A PERIODISED RECOVERY STRATEGY FRAMEWORK FOR THE ELITE FOOTBALL PLAYER

– *Written by Warren Gregson, Qatar, Glyn Howatson, UK, and Robin Thorpe, USA*

INTRODUCTION

Elite football players are now routinely exposed to 2-3 matches per week with leading players often competing >60 matches per season interspersed with 2-5 days of recovery between matches. The high frequency of competition, together with the increasing physical demands of competition (Barnes et al, 2014), has served to accentuate the physical and mental load incurred by elite players. As a consequence of these demands, the importance of recovery strategies to alleviate player fatigue, minimise injury risk and enhance performance is of paramount importance to clubs and national federations responsible for managing the elite player (Field et al, 2021).

Recovery techniques deployed in the global game are diverse in nature reflecting the various challenges at play when developing a recovery strategy framework (Altarriba-Bartes et al., 2020; Field et al, 2021). Gaps in scientific research regarding efficacy of some recovery techniques together with the limited data derived on elite players in the field represent key challenges to those faced with developing recovery strategy frameworks. When to apply different techniques to accelerate the stress-recovery-adaptation continuum has also emerged as a 'hot' topic in the area (Peak et al., 2017; Ihsan et al., 2021; Thorpe et al., 2021). This has raised the idea (and the challenge) of using recovery strategies in a manner that is periodised to mirror the demands of the sport to adequately recover from the stress, but also balance the need for an adaptive response. In this article, we attempt to shed some light on the notion of periodised recovery within the context of football. The initial section presents an overview of the key considerations pertinent to developing recovery strategies including the conceptual basis of periodised recovery. This is followed by an overview of key recovery techniques that offer plausible physiological mechanisms through which to influence recovery and adaptation. The final section presents an attempt to develop a periodised recovery approach within the framework of a typical football season.

BASIS FOR RECOVERY INTERVENTIONS

The concept of recovery has been an established ideology of medicine that dates to Hippocrates (c.460 BC). Recovery was principally based on the premise that the restoration of a homeostatic state through rest is central to healing. As years have advanced, the pursuit of greater human performance through training has led to athletes, coaches and practitioners to engage with higher training volumes and often greater intensities. When coupled with ever increasing competition demands and fixture congestion the interest in exercise recovery has never been so important to consider within the training and competition

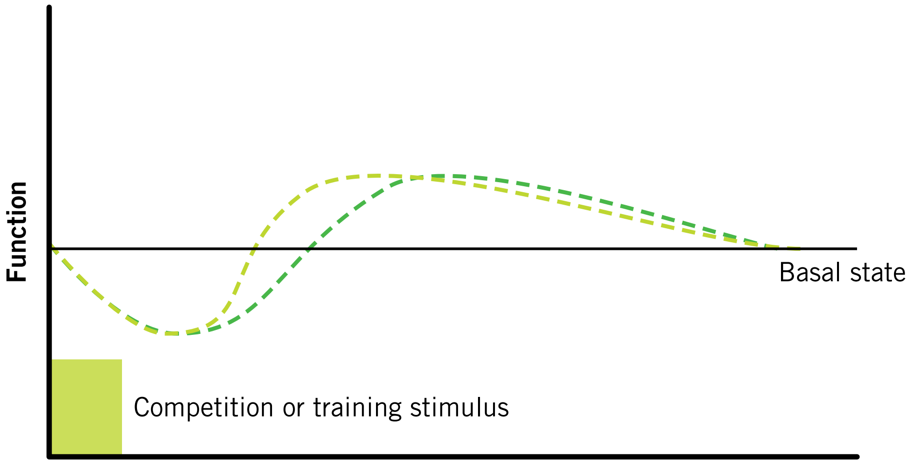

Figure 1: Timeline of the stress-recovery-adaptation continuum. The dashed black line indicates the timeline of unassisted recovery following training, where function is restored to the basal state and the target adaptive response has been achieved. If a further stimulus is not introduced to the system, the function will return to the basal state. The dashed grey line illustrates the concept of a successful recovery strategy where function is accelerated with no loss in any adaptive response.

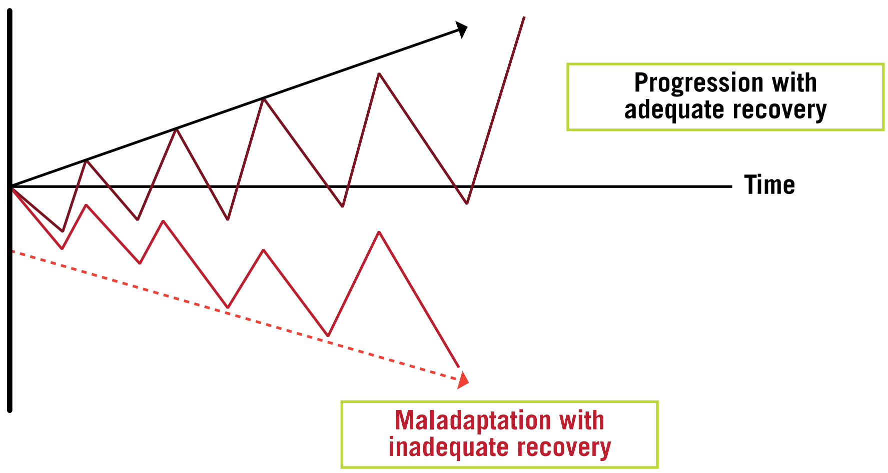

Figure 2: A schematic representation where recovery and regeneration is adequate to resolve functional decline (brown line). In the absence of adequate recovery there is a cumulative decline in athletic performance (red line).

calendar. However, the right balance between the physiological stress of training and competition, recovery and subsequent adaptation is difficult to optimise. A successful recovery regimen could lead to 1) reduced training or competition-induced stress; 2) improved recovery times to allow for an additional training stimulus; 3) optimised recovery in periods of competition congestion; and 4) improved physiological adaptation. Conceptually, the idea of the "right" recovery would result in accelerated return to homeostasis following a training or competition stress. In an ideal scenario (Figure 1) this would be followed a supercompensation period where a positive adaptive response would occur, similar to the General Adaptation Syndrome model (Seyle, 1951).

PRINCIPLES AND APPROACH TO RECOVERY

Most recovery interventions are likely to yield only modest improvements in recovery, but they can have a meaningful impact on the athlete. It is critical to note that any difference can only be realised if the fundamental principles of recovery are well executed; namely, quality sleep and rest, nutrition and hydration. An understanding of whether insufficient recovery is the cause of a reduction in the functional capacity to train or compete is important. Very often, with sufficient time, the athlete will recover without the need for additional interventions above and beyond the fundamentals of hydration, adequate nutrition, sleep and rest. By having a good understanding of the physiological stress that is induced by training and competition, it is possible to discern what interventions might be of use. The nature of football means that high metabolic and mechanical stressors can lead to muscle damage, muscle soreness, inflammation and increase the production of reactive oxygen and nitrogen species, that ultimately reduce functional capacity (Thomas et al. 2017; Goodall et al., 2017). This can be manifested as reduced muscle function, and range of motion that leads to a loss of flexibility, strength, power, skill-based performance, and muscle soreness that can last for several days after the stimulus (Thomas et al. 2017; Goodall et al., 2017). If athletes train or compete whilst experiencing these symptoms, it is highly likely their performance will be sub-optimal and increase the propensity for injury (Howatson and Van Someren, 2008) because of the reduction in force capacity, joint position sense and reaction time. In circumstances such as these, inadequate recovery could be the underlying issue and therefore identification of a recovery strategy to accelerate and restore function is necessary. In a conceptual model of recovery and adaptation (Figure 2), adequate recovery allows progression (or at least maintenance of performance), whereas inadequate recovery has the potential to be maladaptive. Of course, the restoration of function will occur over time, but the application of a recovery strategy could accelerate the return of function to the basal state sooner and hence place the athlete in a better position to subsequently perform. This is particularly important during intensified training and competition schedules where performance at the highest level is required frequently within short time periods.

If the training and competition challenges are a cause for inadequate recovery, strategies could be selected to minimise the deleterious effects on performance. Primarily, the use of recovery interventions should be influenced by, 1) the 'recovery window' determined by the requirement to next train or compete; 2) identification of the causes that have the greatest negative effects on performance and their recovery time-course; 3) what is required versus what is logistically possible based on the environment (e.g., resources), travel constraints and the time of day (e.g., evening kick off). Furthermore, a growing body of evidence indicates that recovery is related to individual preference and perceptions of the intervention (Crowther et al., 2017; Calleja-González et al., 2021; Field et al., 2021). Therefore, it is important to recognise and, where necessary, manage the influence of belief and the power of placebo effects for a successful recovery strategy to be implemented. This also raises the need to achieve coach and athlete buy-in to any intervention, and the challenge to balance an evidence-based approach with the beliefs and expectations of coaches and athletes (Halson and Martin, 2013). In cases where an athlete believes in a particular recovery strategy despite a lack of supporting scientific evidence, the demand on resource and cost (financial, time, effort, scarifies to enable the strategy), and most importantly the potential for harm or negative performance effect, must be evaluated. On balance, if there is no contraindication, or negative effect and the athletes believes in the intervention, then, even in light of little supporting evidence, the intervention might be beneficial. It is therefore important to use recovery strategies that consider the individual responses to the stimulus, thereby ensuring the most benefit from an intervention.

The overarching challenge for the athlete, coach and support team is to identify when it might be appropriate to intervene or not. The issue is further confounded by some lines of enquiry (Roberts et al., 2015; Peake, 2017) suggesting the adaptive response to a training stimulus could be blunted, or at least attenuated, by some recovery interventions. For example, cold water immersion was suggested to have a negative effect on strength adaptation (Roberts et al., 2015), whereas it has no effect on endurance performance (Malta et al 2021). This can be particularly challenging to fathom in a sport where both attributes are important, and when there might be periods of time in the training calendar when intensified training is designed to deliver the greatest adaptative response to the athlete (pre-season training). Although the research examining the negative adaptive response of recovery strategies has limitations, and cannot be wholly translated to performance sport, it raises the important question that being cautious might be prudent. Furthermore, there are some clues in the literature regarding the influence of recovery strategies in males, but there is a worrying paucity of information relating to recovery strategies in females. Something that should become a research priority moving forward.

To this end, adequate recovery is extremely important for regeneration, but when is the right time to apply additional recovery strategies to maximise the stress-recovery-adaptation continuum? Many practitioners currently implement recovery strategies during tournament situations or after specific training sessions when performance in the subsequent round of competition or training session is paramount. The idea being that recovery strategies should be limited or avoided when long-term physiological adaptation to the training-induced stress is the priority and hence the idea of a periodised approach to recovery.

RECOVERY TECHNIQUES

As noted in the preceding section, quality sleep and rest, nutrition and hydration serve as the foundation of any effective recovery strategy and therefore are unsurprisingly central to strategies implemented by elite clubs (Nédélec et al., 2013; Altarriba-Bartes et al., 2020; Field et al., 2021). Away from this foundation, marked variability arises in the recovery strategies adopted following training and matches, including techniques adopted together with the nature of the protocol and timing of application across the recovery continuum (Altarriba-Bartes et al., 2020; Field et al., 2021). Extensive evaluation of the mechanisms underpinning various techniques from a recovery and physiolgical adaptation perspective is beyond the scope of the current article. Rather, in this section, we briefly review recovery techniques commony used in elite football which have been shown to accelerate recovery and/or influence physiological adaptation to training. These include techniques which mediate changes in tissue temperature, blood flow and joint range of motion.

Cooling Techniques

Cryotherapy is an umbrella term describing a plethora of techniques, including, ice, cold-water, cold-air and phase-change materials, all of which promote the withdrawal of body heat (Allan et al, 2022). Cold-water immersion, the most commonly applied crotherapy technique, also represents one of the most common recovery technqiues adopted in elite football (Altarriba-Bartes et al., 2020; Field et al, 2021). Cost effectiveness, access and greater cooling capacity of water versus other forms of cryotherapy (Mawhinney et al, 2017) likely underpin the popularity of cold-water immersion. The recent emergance of phase-change material now also provides an alternative practical means of delivering prolonged post-exercise cooling which has the capacity to accelerate recovery of elite soccer players (Clifford et al., 2018).

Cooling techniques typically serve to reduce tissue temperature, which mediate a reduction in cell metabolism and blood flow to the exercised muscles (Mawhinney et al., 2022). This collective change in temperature and blood flow reduces clinical symptoms of inflammation such as the pain, swelling and triggers post-exercise parasympathetic activity (Al Haddad et al, 2010; Leeder et al., 2012; Roberts et al, 2014). The effects of cold-water immersion on recovery of performance are inconsistent, though a number of meta-analyses have demonstrated enhanced recovery from strenuous exercise in trained athletes (Leeder et al, 2012; Poppendieck et al., 2013). Any inconsistency is likely driven by differences in the type of exercise, immersion protocol and performance measures evaluated. Alongside its effects on acute recovery, increasing evidence has shown that post-exercise cooling, mainly in the form of cold-water immersion, might exhibit a mode-dependant effect on training adaptation (Malta et al, 2021). In this respect, cooling could dimish adaptation to resistance training and associated strength performance, but appears not to affect aerobic exercise performance (Malta et al, 2021). These insights infer that the decision to apply post-exercise cooling following resistance-type exericise is dependant upon the relative importance of recovery time versus the desire to maximise training adaptation.

Heating Techniques

Heating techniques increase body temperature actively through modalities such as submaximal cycling and running (including exercise in water) or passively using external heating sources such as immersion in hot-water and sauna. Active and passive (hot-water immersion) heating techniques are popular in elite football with ~90% of teams in the Spanish top Division

Image: Illustration.

and ~70% of teams surveyed globally using such techniques (Altarriba-Bartes et al., 2020; Field et al, 2021).

Profound differences exist in the metabolic, cardiovascular and thermoregulatory responses to active and passive heating techniques (Francisco et al., 2021). This complexity, together with a wide variation in study experimental designs, present challenges when evaluating the influence of these techniques on exercise recovery (McGorm et al., 2018). Active and passive heating techniques increase circulation (Francisco et al., 2021), while increases in muscle temperature per se, directly ehance contractile function (Rodrigues et al., 2022). These physiological changes suggest heating strategies offer a plausible means through which to enhance recovery, however, evidence to date in humans remains inconclusive (Nédélec et al., 2013; McGorm et al., 2018; Rodrigues et al., 2022). In contrast to post-exercise cooling, less attention has centred upon the influence of post-exercise heating on training adaptation (McGorm et al., 2018). While heating during training might enhance the benefits of strength training (Goto et al., 2011), future research is needed to understand how post-exercise heating technqiues influence adaptation to strength training (McGorm et al., 2018).

Compression Techniques

This category largely surrounds the use of lower limb compression garments with ~70% of teams in the Spanish top Division and clubs/national federations included in a recent global survey reporting use of compression garments (Altarriba-Bartes et al., 2020; Field et al., 2021). Recent advances in technology have led to increasing use of intermittent pneumatic compression with ~60 of clubs/national federations adopting this technique (Field et al., 2021).

Lower limb compression garments typically apply graded external mechanical pressure to the skin which is greatest at the ankle and lower in more proximal areas (Hill et al., 2015). Compression techniques are thought to promote a number of physiological changes though evidence to date remains equivocal in many areas (Weakley et al., 2022). With sufficient pressure, the pressure gradient might enhance venous return through superficial compression to veins and improved capillary filtration (Partsch and Mosti, 2008; Feldman et al., 2012) whilst also increasing arterial blood flow (Dorey et al., 2018). Compression has also been shown to promote positive effects on muscle damage, perceived soreness and pain, sensorimotor systems and muscle oscillatory properties (MacRae et al, 2011; Weakley et al., 2022). Evidence to date, is however, equivocal regarding the efficacy of compression garments on recovery of performance and/or muscle function; however, the potential benefit of wearing compression garments seems to far outweigh the risks of a detrimental effect (MacRae et al, 2011; Brown et al., 2017; Weakley et al., 2022). Various methodological factors are likely to have contributed to the inconsistencies in experimental findings, with inter-individual variation in compression provided by commercially available compression garments possibly representing a key limitation (Hill et al., 2015). This highlights the need to use individualised "made-to-measure" compression garments to ensure the desired level of compression is attained.

Range of Motion Techniques

Maintaining or improving joint range of motion in athletes is often a key component of the work undertaken by support staff (Wilke et al., 2020). Several techniques are used to facilitate range of motion including various forms of stretching (static and dynamic), massage and self-myofascial release or foam rolling. In elite football, self-myofascial release or foam rolling and active and passive stretching remain popular techniques amongst elite clubs (Altarriba-Bartes et al., 2020).

It is well established that stretching is an effective intervention for enhancing range of motion (Wilke et al., 2020). On the contrary, there is no substantial evidence to support the use of stretching to enhance post-exercise recovery (Herbert et al., 2011; Nédélec et al., 2013). In a meta-analysis, Herbert and colleagues (2011) reported that stretching did not induce clinically important reductions in muscle soreness in the days following exercise. The precise mechanisms through which self-myofascial release or foam rolling mediates its effect are yet to be fully elucidated but is thought to involve tissue-specific and systemic adaptations (e.g. central nervous system) including increased intra-muscular temperature and blood flow together with reductions in fluid viscosity in the fascia, viscoelastic stiffness of the fascia and motoneuron excitability (Cheatham etal., 2015; Wilke et al., 2020). Foam rolling on soft-tissue areas is suggested to induce acute improvements in joint range of motion that are comparable with traditional stretching (Wilke et al., 2020). Foam rolling might also attenuate decrements in muscle performance and reduce perceived muscle soreness following exercise (Cheatham et al., 2015). Despite foam rolling being extensively used, the supporting evidence supporting its use in recovery is weak.

AN EXAMPLE PERIODISED RECOVERY STRATEGY FRAMEWORK FOR THE ELITE FOOTBALL PLAYER

The exercise-induced reduction in physical and mental function associated with football training and competition infers that it is illogical that a single recovery strategy and/ or a generic one-size-fits-all approach would address a player's recovery requirement (Minnet and Costello 2015). Alternatively, a framework where strategies are sequenced systematically at independent time points to match the source of physiological stress, alongside consideration to favourable adaptation might be a preferred approach in professional football (Thorpe et al., 2017; Kellmann et al., 2018).

Prioritising sleep and rest, nutrition and hydration is fundamental, thereafter, recovery strategies should be considered that alleviate the specific physiological stress incurred at any given time point on the recovery continuum (Kellmann et al., 2018). Strategies that serve to harness an athlete-belief effect or placebo effect can also be beneficial to compliment an evidenced based physiological strategy. Placebo or belief effect strategies can be categorised as therapeutic interventions; when implemented in the correct time frame these may further enhance the perceptions of recovery. To further individualise the recovery process, practical monitoring processes can be implemented to better understand the effects of training and facilitate recovery strategy prescription (Thorpe et al., 2017). In the absence of such capabilities, a periodised approach linked to the traditional football tactical periodisation model (Aquino et al., 2016) serves as an appropriate methodology to accelerate recovery and adaptation via an analogous approach. Tactical periodization models are commonly implemented by elite coaches to maximise player recovery and preparation (training adaptation). Considering the available scientific evidence, the following case study represents one possible way to develop a periodised recovery strategy framework that serves to optimise the stress-recovery-adaptation continuum in scenarios typically encountered in elite football. Figures 3 and 4 illustrate example frameworks for two and three match competition weeks, respectively.

When competing during two-game weeks, the general priority is to consolidate recovery and enhance adaptive responses (Figure 3). Conversely, during three-game weeks the priority shifts to consolidation of recovery (Figure 4). Competition match-play provides key anchor points for each week since it induces the highest level of stress from a combined mechanical and metabolic stress perspective. When players compete in two-game weeks (Figure 3), cooling is prioritised immediately following the match (MD) and on M+1, targeting likely secondary structural damage. Compression garments might also serve to alleviate muscle damage, perceived soreness and

The exercise-induced reduction in physical and mental function associated with football training and competition infers that it is illogical that a single recovery strategy and/ or a generic one-size-fits-all approach would address a player's recovery requirement.

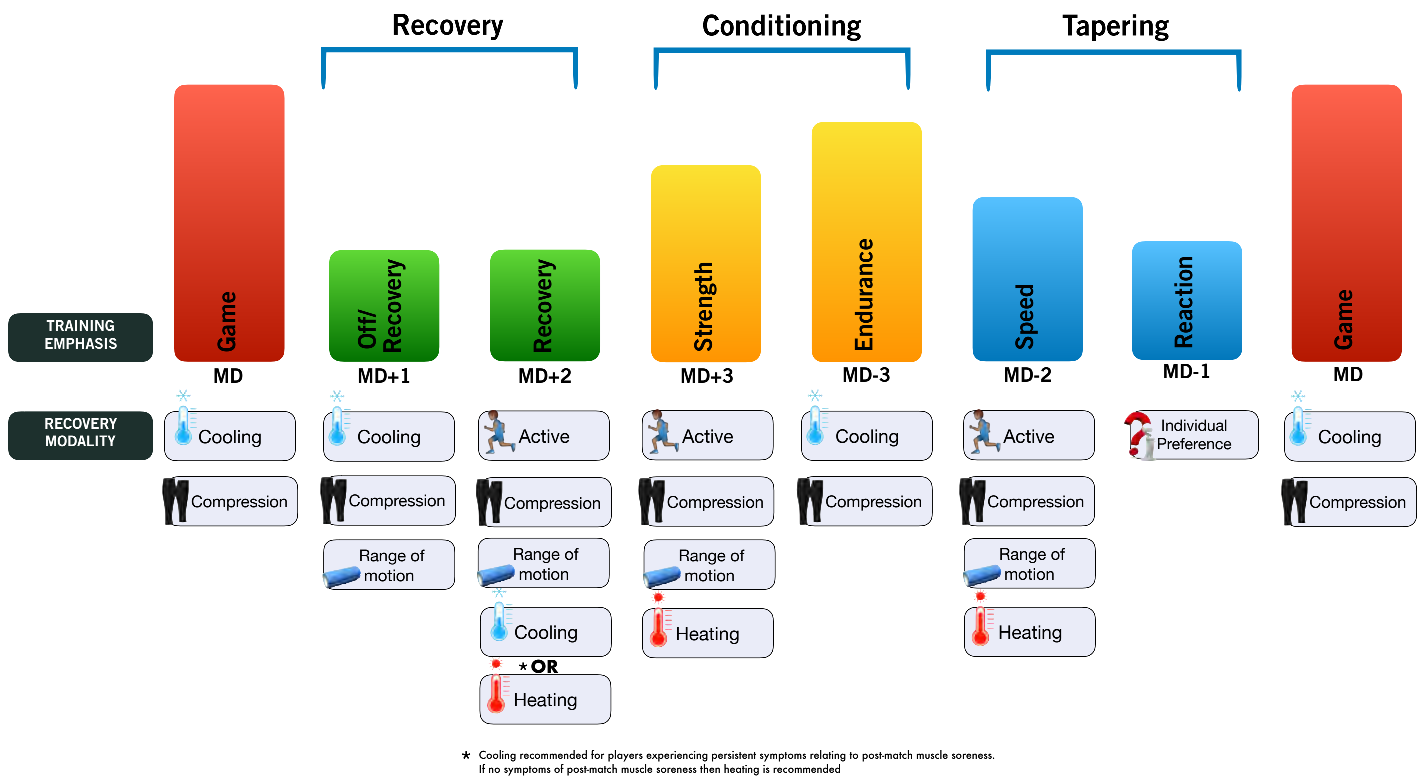

Figure 3: Microcycle involving one game week showing tactical, physical emphasis and recovery strategy periodisation.

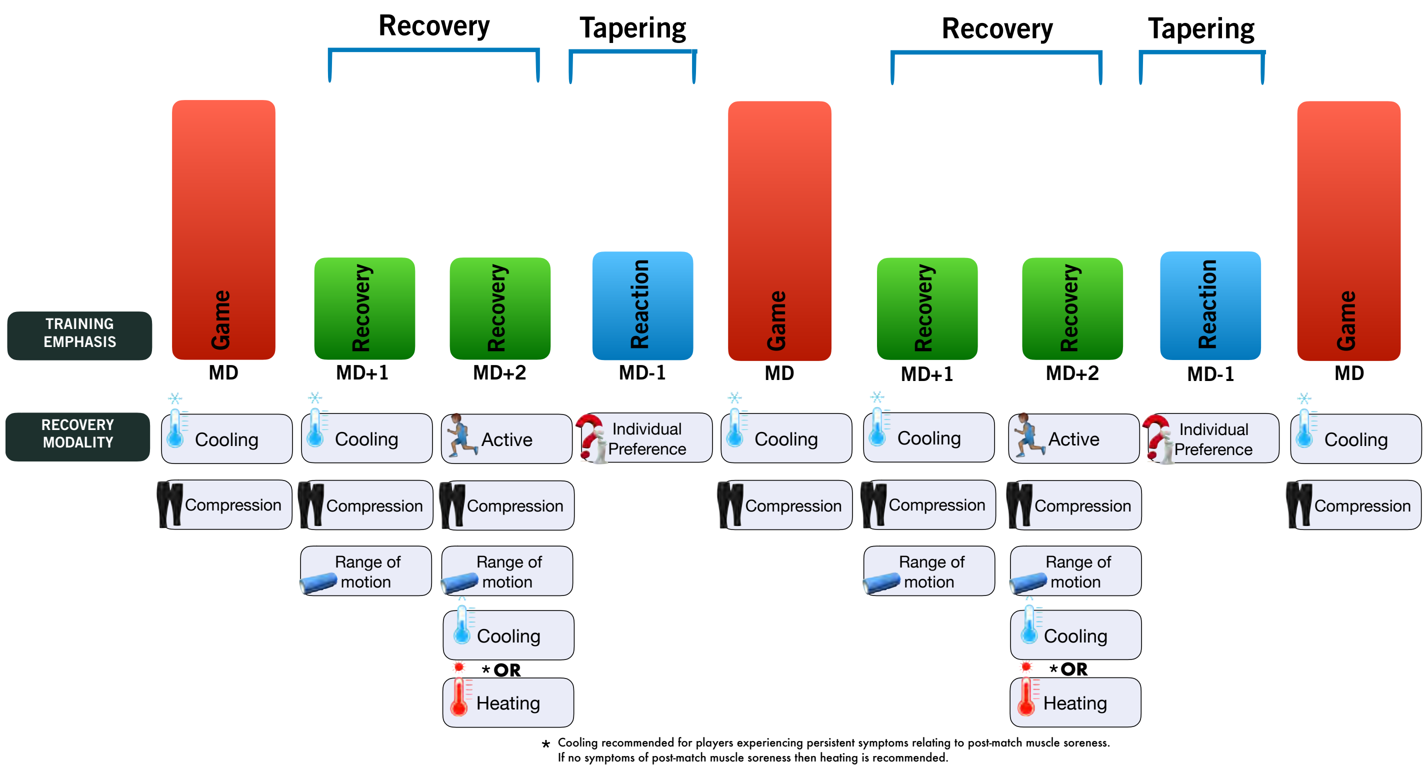

Figure 4: Microcycle involving a three-game week showing tactical, physical emphasis and recovery strategy periodisation.

pain over this period. Professional teams usually vary the scheduling of MD+1 'recovery days', taking place in the training facility and sometimes days off. Improving joint range of motion via low-intensity, dynamic stretching, is a sensible inclusion on MD+1 in both circumstances to prepare the return to technical football recovery-themed activities on M+2. Furthermore, low-intensity, dynamic stretching, should aim to increase joint ranges of motion whilst reducing mechanical load and further structural damage.

On MD+2, coaches usually begin a return to technical football activity through low volume/low intensity training. This serves both as a continuation of post-match recovery and preparation for the intense training scheduled on MD+3. Alongside active recovery, joint range of motion via low intensity, dynamic stretching and heating may facilitate a return to normal homeostasis. Cooling and compression should be prescribed for players where symptoms of post-match muscle soreness persist. The training emphasis on MD+3 shifts from recovery to conditioning in the typical tactical periodization model. Training activities consist of higher volumes of strength related football training and often complimentary resistance-based training. Heating may facilitate the adaptive responses to the strength training. Compression garments may also serve to alleviate any potential secondary structural damage arising from the heavy mechanical load incurred.

On MD-3, larger volume, endurance themed training is typically prescribed. Post-session cooling will not impede the endurance adaptive response, whilst potentially mitigating any metabolically induced muscle damage. Compression garments also remains a plausible option under such conditions to counter any potential secondary structural damage arising from the heavy metabolic load incurred. MD-2 frequently coincides with prescription of speed-based training which elicits a fatigue response not dissimilar to strength-based training (Thomas et al., 2018). The recovery techniques proposed for MD+3 following strength training are therefore advocated for MD-2 in an attempt to optimise recovery and adaptation. The choice of recovery interventions also provide a solid foundation for preparation and tapering leading into the forthcoming match. Finally on MD-1, players are recommended to perform modalities they believe to prepare them optimally for the forthcoming match (MD). However, load monitoring systems can provide additional intelligence whether additional physiological based recovery strategies are required.

Figure 4 shows a similar framework that prioritises recovery rather than a recovery-adaptive balance due to the higher frequency of competition. The emphasis on each day will be to promote recovery, however, deviation may be sensible if players' recovery rates between matches are slower or faster. Similarly, sophisticated monitoring systems can also assist in evaluating the effects of training and matches to provide a greater individualised and optimal approach to accelerating recovery and adaptation (Thorpe, 2021; Deely et al., 2022). Although, this can be used to guide a periodised recovery-adaptive approach in football, there will be some scenarios where a more nuanced approach should be considered. For example, the trade-off between recovery consolidation and adaptation enhancement will shift during various phases of the season. During pre-season and often the early phases of the in-season, adaptation is often prioritised, likely at the cost of acceptable residual acute fatigue. In contrast, the latter periods of the competition season will serve to prioritise recovery. The use of cooling, heating, low-intensity dynamic stretching (range of motion), and compression technique strategies to navigate and facilitate the associated football specific perturbations could be considered appropriate to accelerate recovery via the recovery-adaptive periodisation model.

SUMMARY AND FUTURE DIRECTION

Recovery is a complex and multifaceted process involving physiological and

Image: Illustration.

> **Future research using robust recovery technique protocols is needed to better understand the interaction between various techniques on the stress-recovery-adaptation continuum using well-trained male and female athlete populations.**

psychological parameters which need to be constantly evolving to optimise individual athlete recovery and physiological adaptation. The relative importance of recovery versus adaptation will vary according to the needs of the athlete within the context of the season. This raises the idea of using recovery strategies in a manner that is periodised to mirror the demands of the sport, and to adequately recover from the stress, but also balance the need for an adaptive response. A recovery strategy framework should serve to match a given stress with the most effective intervention to maximise the intended outcome across the stress-recovery-adaptation continuum.

A plethora of recovery strategies are commonly applied in the field despite limited scientific evidence to support their efficacy. The foundation of any intervention strategy should primarily be based on quality sleep and rest, along with adequate nutrition and hydration. Beyond this, there is sufficient scientific evidence to advocate the use of effective cooling and compression techniques to further accelerate the recovery process. Range of motion techniques and heating modalities might support the recovery processes at various time points, although more research is needed to examine their efficacy. Finally, an optimal recovery intervention strategy likely reflects a balance between evidence-based prescription, practitioner experience and individual athlete preferences and response to individual interventions.

Research has traditionally focused on administering a single recovery intervention whereas, in the applied setting, athletes are more likely to administer multiple interventions in varying sequences. Future research using robust recovery technique protocols is needed to better understand the interaction between various techniques on the stress-recovery-adaptation continuum using well-trained male and female athlete populations. This should centre on the influence of different interventions on the restoration of physical performance in real-world settings alongside studies using advanced laboratory techniques (e.g. assessment of neuromuscular, vascular function cellular and molecular, and cognitive responses) to foster a better understanding of the mechanisms that mediate an effect. Finally, recovery remains one of the least understood aspects of the exercise-adaptation cycle (Peak et al., 2017). More work is therefore needed to better understand the impact of the varied intervention strategies on the balance between accelerating recovery and mediating adaptation to maximise the stress-recovery-adaptation continuum.

Acknowledgements
We would like to thank Efthymios Kyprianou (eksportsperformance.com) for producing the figures for this article.

References
Available at www.aspetar.com/journal

Warren Gregson Ph.D., MBA
Head of Physiology & R&D
Aspire Academy
Qatar FA
Doha, Qatar
Football Exchange, Liverpool John Moores University
Liverpool, UK

Glyn Howatson Ph.D.
Professor of Human & Applied Physiology
Department of Sport, Exercise and Rehabilitation, Northumbria University
Newcastle, UK
Water Research Group, Faculty of Natural and Agricultural Sciences, North West University
Potchefstrrom, South Africa

Robin Thorpe Ph.D.
Head of Sports Science and Strength & Conditioning
Red Bull Athlete Performance Center
Los Angeles, CA, USA
Football Exchange, Liverpool John Moores University
Liverpool, UK
Adjunct Professor
College of Health Solutions, Arizona State University
Phoenix, USA

Contact: warren.gregson@aspire.qa