Recovery strategies for football players

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Introduction by the editor Boris Gojanovic

Recovery from intense efforts and matches demands special consideration, and recent years have seen the development of multiple new modalities which promise faster and better recovery. The world of professional football has taken notice, especially due to the repetition of matches and reduction of number of days in between for the best teams playing in the Champions League. Abd-Elbasset Abaïdia presented at the #SportSuisse2018 conference for Grégory Dupont, who was on duty with the World Cup winner French National team.

With all the science, hype and innovation around recovery, you may be surprised to read about the effectiveness and the recommendations for each possible modality discussed in this paper. Everything that glitters is not gold, and the usual wise advice from your grandmother might have been true all along: eat, sleep, drink water. She might have been wrong on the "keep warm" advice, as cold exposure might have advantages.

Keywords: Recovery, football, muscle, cold water immersion, nutrition

La récupération des efforts intenses et des matchs est un sujet qui s'est passablement développé ces dernières années, avec moult promesses de solutions innovantes qui permettent de récupérer mieux et plus vite. Le monde du football professionnel n'y est pas indifférent, notamment en raison de la répétition des matchs rapprochés, comme c'est le cas pour les équipes jouant la Champions League. Abd-Elbasset Abaïdia a présenté l'état des connaissances et des pratiques actuelles à la conférence #SportSuisse2018, en remplacement de Grégory Dupont, lequel était en déplacement avec les Bleus.

Avec toute la science, la technologie et l'innovation autour de la récupération, vous serez peut-être surpris de lire les recommandations pour chacune des modalités discutées dans cet article. Tout ce qui brille n'est pas de l'or, et les bons vieux conseils sages de grand-maman n'étaient peut-être pas si faux: manger, dormir, boire. Par contre, elle se trompait peut-être par rapport au froid, dont les avantages semblent intéressants.

Mots clés: Récupération, football, muscle, cryothérapie, nutrition

Abd-Elbasset Abaïdia

Introduction

In elite football, the number of matches per season is very high with up to 60-80 matches for some players. In these conditions, the number of weeks with two matches per week is greater than the number of weeks with one match per week. A single match leads to an acute fatigue, characterised by a decline in maximal muscle strength (Magalhães et al., 2010), which requires several days to fully recover. When the schedule is congested (i.e. two matches per week over several weeks), the repetition of matches can lead to a chronic fatigue among the players who play regularly, as the recovery time between two successive matches may be too short. The Federation Internationale de Football Association recommends at least 2 days between two matches, but this is not a rule, it is solely a recommendation. Anecdotal interviews revealed a feeling of exhaustion from the players with the repetitions of the matches. However, these subjective statements may not have a sufficient evidence base. In this instance, a recovery period from 48h to 96h between two matches is associated with and increased injury risk suggesting insufficient time to fully recover. This aspect will be addressed in the first part of the article. One of the questions that can arise is how much time does a professional player need to fully recover? This aspect will be addressed in the second part of the article. The third part will deal with the actions performing during a match that may lead to fatigue and the potential mechanisms involved. In line with the three first part, the effects of recovery strategies will be addressed in a fourth part before finishing with the practical applications.

Effects of a congested schedule on physical performance and injury rate

During a match, players perform some actions inducing muscle damage: sprints, jumps, changes of direction, shoots, tackles. Performing muscle damaging actions leads to a decrease of neuromuscular function immediately after exercise and sometimes for several days. During a match, fatigue occurs temporarily after short- term intense periods in both halves; towards the end of the match and after the match. Many non-contact injuries occur during the latter stages of each half (Hawkins RD et al., 2001; Ekstrand et al., 2011), suggesting that fatigue can be a risk factor of injury. However, fatigue can also come from the repetition of the matches. During periods where the schedule is particularly congested (i.e. two matches per week over several weeks), the recovery time between two successive matches can be between 2 and 4 days, which may be insufficient to restore normal homeostasis. As a result, players may experience acute and chronic fatigue potentially leading to underperformance and/or injury. Dupont et al. (2010) showed that injury incidence in professional football players playing the UEFA Champions League, is 6.2 times higher when two matches per week were played (25.6 injuries per 1000 hours of exposure) in comparison with one match in a week (4.1 injuries per 1000 hours of exposure). The authors studied match-related physical performance and injury rate playing either one or two matches per week during two seasons. These results were supported by an absence of significant difference between 1 versus 2 matches per week in physical performance during official matches, characterised by total distance covered, high-intensity distance, sprint distance and number of sprints. Bengtsson et al. (2013) reported also, in a UEFA study, that muscle injury rates were increased in matches with a recovery period of 4 days or less in comparison with a recovery of 6 or more days. This study involved 27 professional teams over 11 seasons. Taken together, these results show that a recovery period from 48h to 96h between two matches is associated with and increased injury risk suggesting insufficient time to fully recover. The present data highlight the need for improved recovery strategies to maintain a low injury rate during periods with congested match fixtures. However, before focusing on recovery strategies, it is necessary to identify the time course of recovery, to determine the fatigue mechanisms as well as the actions in a match that may lead to fatigue. The knowledge of these mechanisms should allow the application of appropriate and rationalized recovery strategies.

Time course of recovery

Several research teams have studied recovery kinetics of muscle damage markers after a football match. Sprint performance impairment ranges from –3% to –9% post-match, and the delay to fully recover varies between 24h and more than 72h (Andersson et al., 2008; Ispirlidis et al., 2008; Magalhães et al., 2010). When tested immediately after a match, jump performance decrements range from no decrement (Krustrup et al., 2010) to –12% (Magalhães et al., 2010). The time for jump performance to completely recover is between 48 hours (Ispirlidis et al., 2008) to more than 72 hours after the match (Andersson et al., 2008; Magalhães et al., 2010). Immediately post-match, neuromuscular function is impaired with a decrease of muscle strength ranging between –4% and –36% for knee flexors and –6.5% and –14% for knee extensors. The recovery response is highly variable, as in some cases players have recovered 48h after the match (Andersson et al. 2008; Thorlund et al., 2009; Rampinini et al. 2011), while others still did not have recover 72h post-match (Ascensão et al. 2008; Magalhães et al. 2010). Although the validity of biochemical markers for muscle damage is questionable (Warren et al., 1999), creatine kinase concentrations are frequently used to investigate the underlying physiology of the recovery process. Immediately after a match, rises in creatine kinase concentration range from +75% (Ascensão et al., 2008) to +250% (Magalhães et al., 2010). Creatine kinase concentrations peak at 24–48 hours after the match and return to baseline between 69 (Andersson et al., 2008) and 120 hours (Ispirlidis et al., 2008) following the match.

The differences between studies regarding the magnitude of performance decline and the subsequent time course of recovery could be explained by the fact that the recovery process was tracked following football match (Ispirlidis et al., 2008; Andersson et al., 2008; Magalhães et al., 2010; Ascensão et al., 2008). Several studies (Di Salvo et al., 2009; Dupont et al., 2010) have pointed out the high variability and poor reliability of physical performance such as high-intensity running distance during football matches, which depends not only on the fitness level but also on the match status (i.e., whether the team is winning, losing or drawing), quality of the opponent (strong or weak), and the match location (i.e., playing at home or away). Secondly, some extrinsic factors may also influence players' work rate such as the climatic conditions and type of pitch (e.g. grassy, muddy, artificial). As a consequence, the amount of fatigue induced by the different football matches may vary greatly and affect the time course of recovery. This variability inherent to a football match makes it difficult to translate findings from one study to another.

To conclude for this part, scientific evidence indicates that a recovery period between 48h and 72h is insufficient to fully recover after a football match. Studies have not shown a normalisation of physical performance within the 3 days consecutive to a football match (Andersson et al., 2008; Ascensão et al., 2008; Fatouros et al., 2009; Magalhães et al., 2010). The results suggest that performance can be impaired for 72 hours and more. When playing two matches per week, the 3-day recovery time between two successive matches may consequently be insufficient to fully recover. This long-lasting reduction in physical performance testifies the presence of some fatigue processes that recover slowly after the match.

Fatigue mechanisms

This part focuses mainly on the mechanisms that contribute to post match fatigue. The decrement in performance characterizes post football match fatigue. Long-lasting fatigue may be caused by both impaired excitation-contraction coupling and structural damage (Allen, 2001). According to Rampinini et al. (2011), fatigue in football is determined by a combination of central and peripheral factors both immediately after the match and within hours of recovery. Central fatigue seems to be the main cause of the decline in maximal voluntary contraction and sprinting ability, whereas peripheral fatigue seems to be more related to increased muscle soreness and therefore may be linked with muscle damage and inflammation

Muscle glycogen is a major substrate for energy production during a football match. Studies have shown a relation between muscle glycogen depletion and the decrement in high-intensity distance frequently observed at the end of a match (Mohr et al., 2003). As muscle glycogen repletion after a high-level football match requires between 2 and 3 days when a specific nutrition plan is provided, this fatigue can also affect the post-match fatigue. Additional factors involved in the fatigue may be observed in the last quarter of the match such as dehydration and thirst. Mohr et al. (2010) reported a net fluid loss of more than 2% of the initial body mass, after a match played in a hot environment (31.2 to 31.6 °C). The net fluid loss during the match and the fatigue index in a post-match sprint test were significantly correlated ($r=0.73$; $p < 0.05$). However, the role of dehydration in post football match fatigue is likely limited. When guidelines are respected, the time to rehydrate is estimated to be as long as 6 hours (Shirreffs et al., 1996).

Post football match fatigue may also be explained by match-induced muscle damage. The repetition of changes of direction, accelerations and decelerations throughout a football match may induce muscle damage. The actions performed during a match integrate eccentric contractions triggering a mechanical stress on muscle fibers, during which the muscle is stretched to a deformation of some sarcomeres inside the muscle. Muscle soreness and an increase of some biological markers concentrations, such as creatine kinase, may accompany the decrease of muscle force following participation to a football match (Davies and White 1981).

Additionally, mental fatigue is a factor to consider to explain post football match fatigue. During a match, players have to cope with physical aspects but also with cognitive aspects, meaning taking into account, at the same time, the position and movements of the ball, of the opponent and of the teammates. In this context it can be hypothesized that cognitive function may be altered after a football match. When the competitive fixture list is congested, the time in between matches may be insufficient to recover the initial level of psychological resources, potentially leading to lack of motivation and mental burnout. Multiplication of travels may lead to the disruption of circadian rhythms (jet lag or arrival during the night) and sleep leading to an increase of the level of stress.

In summary, the decline in maximal voluntary contraction and sprinting ability seems to be linked to central fatigue, whereas increase of muscle soreness and therefore seems very likely linked to muscle damage and inflammation, which are peripheral factors. Post football match fatigue may be associated with glycogen depletion, muscle damage and mental fatigue.

Recovery strategy

According to Bishop (2008), the general consensus is that the translation of sport science research to practice is poor. In order to reduce the gap between sport science research and practice, a survey on the recovery strategies currently used in professional football teams was performed (Nédélec et al., 2013). The most common recovery strategies used and perceived effective by football clubs include nutrition (97% of respondents), sleep (95%), cold-water immersion and contrast water therapy (78%), active recovery (81%) and compression garments (22%) (Nédélec et al. 2013). However, do these recovery strategies have an evidence base to be able to confidently recommend as part of the recovery strategy to enhance player recovery, especially during match congestion? Following this survey, the level of scientific evidence justifying these recovery strategies was reviewed. For this review, the level of scientific evidence focused on the effects of the recovery strategies on the change in the measured physical performance.

A computerized literature search was performed using PubMed. The following keywords were used in different combinations: "recovery", "muscle damage", "football", "markers", "strength", "force", "blood", "DOMS", "nutrition" "proteins", "carbohydrates", "sleep", "cold-water immersion", "hydrotherapy", "cryotherapy", "massage", "stretching", "compression garments", "meditation", "oxygen therapy", "occlusion", "foam roller", "electrostimulation", "relaxation".

Systematic reviews and meta-analysis were included to define the relevance of the strategies used to accelerate recovery kinetics.

The methodological quality of the included reviews was assessed using the Assessing Methodological Quality of Systematic Reviews (AMSTAR) tool (Shea et al., 2007). The quality and the risk of bias were assessed, based on the AMSTAR score: high quality, very low risk of bias (AMSTAR ≥10); high quality, low risk of bias (AMSTAR 8–9); low quality, high risk of bias (AMSTAR 3–7); low quality, very high risk of bias (AMSTAR ≤2) *(Table 1)*.

Then, when a level of scientific evidence was defined, a final graded recommendation was assigned according to the following classification: A–high, B–acceptable, C–weak, D–insufficient evidence to provide a recommendation or sufficient evidence to reject use/ to implement *(Table 1)*.

Recovery strategy	Review	AMSTAR score	Grade of recom-mendation	Conclusions
Nutrition and hydration	Pasiakos et al. Sports Med. 2014;44(5):655-70	6	A – High	↑ force recovery. ↓ muscle soreness. Recommendation: 500 ml of milk + carbohydrates immediately following the match. Drink volume greater than 150 to 200% of the sweat loss.
	Fouré and Bendahan. Nutrients. 2017;9(10). pii: E1047.	6		
	Rahimi et al. Nutrition. 2017; 42:30-36.	6		
	Davies et al. Nutrients. 2018;10(2). pii: E221.	6		
	Mc Lellan et al. Sports Med. 2014;44(4):535-50	5		
Cold-Water immersion	Bleakley et al. Cochrane Database Syst Rev. 2012;(2):CD008262.	7	A – High	↑ force recovery. ↓ muscle soreness, [CK] and [Mb]. Recommendation: 10 to 15 at 10°C to 15°C immediately after the match
	Poppendieck et al. Int J Sports Physiol Perform. 2013;8(3):227-42.	8		
	Leeder et al. Br J Sports Med. 2012 Mar;46(4):233-40.	6		
	Machado et al. Sports Med. 2016 Apr;46(4):503-14.	7		
	Hohenauer et al. PLoS One. 2015;10(9):e0139028.	8		
Sleep	Bonnar et al. Sports Med. 2018;48(3):683-703.	6	B – acceptable	↑ performance recovery and alertness. Sleeping at least 8 to 10 hours. Nap possible
Massage	Poppendieck et al. Sports Med. 2016;46(2):183-204.	4	B – acceptable	↓ muscle soreness. Contradictory results regarding performance. Recommendation: massage for a duration of 5 to 12 minutes
	Best et al. Clin J Sport Med. 2008;18(5):446-60	4		
	Torres et al. Phys Ther Sport. 2012;13(2):101-14	9		
	Guo et al. Front Physiol. 2017;8:747.	8		
Stretching	Torres et al. Phys Ther Sport. 2012;13(2):101-14	9	A – High	No beneficial effect on muscle performance recovery
	Herbert et al. Cochrane Database Syst Rev. 2011;(7):CD004577.	9		
Compression garments	Brown F et al. Sports Med. 2017;47(11):2245-2267	6	A – High	↑ force and power recovery. ↓ muscle soreness. Recommendation: 15 mm Hg at the thigh level and 25 mm Hg at the calf level
	Marques-Jimenez et al. Physiol Behav. 2016;153:133-48.	8		
	Hill et al. Br J Sports Med. 2014;48(18):1340-6.	5		
Whole-body cryotherapy	Costello et al. Cochrane Database Syst Rev. 2015;(9):CD010789.	9	A – High	Cold-water immersion > whole-body cryotherapy
	Rose et al. Int J Sports Med. 2017;38(14):1049-1060.	5		
Foam roller	Cheatham et al. Int J Sports Phys Ther. 2015 Nov;10(6):827-38.	6	B – acceptable	↓ muscle soreness. Contradictory results regarding performance
	Schroeder and Best. Curr Sports Med Rep. 2015;14(3):200-8	3		
	Beardsley and Skarabot. J Bodyw Mov Ther. 2015;19(4):747-58.	5		
Electrostimulation	Malone et al. J Strength Cond Res. 2014;28(9):2478-506.	7	B – acceptable	No beneficial effect on muscle performance recovery.

Table 1: level of scientific evidence and grade of recommendation of the included reviews.

1. Nutrition and hydration

This goal may be attained by implementing a nutritional strategy after a football match. Such a strategy should include consumption of foods leading to the replenishment of glycogen and water stores and to the optimization of muscle damage repair.

Loss of intracellular volume reduced rates of glycogen and protein synthesis (Shephard and Leatt, 1987). In this context, complete restoration of fluid balance after a match is an important part of the recovery process. After match-induced dehydration (~2% of body mass), full rehydration status will take 6 hours, if a high-sodium (61 mmol.l-1, about 3 times higher than the sodium concentration found in many commercial sports drinks) drink volume greater than 150 to 200% of the sweat loss, is consumed (Shirreffs et al., 1996). The addition of sodium to rehydration beverages (500 to 700 mg/L of water) is recommended as it promotes fluid retention, stimulates the thirst while delaying urine production, and increases glucose absorption in the small intestine (Shireffs and Maughan, 2000). It is recommended to drink a large volume of fluid after the match instead of small quantities gradually. This recommendation is due to the fact that the high rate of post exercise fluid consumption results also in a faster fluid balance restoration compared to a low rate of fluid intake (Kovacs et al., 2002). However, a small volume of fluid should be prescribed after this initial large consumption of fluid. Addition of a small amount of carbohydrate into the water can also be advised as it stimulates fluid absorption in the gut and then improves palatability (Shireffs and Maughan, 2000).

In a survey conducted on a professional team from the Italian Serie A followed during 5 years, 66% of the players declared to be regular drinkers of alcoholic beverages (Volpi and Taioli, 2012). However, alcohol consumption should be avoided after a match as it delays the ability to recover. Firstly, alcohol has diuretic properties, which increases urinary output and consequently the level of dehydration (Shireffs and Maughan, 2000). Secondly, it delays the muscular recovery process. The decline in maximal strength at 36 hours post-exercise was associated to muscle damage and was significantly greater in the alcoholic beverage condition (1 g.kg-1 bodyweight ethanol as vodka and orange juice) compared to an isocaloric non-alcoholic beverage condition (Barnes et al., 2010). Thirdly, it impairs sleep efficiency (Feige et al., 2006), a vital function in the recovery process.

Between 2 and 3 days are needed to observe muscle glycogen repletion after a high-level football match. Without specific guidelines, muscle glycogen concentration in top-level players was about 50% of the pre-match value 2 days after a match (Jacobs et al., 1982). Optimization of the resynthesis of muscle glycogen stores is effective when consuming carbohydrates with a high glycemic index. Studies have shown that an intake of 1.2 g carbohydrate per kg per hour immediately after a match, at 15–60 min intervals for up to 5h, enables maximum resynthesis of muscle glycogen stores (Jentjens and Jeukendrup, 2003).

Performing muscle-damaging exercise, such as seen in football, leads to muscle protein synthesis and muscle protein breakdown. Consuming proteins after a match enables to have a net positive protein balance, to repair muscle damage following exercise. After a match, consuming a high-protein diet may accelerate recovery of muscle function (Cockburn et al. 2008). The timing and the quantity of protein to ingest is not clearly defined, although scientific evidence has shown a beneficial effect of 20g milk protein or an equivalent of 9g amino acids on muscle protein synthesis rates during the first 2 hours of recovery (Beelen et al. 2010) and beneficial effects on cycling exercise performance (Saunders et al., 2004). Flavored milk, which is an easily accessible and relatively inexpensive dairy product, is an effective beverage for post-exercise recovery. It contains carbohydrate and proteins in similar amounts to those used in studies demonstrating improved post-exercise recovery. Many studies have also confirmed the significant effects of post-exercise chocolate milk supplementation on subsequent exercise performance (Pritchett et al., 2009; Ferguson-Stegall et al., 2011).

Some juices such as tart cherry juice, tomato juice or berry juice are also recommended to enhancing the recovery process. These juices are loaded with a high antioxidant capacity, which reduce oxidative stress and inflammation. The ingestion of these juices prior to and following exercise-induced muscle damage is able to accelerate muscle strength recovery (Howatson et al., 2010; McLeay et al., 2012).

In conclusion, immediately after the match, players should drink a large volume of fluid (about 150% of the sweat loss) with a high concentration of sodium (about 500 to 700 mg/L of water), flavored milk and tart cherry or berry juice. Then, they should eat a meal containing high-glycaemic index carbohydrate and protein within the hour following play.

Grade of recommendation:
A – high: to implement.

2. Sleep

Playing football match at night time (8 to 9pm) involves high physical and mental load, as well as a high emotional stress. In addition, post-match routines (medical care, recovery strategies, meal and return trip) frequently lead to a very late bedtime, which may also alter sleep quality and quantity. In a survey performed in a football team participating to the UEFA Europa League, 95% of the players declared a worse sleep after night matches (Nédélec et al., 2015). This may be a consequence of the physical and mental load involved during a match but also to a high emotional stress (Nédélec et al., 2015). Sleep loss negatively affect endurance performance, maximal strength and cognitive performance (Reilly and Edwards, 2007). Sleep and the immune system are also closely linked. Subjects with less than 7 hours of sleep per night in the weeks preceding exposure to a rhinovirus are about 3 times more likely to develop a cold than those with 8 hours or more of sleep (Cohen et al., 2009).

As shown in the previous part, a high-glycaemic index meal is recommended for rapid restoration of muscle glycogen stores. This diet has been shown to significantly reduce sleep onset latency compared with a low-glycaemic index meal (Afaghi et al., 2007) and was most effective when consumed 4 hours before bedtime compared with the same high-glycaemic index meal given 1 h before bedtime. Some other nutrients such as those contenting tryptophan (Halson, 2008) or melatonin (Halson, 2008; Howatson et al., 2012) are also recommended to decrease sleep onset latency and/or to improve sleep quantity and quality. Tryptophan-containing foods include milk, meat, fish, poultry, eggs, beans, and leafy green vegetables, while high concentrations of melatonin are contained in tart cherries.

A poor night's sleep may be compensated by a short post-lunch nap. When followed by a 30-minute recovery period, a nap may improve alertness and aspects of mental and physical performance after partial sleep loss (Waterhouse et al., 2007). The ability to nap for short periods during the day may be a useful skill for players especially during a congested schedule. Sleep quantity extension is another strategy to improve physical performance. According to Mah et al. (2011), extended sleep beyond one's habitual nightly sleep contributes to improved athletic performance, technical skills, reaction time and daytime sleepiness in basketball players.

Other recommendations for sleep induction include benefiting from a dark and quiet environment by using eyeshades and earplugs, listening to relaxing music and adopting regular sleep-wake schedules. Conversely, consumption of caffeine prior to the match for performance enhancement, alcohol as a means of celebrating after the match, and hyper-hydration could lead to sleep disturbance.

Sleep is an essential part of recovery management, as sleep disturbances after a match are common which may negatively impact on the recovery process.

3. Cold-water immersion

The principle of cold-water immersion is to immerse the body into a water with a temperature under 15°C for an exposure period comprised between 10 and 15 minutes (Halson, 2011; Poppendieck et al., 2013). Several meta-analysis performed in order to analyze the effects of cold-water immersion on recovery kinetics. Results have consistently shown a beneficial effect of this strategy on force, sprint and jump recovery (Leeder et al. 2012; Poppendieck et al. 2013). The optimal use of cold-water immersion is a whole-body exposure of 10 minutes at a 10°C temperature immediately after exercise (Versey et al. 2013). Other strategies such as whole-body cryotherapy are based on the principle of using cold to accelerate recovery kinetics. A study compared cold-water immersion and whole-body cryotherapy effects on recovery kinetics. The results showed that cold-water immersion was more beneficial than whole-body cryotherapy to accelerate recovery of jump height and subjective ratings (Abaïdia et al., 2017a).

Grade of recommendation:
A – high: to implement.

4. Active recovery

This strategy involves running, biking or swimming at low intensities for durations of 15 to 30 minutes. When performed between 30 and 60% of maximal oxygen uptake and lasting at least 15 minutes, active recovery enhances blood lactate removal (Belcastro and Bonen, 1975) in comparison with passive recovery. As faster lactate removal does not necessarily involve better performance during subsequent exercise, lactate removal should not be the criterion used to test the quality of recovery. In several studies aimed at comparing active and passive recovery modalities, exercise performance after active recovery did not improve, despite lower lactate concentrations (Weltman and Regan, 1983; Bond et al., 1991), while other studies showed that passive recovery improved performance in subsequent exercise (Dupont et al., 2003; 2004). Additionally, some studies have indicated glycogen synthesis impairment when active recovery is performed immediately after high-intensity (Choi et al., 1994; Fairchild et al., 2003).

In a set of studies on recovery between two football matches separated by 3 days in elite female players, Andersson et al. (2008; 2010) investigated the effects of 1 hour of active recovery (low-intensity cycling and resistance training) performed at 22 and 46 hours after the first match. Results showed that active recovery had no effects on the recovery pattern of physical performance markers (i.e. countermovement jump, 20-m sprint performance, maximal isokinetic knee flexion and extension), perceived muscle soreness and biochemical markers (i.e. creatine kinase, urea and uric acid), oxidative stress markers and antioxidants. According to these results, an active recovery performed after a match does not present any benefit for football-related physical performance.

Grade of recommendation:
A – high: to reject.

5. Massage

In terms of recovery of performance, Studies have shown that massage was not an efficient technique to accelerate recovery kinetics of neuromuscular function (Barlow et al., 2007; Poppendieck et al. 2016) or global exercises (Robertson et al. 2004). Massage therapy attenuates inflammatory signaling after exercise-induced muscle damage (Crane et al., 2012), and presents psychological benefits. Massage decreased the subjective symptoms of delayed onset muscle soreness and increased perceptions of recovery (Hemmings et al., 2000). In conclusion, benefits of massage are still lacking regarding recovery of performance. Conversely, the majority of the evidence points towards massage being effective in alleviating muscle soreness and improving perceptions of recovery.

Grade of recommendation:
B – acceptable: to implement.

6. Stretching

Elite football teams devote a substantial amount of training and match preparation time to stretching. Dadebo et al. (2004) reported that the English Premiership clubs allocated almost 40% of total training time to flexibility training. Stretching exercises are performed for several reasons: to improve range of motion, to reduce musculotendinous stiffness, to prevent injury, as well as to promote recovery. However, there is no substantial scientific evidence to support the use of stretching to enhance the post-exercise recovery of football players. In a meta-analysis including 12 studies, Herbert et al. (2011) reported that stretching is not clinically worthwhile in reducing muscle soreness in the days following exercise. Recovery of physical performance is not improved after stretching (Lund et al., 1998).

Grade of recommendation:
A – high: to reject.

7. Compression garments

Principle of compression garments is to increase the pressure on the ankle and to decrease it on the mid-thigh in order to improve the venous return and thus reduce venous stasis in the lower extremities. Wearing compression garments following a match may have beneficial effects on recovery kinetics. The effectiveness of compression garments on muscle force and power is underpinned by a high level of scientific evidence (Hill et al. 2014; Marques-Jimenez et al. 2016; Brown et al. 2017). Results indicated that the use of compression garments had moderate effect on recovery of muscle strength, muscle power, creatine kinase and in reducing the severity of delayed onset muscle soreness. As studies did not have a placebo condition (i.e., using a garment, but no compression), a placebo effect due to wearing the garments should not be excluded.

In conclusion, the use of compression garments may provide an easy-to-use recovery strategy in a team. They could be useful during air travel, especially during long flight, to reduce the risk of deep vein thrombosis (Bartholomew et al., 2011).

Grade of recommendation:
A – high: to implement.

8. Electrical stimulation

Electrical stimulation involves the transmission of electrical impulses via surface electrodes to peripherally stimulate motor neurons thus eliciting muscular contractions. Transcutaneous electrical nerve stimulation and low-frequency electrical stimulation are the modalities most frequently used for recovery purposes. The effects of electrical stimulation on the recovery of strength production capacity and on the reduction of muscle soreness were reviewed by Malone et al. (2014). This review failed to find a significant effect of electrical stimulation on the ability to maintain performance after an exercise, but reported a beneficial effect of electrical stimulation on the reduction of muscle soreness and perception of fatigue.

In conclusion, although electrical stimulation is often used for recovery purposes, no scientific evidence exists regarding its effects to maintain physical performance. The level of scientific evidence concerning the effect of electrical stimulation on subjective rating such as muscle soreness is also limited.

Grade of recommendation:
B – acceptable: to implement.

9. Strength training session

Performing a heavy load strength training session is also a way to stimulate growth hormone and testosterone secretion. Performing an upper-limb strength training session after lower-limb exercise may accelerate recovery kinetics of concentric force, as previously shown (Abaïdia et al., 2017b). This strategy may be implemented the day after a match during the training session.

Grade of recommendation:
B – acceptable: to implement.

10. Foam roller

Systematic reviews have been performed in order to evaluate the effects on recovery kinetics (Beardsley and Skarabot, 2015; Cheatham et al., 2015; Schroeder and Best, 2015). Conflicting results were found, regarding the effects on neuromuscular performance, but beneficial effects were found on muscle soreness. The ideal dosage is not defined in the reviews focusing on this strategy. Other studies are needed to specify the effects of foam roller on recovery kinetics.

Grade of recommendation:
B – acceptable: to implement.

Conclusion

In summary, some recovery strategies such as hydration, diet, sleep, cold-water immersion and compression garments are effective to accelerate the recovery process. An example of a practical recovery protocol based on scientific evidence is proposed in Figure 1.

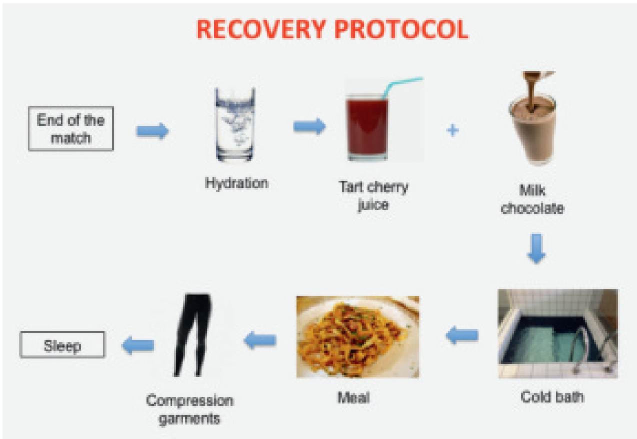

Figure 1: An example of a practical recovery protocol based on scientific evidence.

According to the recommendations previously shown in this article, a protocol of recovery should be implemented immediately after a match. Below and in figure 1, we provide an example protocol of how post-match recovery may be organized:

- Foods with a high amount of high glycemic index carbohydrate and a high amount of protein in the hour following the match should be consumed. Chocolate milk is considered as a good product as it contains protein and carbohydrates, and as some studies have shown its beneficial effect on recovery kinetics (Pritchett et al. 2009; Fergusson et al. 2011). Additionally, post-game re-hydration is an important issue, it is recommended to replenish players water stores by consuming fluid (150% of body mass lost) with a high amount of sodium (500 to 700 mg.l-1 of water) (Nédélec et al. 2013).
- Cold-water immersion soon after finishing the match can be performed ideally in a bath with a temperature of 10°C for 10 minutes.
- Massage for a duration of 5 to 12 minutes. The best results on muscle soreness are obtained with a combination of effleurage, petrissage, tapotement, friction and vibration techniques.

- Wearing compression garments with a high level of pressure (for example: 15 mm Hg at the thigh level and 25 mm Hg at the calf level) until bed time and the days following the match.
- Doing everything possible to have a good night sleep, however, if the 1st night sleep is poor, this should be compensated with a nap the following day (Nédélec et al., 2015). Optimizing sleep is possible by sleeping at least 8 to 10 hours, switching-off all the lights, decreasing the temperature of the room and adapting the food ingested in the afternoon by avoiding drinks such as coffee or tea.

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