 3 times lower compared to other rest day placements. Although the study is observational and does not claim causality, the results strongly suggest the effectiveness of strategic rest day positioning within the microcycle for mitigating injuries in elite football.

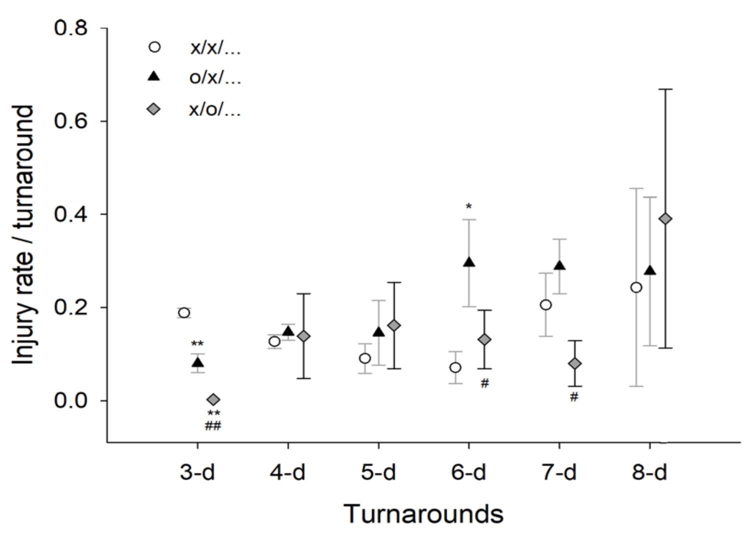

Fig. 4. Average (95% CI) total (training + match) non-contact injury rate per turnaround for the three main sequences including either no day off (x/x/...), or a unique day off either at D+1 (o/x/...) or D+2 (x/o/...) for all turnarounds. * and ** stands for moderate and large differences vs x/x/... sequence, respectively. # and ## stands for moderate and large differences vs o/x/... sequences, respectively (Buchheit 2023a).

As the first author of this study (Martin), I am particularly gratified that our findings corroborate the initial principle posited by Raymond Verheijen in his seminal work on football periodization (2014), which advocates for a rest day at D + 2 as the optimal choice. This study is an example of practice-informed research, where practical insights guide scientific inquiry, ultimately validating the efficacy of these practices through rigorous research.

Principle 3. Managing Post-Match Recovery and Compensation: A Dual Approach for Starters and Substitutes. In this section, we delve into a comprehensive principle that addresses the crucial aspect of managing training content in the first two days following a match in elite football. Recognizing the unique needs of both starting players and substitutes, a dual approach to optimize recovery and performance is generally preferred. By splitting the team into two distinct groups (Figure 1 and Table 2), practitioners aim to tailor training content to match the specific requirements of each category of players (Buchheit 2021a). Starters are often provided with a blend of recovery strategies (low-intensity aerobic conditioning, mobility and flexibility routines, massages, hydrotherapy and advanced nutritional intake) (Buchheit 2011, Nedelec 2013) and targeted upper body work to ensure their readiness for upcoming training cycle (Sabag 2021). In contrast, substitutes likely benefit from compensation strategies that encompass both gym and pitch-based activities, allowing them to maintain their physical preparedness and contribute effectively when called upon (Lacome 2018, Díaz-Serradilla 2023). This principle underscores the significance of tailoring post-match training to individual roles and needs within the team, contributing to overall squad performance and well-being (Buchheit 2021). As we delve deeper, our focus will shift towards critically evaluating the evidence that underpins these practices, with an initial emphasis on the activities conducted on D+1, under the assumption that Principle 2 is applied, positing the day off to be on MD+2. However, it is crucial to note that the occurrence of a day off on D+2 is rarer than initially presumed based on prevailing practices (Buchheit et al., 2023a). For example, Buchheit et al. (2023a) reveal, in a departure from what was previously considered optimal (Buchheit 2021a), that a day off on D+1 is more than four times more common than a day off on D+2 during 7-day turnaround intervals. This discrepancy underscores the necessity of exploring and weighing the potential practices for both days to ensure a comprehensive understanding and application.

Table 2. Practitioners' preference with regard to the programming of recovery and compensation days in relation to match turnover length (Buchheit 2021a).

	Days from last Match	Starters recovery day	Sub compensation
7-d Turnover	D+1/D-6	74%	62%
	D+2/D-5	29%	22%
	D+3/D-4	0%	5%
	D+4/D-3	1%	3%
	D+5/D-2	3%	3%
	D+6/D-1	0%	1%
6-d Turnover	D+1/D-5	78%	55%
	D+2/D-4	22%	16%
	D+3/D-3	0%	4%
	D+4/D-2	0%	0%
	D+5/D-1	0%	4%
5-d Turnover	D+1/D-4	73%	47%
	D+2/D-3	26%	16%
	D+3/D-2	1%	1%
	D+4/D-1	0%	1%
4d Turnover	D+1/D-3	75%	45%
	D+2/D-2	25%	19%
	D+3/D-1	0%	1%
3-d Turnover	D+1/D-2	94%	32%
	D+2/D-1	6%	3%

Principle 3.1 Harmony or Conflict? Integrating Lower Limb Recovery with Upper Body Training. Emerging evidence, including narrative reviews like Nedelec (2013) and real-world interventions such as Buchheit (2011), underscore the effectiveness of specific recovery strategies during the post-match 24-48h period. More specifically, the study by Buchheit et al. (2011) focused on the effectiveness of spa treatments (a combination of sauna, cold water immersion, and jacuzzi) during congested fixtures in 15 young soccer players of the Aspire Academy in Qatar. The research demonstrated that players significantly benefited from this latter strategies, showing improvements in various running performance metrics, including sprinting distance and peak match speed. While these strategies are increasingly recognized as crucial, especially during packed schedules for reducing post-match fatigue and injury risk, the role of upper body resistance training (UB RT) implemented the day after match play (MD+1) remains less certain. Initially, it was speculated that UB RT might expedite

recovery through hormonal adaptations, such as testosterone release, a theory met with skepticism. Our review (Sabag 2021) aimed to scrutinize the potential benefits of UB RT in terms of neuromuscular, metabolic, hormonal, perceptual, and immunological recovery.

The findings of our study (Sabag 2021) highlight that while UB RT, as typically implemented with low volume and intensity, does not significantly enhance recovery kinetics, it remains potentially compatible and does not impair recovery for players post-match. This supports the initial interest in UB RT, especially for injury prevention and core work aimed at pelvic stability enhancement, as discussed by Mendiguchia (2021). Importantly, the review points out that the effectiveness and suitability of these sessions can vary from player to player, advocating for a personalized approach in programming UB RT.

Furthermore, it is crucial to integrate that UB RT can also be applied with other objectives in mind, such as maximizing strength and hypertrophy, particularly in specific sub-groups of players like goalkeepers and young players in development who are in need of muscle building (Gómez 2019). For these groups, the UB RT sessions might be more demanding (i.e., higher loads and higher repetitions). However, this increased demand is generally not problematic for these populations. Goalkeepers are accustomed to these types of training regimes, and young players, often having lower playing minutes, have less to recover from. This allows for a more intensive approach to UB RT without significantly interfering with recovery processes since their recovery needs are comparatively lower.

The decision-making process for incorporating UB RT at MD+1 (or possibly at MD+2 if MD+1 is the day off) should thus take into account not only the general compatibility and potential benefits of such training in the context of recovery but also the specific goals and needs of different player groups. The provided decision tree (Figure 5) offers a structured method for scheduling UB RT, considering factors like match minutes, location, and the length of the microcycle, ensuring a tailored and effective training program that can accommodate both general recovery needs and specific developmental goals.

Despite the uncertainty surrounding the exact benefits of UB RT in terms of recovery, the study provides a comprehensive overview of the potential implications of incorporating UB RT into the post-match recovery process. It also highlights the need for further research to establish a minimally effective UB RT dose for professional soccer players within congested fixture schedules.

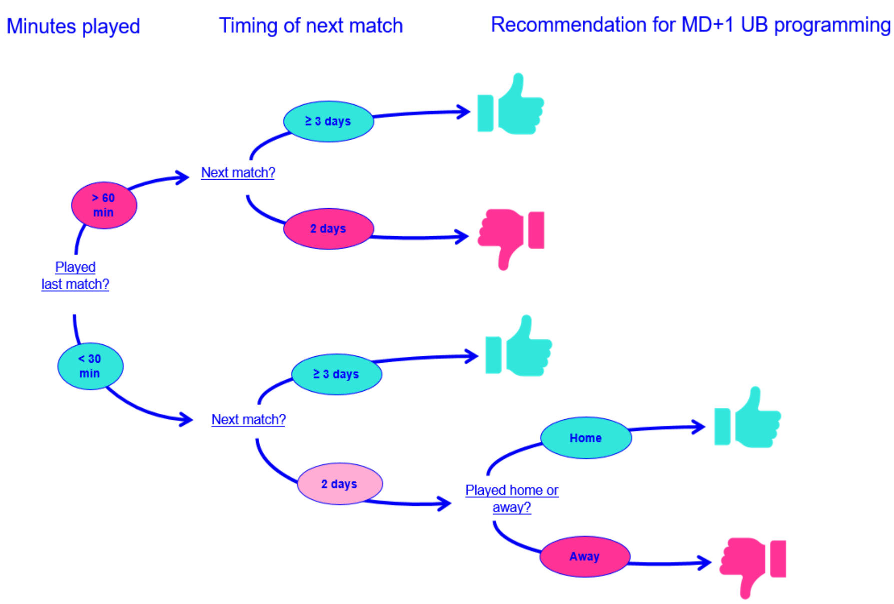

Fig. 5. Decision tree to help practitioners decide on the scheduling of such sessions based on match minutes, match location (home vs away), and the timing of the next match (i.e., microcycle lengths, days between matches) (Sabag 2021).

Principles 3.2 Strategic Training Periodization for Substitute Players. The management of training load and content at the individual level is crucial for maintaining players' performance, fitness, and health throughout the season (Morgans 2018). The rationale for this principle originates from the significant findings of Anderson et al. (2016), Moreno-Pérez et al. (2023), and Morgans (2018), which together build a compelling narrative for the necessity of high-intensity training compensation for non-starting players.

Anderson et al.(2016) embarked on a detailed analysis of the English Premier League (Liverpool FC), categorizing players as starters, fringe, and nonstarters during the 2013-2014 season. They utilized typical tracking technologies (GPS and Prozone at the time) to monitor and quantify the players' training and match load throughout an entire season. The findings were revealing, showing a clear disparity in high-speed running between starters and their less frequently used counterparts, thus highlighting a gap in physical conditioning that needed to be addressed (Figure 6).

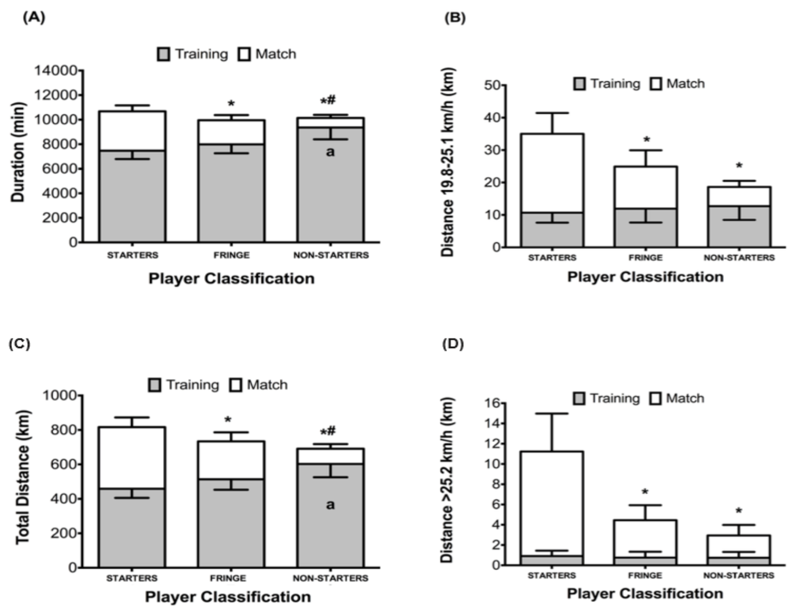

Fig. 6. Accumulative season-long (A) duration, (B) total running distance, (C) high-speed running distance, and (D) sprinting distance in both training and matches. Shaded bars = training, and open bars = matches. *Difference to starters, P <0.05 (Bonferroni corrected) (Anderson 2016).

In the comprehensive study by Moreno-Pérez et al. (2023) within Spain's 1st Division LaLiga (144 professional outfield football players listed in multiple seasons from 2 teams), the relationship between match exposure, specifically HSR, and the rate of hamstring injuries was meticulously analyzed. The study pinpointed that players with less than 45 minutes of play and insufficient HSR (less than 300m) in the preceding two matches had a markedly higher incidence of hamstring injuries. These precise findings highlight the significant rate associated with reduced exposure to match-intensity physical demands. Moreno-Pérez et al.'s work underscores the crucial need for structured training interventions, especially for nonstarters, to mitigate the heightened injury risks by ensuring adequate physical conditioning and exposure to high-speed activities.

To address the issue of underexposure for substitute players, Buchheit et al. (2021) aimed to identify optimal strategies for compensating the training load of benched and substitute players. The consensus among these 100 top professionals was that the most effective approach involves distributing the load across several days, ideally starting immediately post-match and continuing the next day. Interestingly, the survey also revealed that if the day following a match is designated as a rest day, it's advisable to postpone the compensatory training load to two days after the match. This strategy ensures a balanced approach to maintaining fitness and performance levels without overburdening the players (Table 2 and 3).

Table 3. Substitutes compensation: when? (Buchheit 2021a).

	1st choice	2nd	3rd	4th	5th
Post-match D0 only	20%	32%	11%	13%	1%
D0 and D+1	47%	24%	3%	2%	1%
D+1 and 2	13%	18%	41%	5%	0%
D0, +1 and +2	9%	7%	18%	41%	2%
Not needed	5%	0%	3%	5%	64%

In theory, substitute sessions aim to mirror actual football demands such as HSR, sprints, and mechanical work (a compound measure of acceleration, deceleration, and change of direction work, Buchheit & Simpson, 2017), compensating for missed game time. Yet, realizing this specificity faces hurdles like limited time, space, and resources, often leading to reliance on generic fitness drills. Moreover, player receptivity can be a challenge, particularly when dealing with disappointment from non-selection, exhaustion from travel, or the aftermath of late-night matches. These factors introduce added complexity necessitating a balanced approach that addresses both the physical requirements and the psychological state of the players in session planning. Lacome et al. (2018) offer nonetheless a comprehensive framework for designing compensation sessions, emphasizing the need to customize the session content to meet the specific physical demands of players (Table 4). The study underlines the importance of carefully planning these sessions to maintain physical fitness while avoiding overloading, thus ensuring that substitute players are optimally prepared for the demands of match play.

MD+1 Session (When nothing is done on MD). The session on MD+1 is designed to provide a balanced workload that addresses various aspects of physical fitness, including endurance, speed, and strength. The session spans approximately 60 minutes, covering a total distance of around 4600 meters, including 950 meters at high-speed running (HSR). The details of the session are as follows (Table 4):

Table 4. Suggested session content for a MD+1 with nothing done immediately after the match (Lacome 2018). HSR: High-speed running distance >19.8 km/h. Mechanical work: a compound measure of acceleration, deceleration, and change of direction work.

Activity	Format	Total Distance	Mechanical Work (MechW)
8v8 Small-Sided Game	2 sets of 10 min each	1900m	15
4v4 Small-Sided Game	4 sets of 4 min each	1600m	30
Max Speed Exposure >Vmax 90-95%	As per case study 6 (individualized)	>50/100m >25 km/h	5
Run-based HIIT	1 set of 6 min (15-s on / 15-s off)	800-1200 m (inc. 75% HSR) (individualized)	5
Strength (Eccentric)	-	-	-

MD Session (When MD+1 is a day off). The post-match session on MD, while effective in addressing immediate physical conditioning needs through HSR, speed work, and eccentric strength training, comes with notable limitations (Table 5). Primarily, the lack of specific football-related stimuli reduces its effectiveness, relegating it to a more generic fitness session. This absence of specificity is a significant compromise, yet it's a strategic choice to ensure that substitutes retain a certain level of physical readiness, marking it as a better alternative than a complete absence of training.

As indicated in principle 2, having a session on MD+1 should be the preferred option. This preference is based on the ability to provide a more comprehensive training session with higher volume and a broader range of physical stimuli, ensuring a more effective compensation for the lack of game time for substitute players. This approach allows for a more balanced distribution of training load, contributing to maintaining the physical conditioning and performance readiness of the substitutes.

Overall, this 3rd principle highlights the importance of considering match participation levels, training load dynamics, and specific physical demands when designing training sessions, ensuring that all players, regardless of their starting status, are optimally prepared for the rigors of elite-level football.

Table 5. Suggested session content for a MD session (with nothing is done at MD+1). HSR: High-speed running distance >19.8 km/h. Mechanical work: a compound measure of acceleration, deceleration, and change of direction work.

Activity	Format	Total Distance	Mechanical Work (MechW)
Jog/strides/mobility	Laps around the pitch	1500m	0
Acceleration Deceleration Change of Direction work	4 sets of 4 min each	300 m	15
Max Speed Exposure >Vmax 90-95%	As per case study 6 (individualized)	200 m (including >50-100m >25 km/h)	5
Run-based HIIT	1 set of 6 min (15-s on / 15-s off)	800-1200 m (including 75% HSR) (individualized)	5
Strength (Eccentric)	-	-	-

Principle 4: Strategic Load and High-Speed Running Management During the Week: Insights for Injury Mitigation and Performance. In this comprehensive principle, we delved into the intricate relationship between training loads and injury risks in elite football, with a specific focus on HSR and sprinting volumes. Our choice to emphasize HSR and sprinting was driven by the recognition that these elements are believed to be the top factors that must be managed effectively in relation to injury risk, as elucidated by the excellent survey conducted by McCall et al (2020). To do so, Buchheit et al. (2024) employed advanced machine learning models to analyze data from a diverse cohort of teams and players, further enhancing our understanding of the complex interplay between training loads and injury outcomes in elite football. The study encompassed data from 12 teams across various prestigious leagues, including the EPL, Championship, Bundesliga, Serie A, Ligue 1, Eredivisie, Scottish Premiership, and MLS. The dataset comprised 734 season-players, accounting for 1-3 seasons per club, and a total of 44,000 exposures, including 7,500 matches. The focus was on 172 non-contact injuries that occurred during the second match of a turnaround, with each injury resulting in a loss of at least 3 days.

The machine learning models, specifically eXtreme Gradient Boosting (XGBoost) combined with SHapley Additive exPlanations (SHAP), were utilized to scrutinize the impact of HSR and sprinting distances during training on match injury risks. The analysis was particularly concentrated on match turnarounds spanning 3 to 9 days, with a special emphasis on 6- to 8-day turnarounds due to their significant sample size and the notable presence of HSR and sprinting distances (Figure 7).

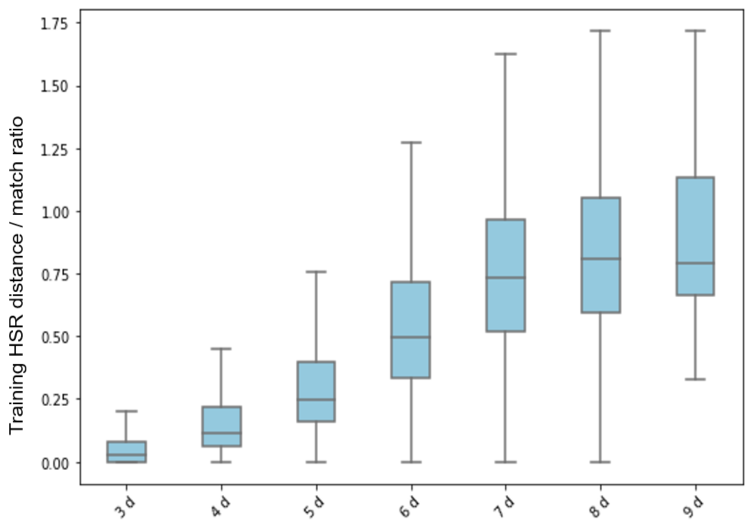

Fig. 7. Cumulated high-speed running distance (>20 km/h, expressed as a ratio of match demands) during training for each turnaround (match excluded) (Buchheit 2024).

The models indicated a non-linear relationship between training loads and injury risks, suggesting that accumulated HSR distances between 0.6 and 0.9 match load (Figure 8), and accumulated sprinting distances between 0.6 and 1.1 match load, might be associated with a lower risk of injury. However, it's crucial to approach these results with caution, as the study's design and the nature of machine learning models imply that correlation does not necessarily equate to causation. Recommendations for practitioners include closely monitoring HSR and sprinting distances, considering the specific context of each team and player, and remaining cautious in interpreting and applying model predictions. Beyond the weekly totals, further studies should also examine the effect of the distribution of this locomotor load across the microcycle on the present results.

However, it's important to acknowledge that while the recommended HSR training loads of 0.6-0.9 of match load per week may have been identified as optimal in the elite setting to mitigate injuries (Figure 8), this loading strategy may not be suitable for all contexts. In the academy setting (Douchet 2024) or when working with developmental programs, practitioners may have different objectives, such as player development and performance enhancement, that require a more aggressive approach to training. In such cases, the trade-off between injury risk and performance gains becomes a critical consideration, and some practitioners may choose to take calculated risks in pursuit of greater rewards.

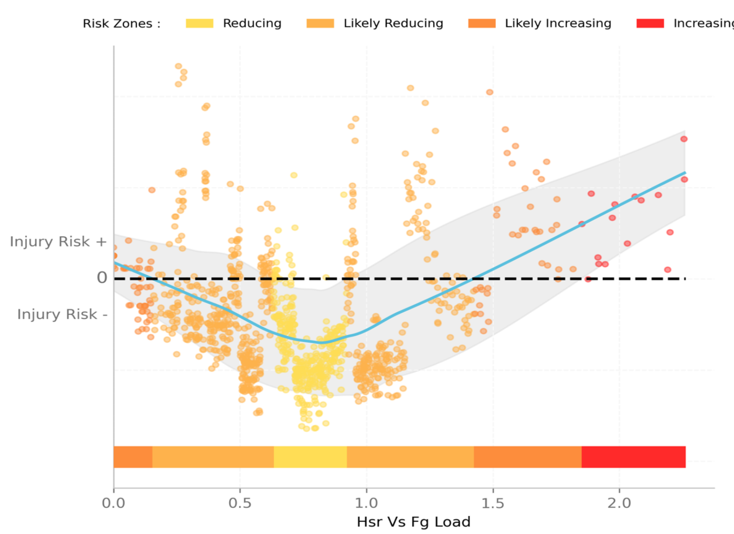

Fig. 8. SHAP feature dependence plots for match injury risk vs. cumulated high-speed running distance (>20 km/h) during training over 6- to 8-day turnarounds (expressed as a ratio of match demands). Injury (+/-) is quantified as the magnitude of the SHAP contribution (Buchheit 2024).

It is also worth noting that while these running targets may offer guidance, they should not overshadow the primary objective of football training: fostering player interactions and ball play to create dynamic in-game scenarios. This approach negates the need for additional running-focused activities, as well-crafted sessions will inherently meet these targets through game-specific behaviors.

Building on the insights from the Buchheit (2024) study on injury mitigation, a recent study by Modric et al. (2021) offers a complementary perspective by examining the relationship between weekly training loads and match outcomes in professional football. The research focuses on various running performance variables during training sessions and their association with the outcomes of matches. The study analyzed data from a top-level Croatian football team during the 2019/20 season. The main results were that most running performances in training were negatively related to the match outcome, indicating a lower likelihood of winning if players achieved higher distances and intensities during weekly training sessions. The study presents valuable preliminary insights, yet its examination of only 12 matches is a notable limitation. The research provides an interesting viewpoint, but there's room for expansion and depth. Incorporating a broader range of variables, beyond just the home/away factor, could enrich the findings. As emphasized in our recent study on the factors associated with match performance (Settembre 2023), variables like team status and ranking (ELO), recent team performance, and lineup stability play a crucial role in a team's success. Integrating these factors in future studies could offer a more holistic view of the dynamics influencing match outcomes.

Principle 5. Optimal Training Sequencing: Enhancing Physical Performance and Readiness on Match Day. While Principle 4 may have brought some understanding about the locomotor volumes that may be part of injury mitigation strategies in elite football, the relationship between these volumes and match day readiness, as well as the impact of weekly programming on these outcomes, remains less clear. To shed light on these aspects, we delve now into two pivotal studies by Douchet et al (2021, 2024). These studies explore how modifications in microcycle periodization and the sequencing of physical training within a week can influence both the training load and the readiness level of players for match day. This exploration offers valuable insights for optimizing training strategies in elite football.

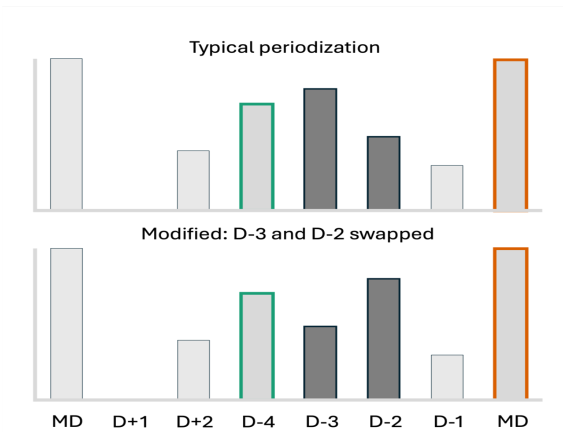

Fig. 9. Typical (upper graph) and Modified (lower graph) loading periodization (Douchet 2024).

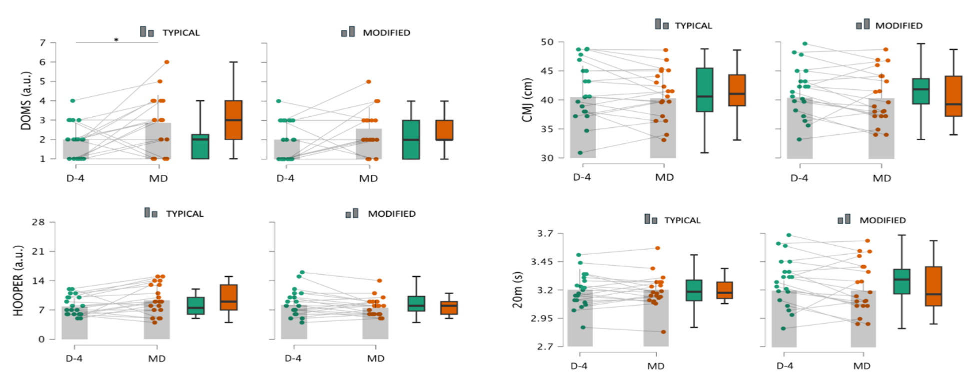

Fig. 10. Change in perceived muscle soreness (DOMS), Hooper score (the lower the score, the fresher the player), countermovement jump height (CMJ) and 20-m sprint time from D-4 to match day (MD) during Typical and Modified loading periodization. n = 20 players from an elite academy (11 U17 and 9 U19 players) (Douchet 2024).

In the first study (Douchet 2024), the authors investigated the impact of different periodization strategies on the training load and match-day readiness of elite soccer academy players. The research used a randomized cross-over design with 20 players (11 U17 et 9 U19) from the academy of a professional Ligue 2 football club. It compared a typical periodization strategy (most demanding sessions on consecutive days) against a modified strategy (interspersing a low-load session between the two most demanding sessions) (Figure 9). The weeks tested were randomized. Players wore a GPS and assessed their perceived exertion (RPE) at each session. Tests were carried out on D-4 for baseline values and repeated on match day (MD). The tests consisted of a countermovement jump (CMJ), a 20-m sprint, an Illinois Agility Test (IAT) and the Hooper questionnaire (for subjective wellness). The modified periodization resulted in players covering greater distances at high speeds and sprint intensities during the second most demanding session. Importantly, there was no detrimental effect on match day physical performance and readiness levels on match day (Figure 10).

Building upon the above-mentioned research indicating the potential benefits of modified microcycle planning in soccer (Douchet 2024), this second study (Douchet 2021) further explores the influence of the sequence of physical training—specifically aerobically-oriented and speed-oriented sessions—on weekly external loads and match-day fitness. It aims to understand how the arrangement of these sessions within a week can enhance or diminish player performance and readiness (Figure 11). Thirty-two U17 and U19 players were included in this study and performed the same tests as described before at MD-4 and on MD. Key results showed that during the modified planning strategy, players covered greater distances at high intensities compared to a typical strategy, without any significant change in physical performance or wellness measures on MD (Figure 12).

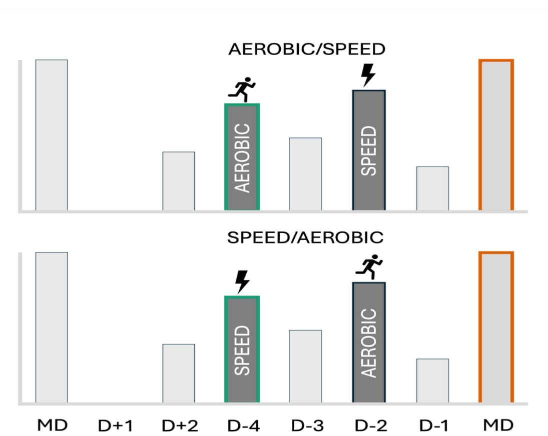

Fig. 11. Periodization including an Aerobic-oriented session on D-4 and a Speed-oriented session on D-2 (AEROBIC/SPEED, upper panel), and a periodization including a Speed-oriented session on D-4 and an Aerobic-oriented session on D-2 (SPEED/AEROBIC, lower panel) (Douchet, 2021).

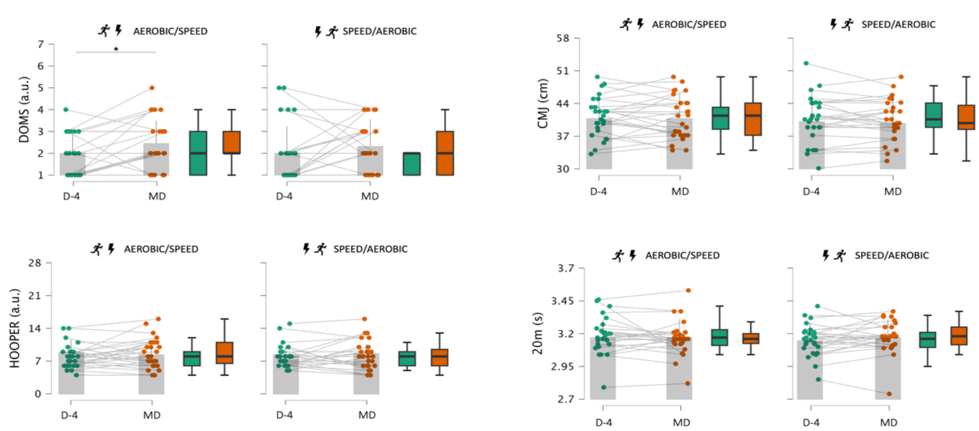

Fig. 12. Change in perceived muscle soreness (DOMS), Hooper score (the lower the score, the fresher the player), countermovement jump height (CMJ) and 20-m sprint time from D-4 to match day (MD) during a periodization including an Aerobic-oriented session on D-4 and a Speed-oriented session on D-2 (AEROBIC/SPEED), and a periodization including a Speed-oriented session on D-4 and an Aerobic-oriented session on D-2 (SPEED/AEROBIC). n = 32 players from an elite academy (12 U17 and 13 U19 players) (Douchet 2021).

Overall, these two studies suggest that a modified periodization strategy, which includes inserting light sessions among intense ones and rearranging the order of physical training (such as prioritizing speed-oriented sessions before aerobic-oriented ones), could enhance high-intensity performance during training without compromising match-day readiness in youth players. This approach may offer the potential to develop or at least maintain certain physical capacities during the demanding competitive season, which is a challenging task in practice. However, it's important to note that the applicability of these findings may be limited since the studies focused on specific teams and seasons. This underscores the need for additional research in diverse contexts and with larger participant samples. Furthermore, it remains uncertain whether these principles can be extrapolated to elite adult players who may experience different training loads and recovery capacities.

Principle 6. Speed Matters: The Significance of Maximum Speed Exposures in Elite Football. Among all the various components of training in elite football with regard to both performance and injury, exposure to maximum sprinting speed stands out as one of the most crucial (McCall 2020). This principle is substantiated by two comprehensive studies conducted in elite football settings, each with remarkable datasets and methodologies.

In our first study (Buchheit 2023b), we analyzed data from 627 players with 96 non-contact time loss match hamstring injuries across 36 team seasons, encompassing a staggering 6698 training sessions involving 19 teams from top leagues (EPL, Serie A, Bundesliga, Scottish Premiership, MLS, and Eredivisie), with the focus on the occurrence of near-to-maximal sprinting speed (near-to-MSS) running bouts during training sessions. This extensive dataset allowed for a thorough examination of the relationship between sprinting exposures and match hamstring injuries. The main findings were that near-to-MSS exposures, particularly at >95% MSS (and not at lower intensities), during training sessions close to the match day (MD-2) are associated with lower rates of hamstring injuries (Figure 13).

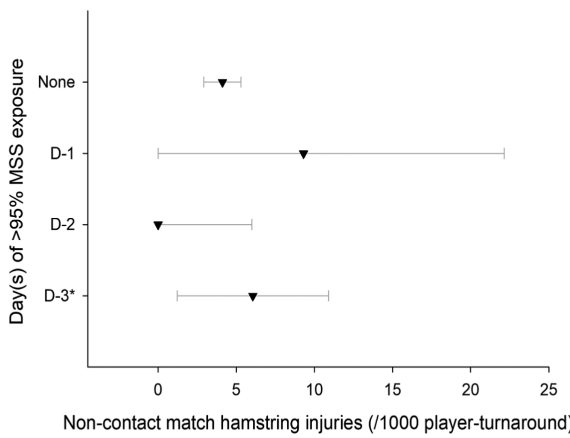

Fig. 13. Match hamstring injury rate (with 95% confidence intervals, and per 1000 player-turnarounds) in relation to the training session day(s) of the turnaround when running bouts >95% MSS occurred. *Note that D-3 is an aggregation of all training session days of the turnaround before D-3 included (e.g., D-3 summarizes occurrences from D-6 to D-3 for a 7-d turnaround). Data presented here are from 4- to 8-d turnarounds pooled together; since there is no D-3 data during 3-d turnarounds, data from the entire 3-d turnarounds is excluded from this analysis. Turnarounds refer to the number of days separating matches, match day included. In this paper, the terminology to denote the days in relation to a match day is referred to as 'MD-3', diverging from the original study's notation of 'D-3' (Buchheit 2023b).

While these results (Buchheit 2023b) shed light on the importance of maximal speed exposure in injury prevention, it's essential to acknowledge some important limitations. The univariate focus of the study means that while trends may exist, they should be interpreted cautiously in the context of the broader training program. Achieving optimal maximal speed exposure on MD-2 requires careful adjustment of content in preceding days (MD-4 and MD-3), including considerations for lower leg strength work (Buchheit 2021a). Additionally, when facing shorter microcycles, as we've observed, maximal speed exposures tend to decrease, potentially impacting their relevance for injury prevention. In such cases, employing a modified periodization approach, as discussed earlier (Douchet 2021), may help maintain these exposures if they prove to be crucial for injury prevention. Nonetheless, further research is needed in this area to refine our understanding and preventive strategies.

The second study (Buchheit 2021b) delved into the occurrence of near-to-maximal speed-running bouts during matches, tracking data from 35 top professional players at Paris Saint Germain over four seasons (2015-2019, Figure 14). Despite the infrequent nature of near-to-maximal speed bouts during matches, this study underscores the paramount importance of ensuring their inclusion in training regimens. It emphasizes the necessity for customized high-speed training programs to address the deficits observed during matches, particularly on non-playing days. Based on the match data collected, the study recommends a structured regimen comprising 6–8 runs at >80% MSS, including 3 at >85% and 1–2 at >90-95% MSS for a wide defender for example. Taken together, these findings highlight the significance of targeted, high-intensity training to adequately prepare players for the rigors of the game and mitigate the risk of injuries.

Aligning with our earlier discussions in Principle 4 regarding HSR, these exposures should not be seen merely as standalone objectives but as integral components of holistic, strategically designed sessions. This approach ensures that maximal speed work is seamlessly woven into the fabric of skill and strategy development, with the collaboration of coaching, fitness, and sports science teams, ensuring that high-intensity efforts are a natural extension of football-specific actions and game-play.

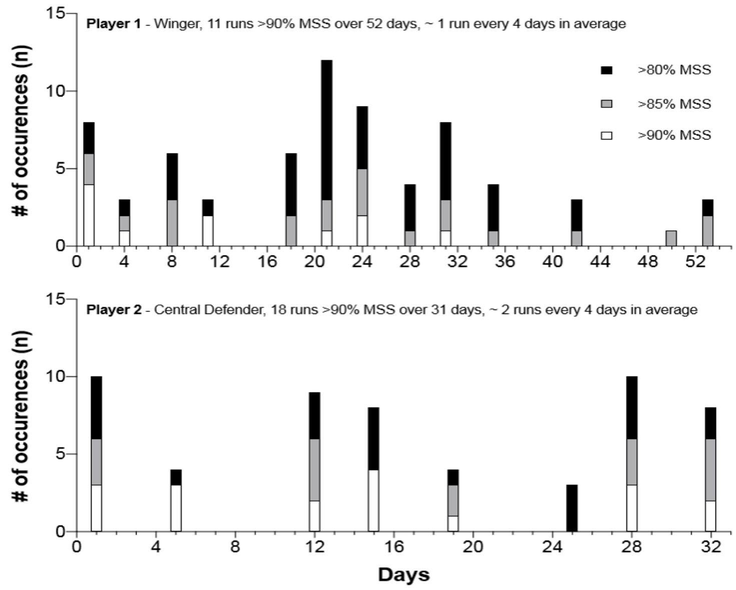

Fig. 14. Examples of periods including three repeated congested periods (playing with ≤4 days between matches) showing the occurrence of >80%, >85% and >90% MSS running bouts in two representative players (Buchheit 2021b).

Principle 7. Mastering Strength Training: Strategic Scheduling, Tailored Volume, and Progressive Intensity. For this 7th principle, we delve into the use and implementation of strength training in elite football, a key aspect of injury prevention and performance enhancement (Beato 2020; Ramirez-Campillo 2022; Silva 2015). Research suggests that strength training can significantly benefit soccer players by improving certain running-based actions, such as sprinting and change of direction speed, as well as jump performance. High-intensity resistance training and plyometrics appears to be more efficient than moderate-intensity resistance training, particularly for increasing force production and muscle power-based actions during pre-season. Training frequency of two weekly sessions during pre-season and one weekly session during in-season periods is recommended to maintain and enhance strength. Additionally, strength/power training programs that incorporate soccer-specific power-based actions targeting the neuromuscular system are preferred.

However, it's important to acknowledge that while the significance of strength in soccer is well-established (Beato 2020; Ramirez-Campillo 2022; Silva 2015), there remains a scarcity of robust evidence guiding the programming of strength training within the microcycle. Notably, the Buchheit survey (2021a) offers some valuable insights, outlining that "preventive" strength work is typically scheduled for D+3 in a 7-day microcycle, with typical maximal strength or power sessions distributed between D+2 and D+3 for a 6-day microcycle. Additionally, it reveals a consistent allocation of strength work on D+1 for microcycles ranging from 7 days to 4 days (Table 1 and Figure 2). Given the diversity of approaches to strength training (e.g., maximal strength, eccentric, prevention, isometrics), these recommendations by expert practitioners may provide a general framework but may not offer the level of precision needed for tailored and optimized microcycle planning.

While evidence for the programming of strength training within the microcycle remains limited, our focus in this paper centers particularly on eccentric training, as it represents an area with more concrete findings and potential implications for optimizing the microcycle. Eccentric-biased exercises are not just a small piece of the puzzle; they are essential, as underlined by their high ranking in practitioner surveys, just behind the key aspect of high-speed running and sprinting discussed earlier (McCall 2020). Our discussion is anchored around three pivotal scientific papers, each shedding light on different facets of this training approach: early scheduling within the weekly micro-cycle (Lovell 2018), the efficacy of micro-dosing training volume (Lacome 2020), and the progressive introduction of exercises using bands to modulate intensity and prevent initial overload (Buchheit 2019a). Collectively, these studies guide the nuanced incorporation of eccentric training, ensuring it's not just an exercise but a well-integrated component of elite football training.

The study by Lovell et al. (2018) examined the optimal timing for implementing eccentric-biased exercises during the typical 7-day soccer micro-cycle. The research involved 18 semi-professional players over three in-season micro-cycles, with weekly matches. The study focused on evaluating muscle damage, neuromuscular performance, and perceptual responses by measuring creatine kinase levels (CK), isometric peak force (PF), counter-movement jump (CMJ) performance, and muscle soreness. These metrics were assessed before match-day (baseline) and then daily up to 120 hours post-match. The exercises included lunges, single stiff leg deadlifts, single leg squats, and Nordic hamstring exercises. Findings revealed that conducting these exercises one day post-match (MD+1) mitigated the usual post-match increase in CK, while performing the exercise 3 days post-match (MD+3) resulted in higher CK levels and sustained muscle soreness, particularly on days 4 and 5 post-match (Figure 15). The study concluded that eccentric-biased exercises should be scheduled early in the micro-cycle to minimize muscle damage and soreness, ensuring players are better prepared for the next match.

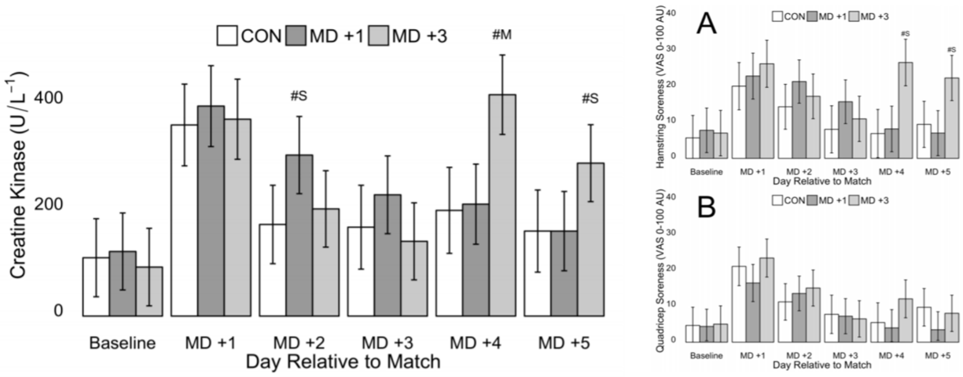

Fig. 15. Creatine Kinase concentration (left panel) and Hamstring (A) and Quadricep (B) soreness ratings (right panel) (estimated marginal mean ± 90% confidence intervals). # Denotes very-likely difference versus CON and MD+1 trials; * Denotes likely difference versus CON and MD+1 trials; S Denotes likely small effect size (Lovell 2018).

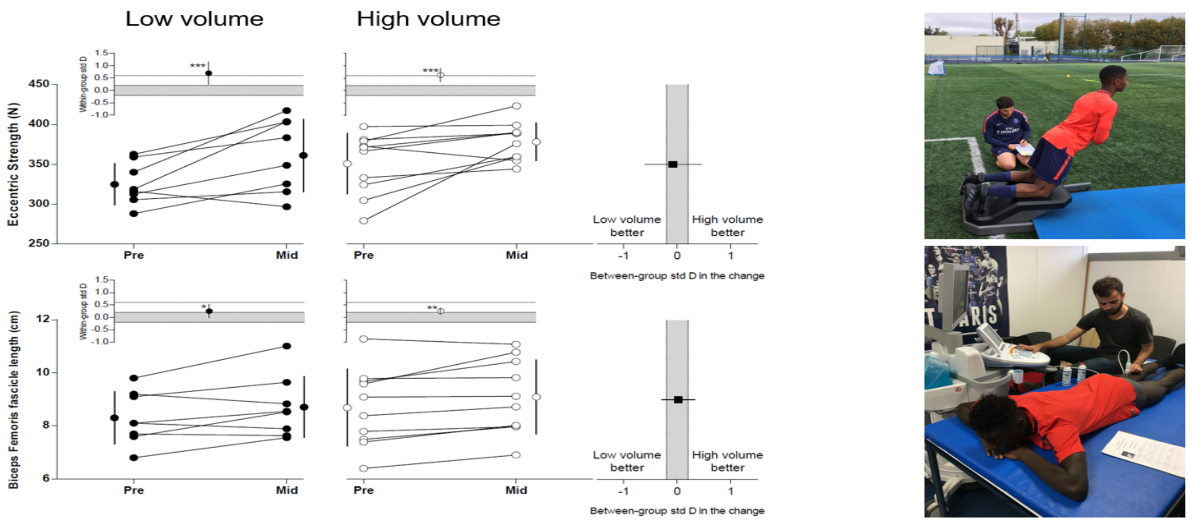

Fig. 16. Individual changes in knee-flexor strength and fascicle length following the first phase (PREtoMID in low-high-volume groups). The inserts above each panel represent within-group standardized changes (Δ symbol). The graphs on the right side show between-group standardized differences in the changes. Gray bars represent trivial changes/differences in the changes. *Possible change/difference in the change; Likely; *Very likely. PRE and MID values are represented as individual values and mean (SD). Standardized changes/differences in the changes are represented as mean and confidence intervals. PRE indicates pretraining; MID, mid-training (Lacome 2020).

Lacome et al. (2020) investigated the impact of training volume in eccentric hamstring strengthening programs on knee-flexor strength and muscle fascicle length in 19 U19 soccer players from the Paris Saint Germain Academy. They divided into two groups to follow either a low-volume (1 set, 10 repetitions) or high-volume (4 sets, 40 repetitions) training regimen for 6 weeks. The regimen included exercises like the Nordic hamstring exercise and bilateral stiff-leg deadlift. Assessments were conducted pre-training, mid-training (after 6 weeks), and post-training, focusing on eccentric knee-flexor strength and the fascicle length of the biceps femoris long head and semimembranosus. Results indicated significant improvements in knee-flexor strength and muscle fascicle length for both groups from pre-training to mid-training, with no substantial changes from mid-training to post-training (Figure 16). The study concluded that low-volume training is equally effective as high-volume training in enhancing knee-flexor strength and muscle fascicle length and may be more suitable for elite soccer teams with tight schedules due to its lesser demand on time and recovery.

The study by Buchheit et al. (2019a) underscores the simplicity and efficacy of using elastic bands for the gradual integration of the Nordic hamstring exercise into training routines. The ability to modify the exercise intensity through band usage, achieving reductions of 15% to 40% (Figure 17), is a key strategy for easing players into this strenuous activity. It's crucial to recognize that while the Nordic hamstring exercise is a primary focus here, it represents just one of many eccentric exercises. This approach can be easily adapted to assess and incorporate various eccentric exercises, reinforcing their role in a well-rounded, effective training program for elite footballers.

It is however very important to stress that the integration of these principles demands more than a mere checklist; it necessitates careful adaptation of strength training to the overall training regimen. This fine-tuned dosage is essential to ensure that players benefit from the work without being overloaded, requiring nuanced adjustments tailored to each context.

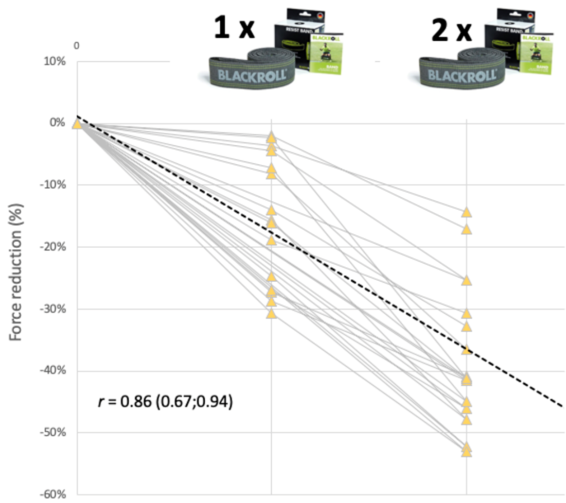

Fig. 17. Individual reduction (%) in Force applied to the Nordbord sensors when using 1 or 2 bands. n = 15 (Buchheit 2019).

Principle 8. Strategic Tapering in Elite Football - Balancing Training Load and Recovery for Optimal Performance. The initial segment of this principle draws from the extensive survey by Buchheit (2021a), particularly focusing on the dynamics of training loads in the two days leading up to a match. The patterns observed in the data are telling; there's a consistent approach among practitioners to ensure that players do not endure two consecutive days of moderate load. The typical pattern oscillates between moderate and light loads or vice versa, but rarely, if ever, features two successive days of moderate load (Table 6). This trend underscores a fundamental understanding among practitioners of the need for tapering and recovery, ensuring that at least one of the two days serves as a period for the players to rejuvenate and restore their energy levels.

The second part of this principle delves into data collected over three years from a top 5 team in one of the top 5 european leagues, with a particular focus on injury data as depicted in Figure 18. The bivariate analysis presented in this figure paints a clear picture: insufficient recovery or excessive work in the two days leading up to a match correlates with a higher likelihood of injuries. Specifically, the left panel of the figure reveals that higher injury rates are associated with a combination of lower perceived recovery scores and significant amounts of high-speed running (HSR) earlier in the week. Conversely, the right panel indicates that players engaging in substantial workloads on MD-2 and MD-1, coupled with a high volume of work earlier in the week, are at an increased risk of injury. This part of the study emphasizes the delicate balance between training intensity and adequate recovery, highlighting the risks of overloading players close to match day.

Building upon the insights from the previous sections, the third component of this principle integrates findings from another study by Douchet et al. (2022), which investigated the physical impact of different training session volumes on the day preceding a match among 11 U19 elite academy soccer players. The study's methodology involved a comprehensive set of physical tests and subjective questionnaires to assess the fitness and performance levels of the players (Figure 19). The results were unequivocal: shorter training sessions (45 minutes) were linked to enhanced fitness levels and performance on match day, as opposed to longer sessions (60 and 75 minutes), which were associated with underperformance (Figure 20 and 21). This finding aligns with the earlier components of the principle, reinforcing the concept that strategic tapering and well-calibrated training sessions are pivotal in optimizing player performance and reducing injury risks.

This principle underscores the critical role of managing training loads in the two days leading up to a match, a theme consistently echoed across three distinct research perspectives. The Buchheit survey (2021a) first highlights a prevalent practice among elite football practitioners: the strategic alternation between moderate and light training loads during this crucial pre-match period, emphasizing the importance of recovery (Table 6). Complementing this, an analysis of data from a Top team (Figure 18) reveals a direct correlation between inadequate recovery or excessive training loads during these two days and an increased risk of player injuries, particularly when high-speed running is involved earlier in the week. The Douchet (2022) study further cements the significance of this pre-match period, demonstrating that shorter, focused training sessions (45 minutes) are optimal for enhancing player fitness and performance, as opposed to longer sessions which may lead to underperformance (Figures 20 and 21). Collectively, these studies converge on a crucial point: meticulous load management in the days leading up to a match is paramount, not only for optimizing player performance but also for minimizing the risk of injuries, thereby underscoring the importance of strategic tapering and recovery in elite football. Of note, the effectiveness of this load management and tapering approach can be monitored in practice using a simple wellness questionnaire, as demonstrated in the Guridi Lopategui study (2021), where this type of periodization resulted in a significant rebound in wellness scores by 4 points on a scale of 10.

Table 6. Load dynamic two and one day before competition as a function of turnover length Buchheit (2021).

Matches Turnover	D-2 LOAD		D-1 LOAD	
7-d	Moderate	60%	Moderate	3%
			Low	97%
	Low	40%	Moderate	48%
			Low	52%
6-d	Moderate	65%	Moderate	17%
			Low	84%
	Low	35%	Moderate	16%
			Low	17%
5-d	Moderate	84%	Moderate	16%
			Low	84%
	Low	16%	Moderate	71%
			Low	29%
4-d	Moderate	43%	Moderate	10%
			Low	90%
	Low	57%	Moderate	88%
			Low	12%
3-d	Moderate	27%	Moderate	15%
			Low	85%
	Low	73%	Moderate	83%
			Low	17%

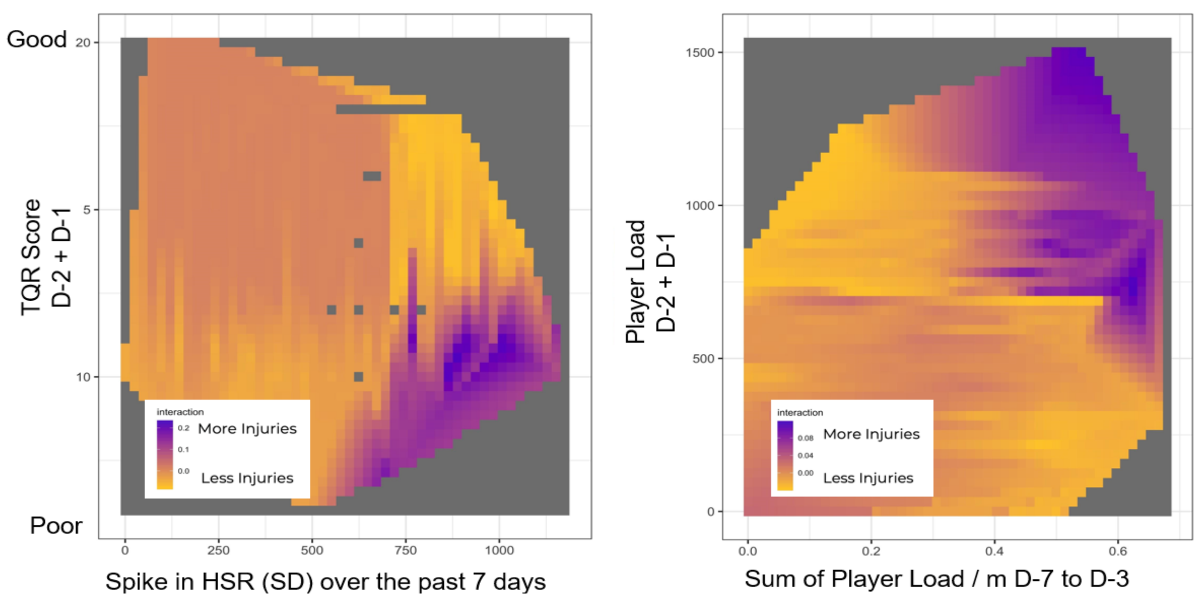

Fig. 18. Association between injury rate and different independent variables. The bidimensional analysis illustrates the effect of the interaction of two variables on injury rate, with the magnitude of the interaction effect color-coded. The left panel depicts the interaction between the Total Quality of Recovery (TQR) over the 2 days preceding a match (y-axis) and the Standard Deviation (SD) of High-Speed Running (HSR) over the past 7 days (reflective of a high volume of high-intensity work, likely from a match or a very hard session, x-axis) in relation to injury rates. The right panel illustrates the interaction between Player Load (as a measure of overall external load) over the 2 days preceding a match (y-axis) and the sum of Player Load / m 7 to 3 days before (i.e., the overall external work done over small spaces earlier in the week, x-axis) in association with injuries (courtesy of kitman labs). Data captured over 3 seasons and included 110 injury occurrences in a Top 5 club in one of the 5 top European leagues.

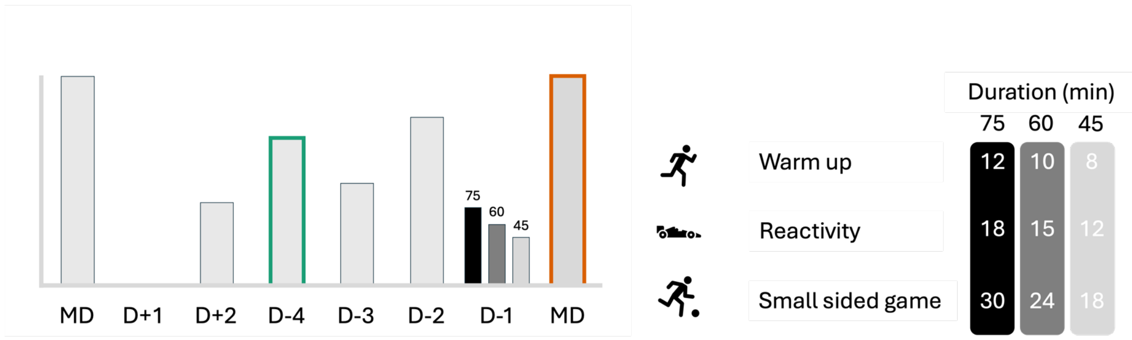

Fig. 19. Periodization models that include either 45 min (45), 60 min (60) or 75 min (75) D-1 session and associated training content for this latter session. D+2 : recovery-oriented session implementing aerobic technical exercises (60min). D-4: strength-oriented session with small-sided games (90min). D-3: aerobic-oriented session with medium- to large-sized games (90min). D-2: speed-oriented session using large-sided games (75min) (Douchet 2022).

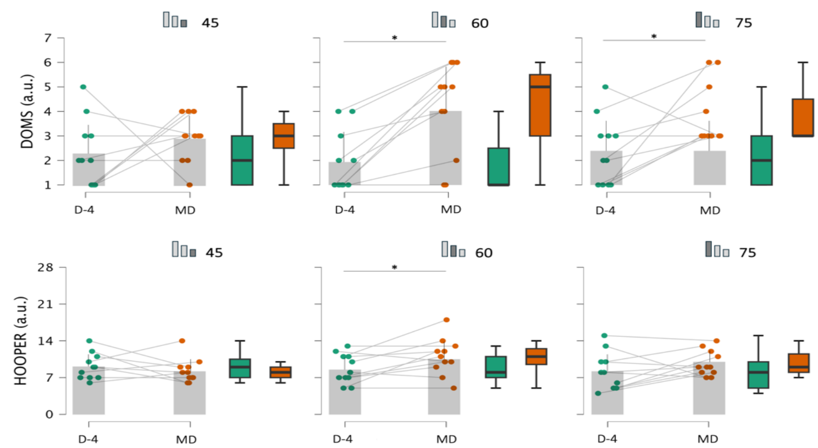

Fig. 20. Change in perceived muscle soreness (DOMS), Hooper score (the lower the score, the fresher the player) from D-4 to match day (MD) during three different periodization models including either 45 min (45), 60 min (60) or 75 min (75) D-1 session (Douchet 2022).

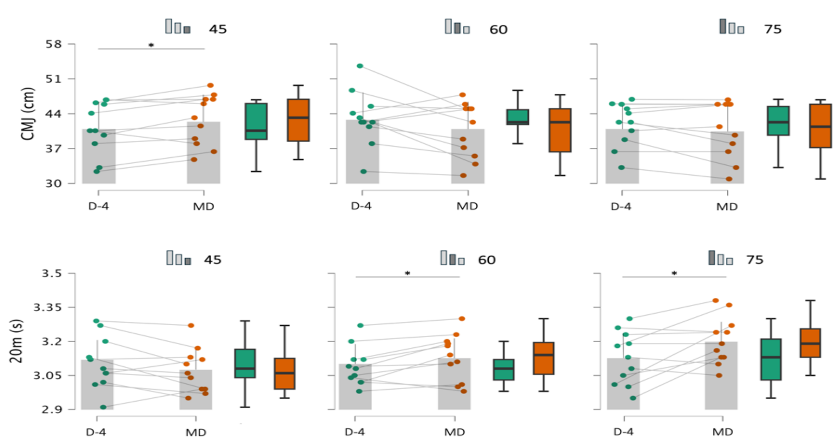

Fig. 21. Change in countermovement jump height (CMJ) and 20-m sprint time from D-4 to match day (MD) during three different periodization models including either 45 min (45), 60 min (60) or 75 min (75) D-1 session (Douchet 2022).

Principle 9: Enhancing Match Day Locomotor Potential: The Impact of Morning Priming Sessions. This principle examines the efficacy of morning priming sessions on the physical and technical activities of elite-level soccer players during competitive matches. In their study "To Train or not To Train (on Match Day)? Influence of a Priming Session on Match Performance in Competitive Elite-Level Soccer" Modric et al. (2023a) scrutinize the outcomes of 32 official matches in the Latvian first division. Twelve matches featured players who participated in a priming session, while 20 did not. Overall, the study compiled observations from 92 instances where players engaged in a priming session and 174 instances where they did not. The priming protocol included stretching, mobility, core, lower-body resistance, and reactive agility exercises performed on the morning of the match day for 15-20 min. The study's methodology accounted for matches played exclusively in a 4-3-3 formation, with individual player observations exceeding 75 minutes extrapolated to full 90-minute matches.

The findings demonstrated that morning priming sessions were beneficial, leading to small yet significant increases in the distance covered at moderate and high intensities, as well as a higher frequency of duels (Figure 22). These enhancements in physical performance were achieved without any detrimental effects on technical performance. Despite some limitations inherent to the study design and sample size, the results suggest that morning priming sessions could be recommended as an effective pre-match strategy to boost physical performance in soccer players.

While the current manuscript primarily focuses on understanding the impact of specific training practices on various outcomes, such as injuries (case studies 2, 4, 6, and 7) and readiness to perform (case studies 4, 5, and 7), it's important to note that match running activity alone does not directly influence match outcomes such as winning or losing. Expert analyses and research consistently refute a direct correlation between running and winning, highlighting the multifaceted relationship between running and game outcomes. This relationship extends beyond the mere quantity of running, involving a multitude of tactical, technical, and psychological factors (Hoppe 2015; Modric 2019, 2022a, 2022b, 2023b; Oliva-Lozano 2023). Contrary to the idea of running without purpose, the Modric study (2023a) underscores the preparatory nature of priming. The findings suggest that priming sessions may enhance players' physical readiness, potentially enabling them to cover more distance during a match if needed. This distinction is crucial, highlighting the importance of being prepared when required rather than engaging in aimless running. Additionally, unpublished data from the Modric study (2023a) revealed that the odds of winning were approximately 2.187 times higher when "priming" was implemented compared to when it was not ($p = 0.02$).

Despite these positive outcomes, aligning these findings with Principle 8's emphasis on tapering and ensuring player freshness underscores the importance of managing training loads to prevent these priming sessions from being counterproductive. Balancing the benefits of morning priming sessions against the need to avoid overload during tapering days is critical, ensuring that such strategies do not conflict with the overarching goal of player readiness and performance optimization.

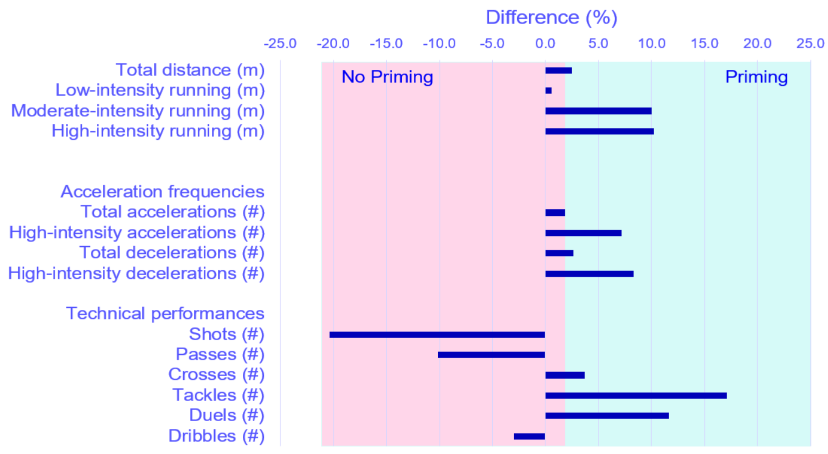

Fig. 22. Differences in locomotor and technical activities during matches preceded (n=12 matches) or not (n = 20) by a priming routine earlier in the day (Modric 2023a).

Principle 10 (Inferred) : Running as Part of Football Training: A Logic-Driven Principle. This section unveils Principle 10, an inferred yet pivotal addition to our study on training periodization in elite football, distinguishing it from earlier, evidence-based principles. As authors, we emphasize this principle from a logic-driven standpoint due to its inherent importance, dedicating a separate section to underscore its significance. It underlines the natural inclusion of physical demands in football training, equating running as fundamental to football as breathing is to life; both are indispensable, with running being as crucial for football participation as breathing is for survival. This analogy emphasizes that without these essential elements—running, akin to breathing—engagement in football is unfeasible. Measuring running dynamics, therefore, is not an aim in itself but a foundational aspect to inform more effective football training. While metrics such as HSR distance (Principle 4) and maximal speed exposures (Principle 6) provide insights into performance and injury risks, they should not detract from the primary goal of football training: to enhance player interactions and the development of dynamic in-game scenarios through ball play (Training Science Podcast 2024). It advocates for the crafting of training sessions that organicaly incorporate locomotor "targets" (i.e., Principles 4 and 6) within a football-specific framework (as running is an integral part of football by definition), eliminating the necessity for isolated running drills. This methodology ensures training remains directly relevant to football, with physical demands and running metrics naturally arising from engaging, tactical play. Realizing this comprehensive training paradigm requires a concerted effort from coaches, fitness professionals, and sports scientists, aiming for a harmonized strategy where enhancing football actions and tactical acumen is paramount, and running metrics serve as instrumental tools/guides to fine-tune football training purposefully.

Principle 11 (Inferred): Embracing Chaos in the Pursuit of Perfection. Introducing Principle 11, it's essential to reflect on how the first 9 (or 10) principles lay the foundation for constructing an ideal, evidence-informed world within the context of elite football training and management. This ideal world serves as the objective baseline from which coaches can navigate the complexities of the real world, particularly the external factors that impact the game beyond the pitch. By meticulously designing these ideal scenarios first, coaches establish a clear, objective reference point (Figure 23). This approach ensures that any adaptations or decisions made in response to real-world unpredictability are grounded in a well-considered, evidence-informed framework, rather than being made from a more subjective or arbitrary standpoint. It is against this backdrop that this inferred Principle 11 emerges, acknowledging the inherent chaos and unpredictability not just within the game of football, as Johan Cruyff famously remarked, "Football is chaos," but also in the external environment surrounding it. This principle emphasizes the need for adaptability and preparedness to address the unforeseen challenges that lie outside the structured world of play, ensuring that planning and strategy remain responsive and relevant in the face of constant change.

From last-minute fixture changes to unexpected weather conditions, football constantly presents challenges that demand flexibility. As professionals, we need to adapt to these situations, understanding that the pursuit of perfection is often met with chaos. In the quest for success, factors like player and staff dynamics, external influences, and unforeseen circumstances can alter the course of our perfectly laid-out plans. However, it's in these moments of uncertainty that true innovation and creativity often emerge.

To excel in elite football, we must be willing to embrace the chaos, recognizing that the ability to adapt and make informed decisions on the fly is as vital as any meticulously designed microcycle. Flexibility should not be seen a deviation from our principles; but as an integral part of our strategy (Buchheit 2019b). In the end, the balance between structure and adaptability will define our success. By staying true to our evidence-informed principles while remaining open to change, we can navigate the chaos of football and strive for perfection in a world where uncertainty reigns supreme.

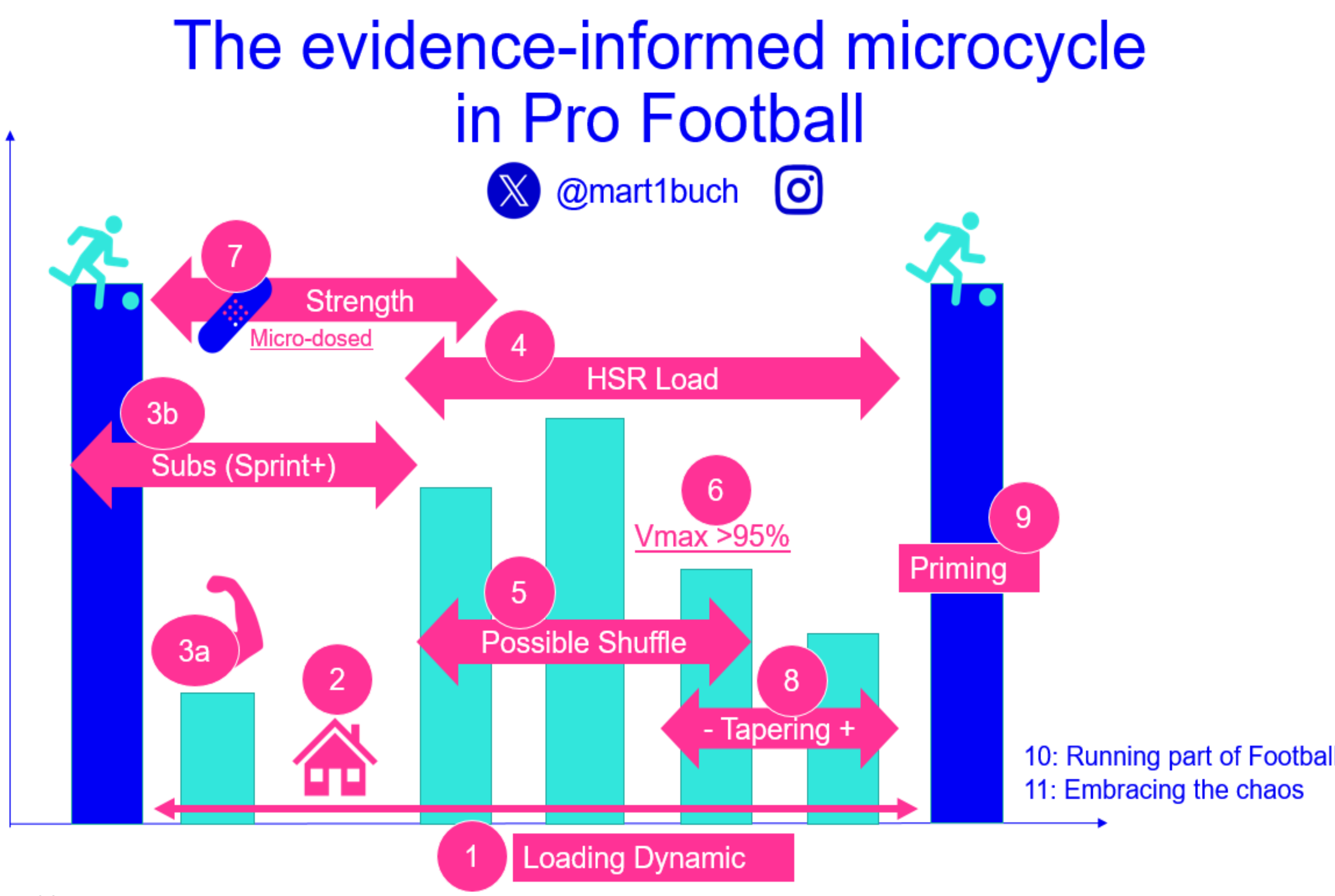

Fig. 23. Consolidated overview of the 9 key evidence-informed principles examined, guiding practitioners in making informed decisions for the optimal periodization of load and contents during a typical 7-day microcycle in elite football. While not explicitly depicted in this figure, it is important to note that Inferred Principles 10 and 11, namely 'Running as an Intrinsic Aspect of Football' and 'Embracing the Chaos,' should be considered as embedded throughout the background.

Conclusion

In this narrative-style review, we explored the foundational 11 principles that can serve as the cornerstone for evidence-informed decision-making in the context of microcycle periodization for elite football. These principles encompass every vital facet of programming, encompassing optimal rest day timing, overall loading patterns, compensation strategies for substitutes, and targeted content periodization, including locomotor load volumes, maximal speed exposures, upper body work, priming sessions, and injury mitigation gym work. The amalgamation of these principles offers a comprehensive understanding of how data-driven insights can guide practitioners in optimizing training load and content distribution across a typical 7-day microcycle. The key findings from this narrative-style review are succinctly presented in Figure 23, serving as a practical roadmap for practitioners seeking to enhance performance and mitigate injury risks through evidence-informed periodization strategies in elite football.

This review strives to bring objectivity and a reasoned approach to decision-making, acknowledging the importance of context in shaping these decisions. While the objective is to minimize uncertainty by providing an optimal plan, it's understood that flexibility is key (Buchheit 2019b), allowing for exceptions based on specific situations (Principle 11). It is also worth noting that we stress the importance of viewing running targets (e.g., accumulated HSR distance over the microcycle, maximal speed exposures) as benchmarks within the broader context of football training, which primarily aims to cultivate player interaction and strategic gameplay. Running itself is of course not the ultimate objective (Principle 10).

It is also worth noting that we've focused here on presenting training principles in elite football that are substantiated by robust research and clear empirical data - at least the 9 first of them. While there are undoubtedly numerous other topics and training concepts that could be discussed (e.g., gym activation strategies in relation to pitch session content, nutrition and recovery, Gomez 2019), their exclusion from this review is only due to the absence of strong supporting evidence or research specifically addressing their integration into weekly periodization within the football context.

Key findings and recommendations

Integration of the 11 Key Programming Principles

The seamless integration of these principles is paramount, as it cannot be merely a copy/paste or a juxtaposition of principles alongside each other. While the individual studies examined in this review provide valuable insights for guiding practice and forming key programming principles, the integration of these principles requires particular attention from practitioners to ensure smooth implementation and maximize their effectiveness. It's essential to recognize that these principles are additive and not simply applied one after another; adjustments must be made to integrate them seamlessly. For instance, if implementing the principle of speed exposure on D-2, it must consider factors such as strength training on D-4 and high-speed running load in preceding or subsequent days. This underscores the importance of tailored approaches, where strength training in the gym aligns with pitch-based work, ensuring a cohesive and optimized training regimen. Finally, while topics like activation gym work, nutrition, and recovery are undoubtedly important, their omission from this review was primarily due to the lack of strong supporting evidence addressing their integration into weekly periodization. However, their significance warrants further research to explore their role in optimizing training strategies.

- **Principle 1 - Overall Load Dynamics and Content Periodization**: Highlights a structured three-phase microcycle: recovery, acquisition, and tapering, tailored to match schedules (i.e., microcycle length).
- **Principle 2 - Mapping Rest Days**: Emphasizes strategic rest day placement, particularly effective at D+2, to reduce injury rates within varying microcycle lengths (and likely as well allowing substitutes to train on D+1, as per principle 10).
- **Principle 3 - Managing Post-Match Recovery and Compensation**: Suggests post-match (MD+1) upper body training is compatible with recovery, with benefits potentially varying among players, and stresses the need for high-intensity and speed training compensation (at MD+1 as per principle 2) to maintain substitutes' performance and reduce injury risks.
- **Principle 4 - Weekly Training Loads and High-Speed Running Management**: Identifies optimal training load ranges (60-90% of match load, reached via football training) for balancing performance enhancement and injury mitigation.
- **Principle 5 - Optimal Training Sequencing**: Demonstrates that modified microcycle planning and session sequencing (e.g., switching typical MD-3 vs MD-2) could improve training impact without affecting match-day readiness.
- **Principle 6 - Maximum Speed Exposures**: Highlights the importance of near-to-maximal speed training (>95%) at MD-2, which may be associated with reduced injury rates.
- **Principle 7 - Mastering Strength Training**: Focuses on early scheduling of eccentric training, effective micro-dosing, and progressive intensity for optimal integration.
- **Principle 8 - Strategic Tapering Leading to the Match**: Advocates a balance between moderate and light loads pre-match (MD-2 and MD-1) with an increased focus on recovery for optimal performance and injury prevention.
- **Principle 9 - Match Day Morning Priming Sessions**: Shows MD morning priming sessions can enhance physical potential without affecting technical skills.
- **Principle 10 (Inferred) - Running as an Intrinsic Aspect of Football**: Asserts that running is as fundamental to the game as breathing is to life, underscoring the importance of viewing running metrics (i.e., Principles 4 & 6) not as separate components but as instrumental tools to design football training purposefully.
- **Principle 11 (Inferred) - Embracing the Chaos**: Introduces the concept of navigating unpredictability in elite football, emphasizing the importance of adaptability to external factors and the need for a structured, objective framework to effectively manage chaos beyond the pitch (i.e., Principles 1-10).

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