Routledge
Taylor & Francis Group

Managing Sport and Leisure

ISSN: 2375-0472 (Print) 2375-0480 (Online) Journal homepage: https://www.tandfonline.com/loi/rmle21

Return to elite football after the COVID-19 lockdown

Magni Mohr, George P. Nassis, Joao Brito, Morten B. Randers, Carlo Castagna, Dan Parnell & Peter Krustrup

To cite this article: Magni Mohr, George P. Nassis, Joao Brito, Morten B. Randers, Carlo Castagna, Dan Parnell & Peter Krustrup (2020): Return to elite football after the COVID-19 lockdown, Managing Sport and Leisure

To link to this article: https://doi.org/10.1080/23750472.2020.1768635

Published online: 18 May 2020.

MANAGING SPORT AND LEISURE
https://doi.org/10.1080/23750472.2020.1768635

Routledge
Taylor & Francis Group

COMMENTARY

Return to elite football after the COVID-19 lockdown

Magni Mohr [a,b], George P. Nassis [a,c], Joao Brito [d], Morten B. Randers [a,e], Carlo Castagna [f], Dan Parnell [g] and Peter Krustrup [a,c,h]

[a]Department of Sports Science and Clinical Biomechanics, SDU Sport and Health Sciences Cluster (SHSC), Faculty of Health Sciences, University of Southern Denmark, Odense, Denmark; [b]Centre of Health Science, Faculty of Health Sciences, University of the Faroe Islands, Tórshavn, Faroe Islands; [c]Shanghai University of Sport, Shanghai, China; [d]Portugal Football School, Portuguese Football Federation, Lisbon, Portugal; [e]School of Sport Sciences, Faculty of Health Sciences, UiT The Arctic University of Norway, Tromsø, Norway; [f]Fitness training and biomechanics laboratory, Technical Department, Italian Football Federation (FIGC), Florence, Italy; [g]University of Liverpool Management School, University of Liverpool, Liverpool, UK; [h]Sport and Health Sciences, University of Exeter, Exeter, UK

ABSTRACT

The COVID-19 pandemic has changed the conditions for competitive football around the globe dramatically. Several competitions and leagues have been cancelled or postponed. Players have firstly been forced to training in solitude. In a second stage, players start training in small groups with strict contact restriction and return to competitive play might occur after only few weeks of normal team training preparation. These special circumstances are likely to impact football performance and injury risk in the upcoming competitions. Thus, clubs, coaching and medical staff, as well as players are challenged on the prioritization of fitness and performance, which easily can create several "catch-22-dilemmas". The present article presents views on fitness training, physical preparation and recovery during these uncommon conditions, and how elite football players can return to the competitive field well-prepared for post-crisis football endeavours around the world. Due to the multifaceted physiological demands in elite football, the long recovery requirements after match-play and an upcoming reality with many games within a short period, elite football players, managers and clubs may face extraordinary challenges associated with return to play under the current circumstances.

KEYWORDS

Fitness training; performance; fatigue; recovery; testing; injury; soccer

Introduction

The outbreak of the COVID-19 pandemic may be considered as the greatest global state of emergency since World War II. COVID-19 will no-doubt result in a global economic crisis. Whilst the last economic crisis of 2007-2008, had major consequences for non-sporting and sporting industries across Europe (Parnell et al., 2017), it had a limited negative impact on elite professional football industry. Indeed, the football industry was somewhat protected and delivered impressive revenue performance (Deloitte, 2017). The COVID-19 crisis is somewhat different and has had real and tangible impacts on the sport and football industry (Parnell et al., 2020). Moreover, like the rest of the population, elite athletes including football players have been living restricted lives and have been instructed to self-isolation and assigned individual training protocols. Such individual training regimes may be especially

CONTACT Magni Mohr magnim@setur.fo Department of Sports Science and Clinical Biomechanics, Sport and Health Sciences Cluster (SHSC), University of Southern Denmark, Odense 5250, Denmark

challenging in a multifaceted competitive team sport like football as they are lacking match-intensity and timing in football-specific intense actions such as headers, shots, tackles and decelerations and are lacking football specific movement patterns and muscle involvement during the high-intensity aerobic training and anaerobic speed endurance training. Therefore, we are expecting a lowered football-related physical fitness, elevated match-induced fatigue and injury risk as well as longer recovery times of the players returning to football after a period with individual training. As such, for the survival and future of the game intense scrutiny is quite rightly placed on the helping prepare players for their return to protect well-being, maintain their competitiveness and for the football industry to survive.

Football match-play can be considered as a multiperformance sport where endurance exercise, high-intensity runs and explosive muscle actions are performed in a random order with varying recovery intervals (Bangsbo et al., 2006). In addition, a high number of specific skills are performed with simultaneous cognition efforts such as decision making under high physiological stress. Thus, athletes in complex sports such as football may experience the greatest challenges in relation to maintaining training status during the COVID-19 lockdown (Christensen et al., 2011; Krustrup et al., 2006). Performance in competitive football is governed by different physiological systems. Football endurance appears to be largely related to the muscle oxidative capacity, high-intensity football performance is related to ion regulation and football speed is related to recruitment of fast-twitch muscle fibres (Mohr et al., 2016b). Thus, the multifactorial physiological demands in elite football are linked to a multitude of physiological systems, which must be stimulated in training (Mohr & Iaia, 2014). Table 1 provides principals of aerobic and anaerobic training in elite football, which are the main physical training categories in the sport. This may create a situation hard to comprehend when players return to normal training after the longest "self-managing" period in modern elite football history and may be obligated to be match-fit within a short period, with awaiting congested fixtures over the coming months.

A further physiological characteristic of elite football is the long recovery of performance and several physiological systems after a game (Krustrup et al., 2011; Mujika et al., 2013). In the aftermath of the COVID-19 lockdown players are likely to be required to play games with short recovery, which may affect the physical performance (Rago et al., 2019) and tactical synchronization (Folgado et al., 2015) and increase the risk of injury (Bengtsson et al., 2018). Similarly, changes in physical performance affect individuals differently; reductions in physical outcomes vary between positions and players should be monitored on an individual basis (Varley et al., 2018). Therefore, clubs, coaches and clinical staff may face extraordinary challenges in the organization of physical preparation for football competition and fitness-related decision-making during matches. The objective of this article is to discuss the organization of fitness training and fitness-related decisioning when elite football players are returning to play, to elucidate physiological effects of the COVID-19 lockdown management and the potential impact on performance and injury risk.

Return to training during the COVID-19 outbreak

Fitness training in football is multifaceted due to the multidimensional nature of the game. Table 1 displays an overview over fitness training categories in elite football. Especially, aerobic high-intensity training and speed-endurance training have been demonstrated as highly potent and efficient methods to improve aerobic power and anaerobic capacity of elite football players (Fransson et al., 2018; Iaia et al., 2009; Thomassen et al., 2010). Power training in football can be separated into

Table 1. Principles of aerobic (A) and anaerobic (B) training in elite football.

	Exercise intensity				Examples within categories			
	% HR_{max}	HR (bpm)*	Running speed (km/h)	RPE	Example 1		Example 2	
	Mean (range)	Mean (range)	Mean (range)	Mean (range)	Work/rest (min)	% HR at end	Work/rest (min)	% HR at end
(A) Principles of aerobic training in elite football								
Aerobic low-intensity (ALI) training	65 (50–80)	130 (100–160)	11 (9–13)	2 (1–3)	Continuous	60–65	20/2	65–70
Aerobic moderate-intensity (AMI) training	80 (70–90)	160 (140–180)	14 (12–16)	4 (3–5)	Continuous	75–85	10/1	80–90
Aerobic high-intensity (AHI) training	90 (85–100)	180 (170–200)	17 (15–19)	6 (5–7)	4/1	80–90	2/1	85–95
	Exercise time (s)	Recovery	Intensity (% of max speed)	Number of repetitions per set	Number of sets	Recovery between sets (min)		
(B) Principles of anaerobic training in elite football								
Speed endurance maintenance training	30–90	1–3 times exercise duration	50–80	5-8	2–3	2–3		
Example 1	30	30	75	5	3	3		
Example 2	60	60	60	6	2	2		
Speed endurance production training	20–40	>5 times exercise duration	70–90	3–10	1–3	3–4		
Example 1	15	90	90	5	3	4		
Example 2	25	150	70	8	1	0		
Speed training	3–6	>10–20 times exercise duration	100	4–20	2–3	2–3		
Example 1	3	35	100	10	2	3		
Example 2	5	90	100	6	3	2		

The tables provide an overview of exercise intensities as well as exercise and recovery durations, and provides practical examples. Modified from Bangsbo and Mohr (2014) and Hammami et al. (2020).

basic, transference and football-power training (Bangsbo & Andersen, 2015), which all are interconnected and should be performed on a regular basis. Finally, injury prevention training is an essential part of conditioning programmes in football but may need to be highly prioritized during the COVID-19 outbreak. For example, during a normal off-season period football-specific fitness has been shown to decline by 11% in elite male players (Krustrup et al., 2006). However, the lock-down period is likely to have caused a greater decline due to the long duration and restricted possibilities to train. In the model developed by Purdam et al. (2015), only two weeks of training at 60% of the normal volume and intensity – which may resemble the COVID-19 isolation training period – results in a 10-day progressive build up to full training in order to reduce injury risk. The beneficial impact of a qualified preparatory interval prior to competitive games should be further highlighted, since the number of preseason training sessions appears to reduce injuries during the season (Ekstrand et al., 2020).

When a competitive league terminates under normal conditions players go on holidays for around four weeks; still, fitness level might be maintained partly by adhering to individual training programmes (Bangsbo & Mohr, 2014) focussing on attenuating the decay of endurance- and neuromuscular-related performance parameters (Silva et al., 2016). Following the off-season period, clubs may normally allocate around six weeks to preseason team training including training games. Thus, the dire circumstances in most countries during the COVID-19 outbreak has forced players into an individual course of "self-management" under highly restricted conditions (Hammami et al., 2020). Thereafter, training has been completed in small groups for a few weeks in some countries prior to starting up the normal team training potentially lasting only a few weeks before the reopening of the season. The current situation is highly dissimilar to normal off-season and preseason scenarios, which impacts both the probability of optimal performance as well as injury risk.

Injury prevention and potential risks

The potentially higher risk of non-contact injury while returning to football training and matches after the COVID-19 lockdown could be associated with an abrupt increase in workload after a long period of detraining or home-based training (Lolli et al., 2019b). Also, a rapid shift from non-football-specific to football-specific movements, actions and speeds of movement might not allow players to cope with the congestion fixtures that will follow in the period from June to August 2020 (Carling et al., 2016). No doubt that the prolonged isolation-training period due to the COVID-19 outbreak would have a profound negative effect on the physical capabilities (mainly endurance and muscle strength) associated with performance and injuries (Silva et al., 2016). Restoration of fitness to the pre-COVID 19 levels is of paramount importance. Assuming that players stayed without football-specific training for ~4 weeks and that their workload during that period was about 20-40% of that in the normal competitive period, the recommended time for returning to full training without a high risk of injury is estimated to 3–5 weeks (Purdam et al., 2015). Thus, players will need time to re-adapt to football-specific actions.

Preparations to consider

Depending on the length of the isolation-training period, one may expect a decrease on general fitness that would be related to the lack of high-intensity exercise performed during this period (Christensen et al., 2011; Krustrup et al., 2006; Thomassen et al., 2010). Training contents (i.e. in the single session), sequence (i.e. in the session and across the functional micro-cycle) and progression (i.e. across the precompetitive period) should be controlled

and regulated according to the individual responses (i.e. internal load). Biochemical markers of fatigue and muscle damage coupled with psychometrics measurements and heart rate variability would result vital in fine tune the dose-response dynamic in the process of the return to training during the COVID-19 pandemic (Gabbett et al., 2017).

Overall, players might have received general guidelines for home-based exercise training with frequent sessions of aerobic training and strength training (Hammami et al., 2020), whereas players in some countries may have been advised to limit high intensity interval training with the aim to avoid a deterioration in immune system function (Eirale et al., 2020), which is highly controversial (Hull et al., 2020). Thus, players may be advised quite differently on training prescriptions due to cultural diversity and variability in health maintaining approaches. Anyway, it is quite difficult to predict the general fitness of players at re-start and fitness testing seems advisable, including maximal or submaximal Yo-Yo IE2 or IR2 testing (Bangsbo et al., 2008; Krustrup et al., 2015). Assuming the associated risk of return to training in a non-zero risk scenario, the training sessions should be personalized with precision considering the individual bio-physiological make-up of the individual player.

The first week of the return to training in small groups should be devoted to moderate and high intensity aerobic training (see Table 1) performed in a football-specific manner, which is crucial to familiarize players with realistic movement patterns, combined with basic power training (see Figure 1). Still, the use of standardized drills replicated in a progressive way across the training days in the form of structured warm-up or ball-circuit would help in controlling player's readiness to training. This strategy would enable an on-field adjustment of the prescribed external load and a greater control over expected internal load.

The popular, but not evidence-based motto "no pain no gain" should not be in the coaches mind and highly discouraged if in players' mind. This is because exhaustive training sessions may increase injury risk and reduce immune system function. The general medical rules suggest physical distancing. Thus, training prescription should, in an initial stage, grant a 2-m distance between players to prevent saliva droplets to convey to other players. Aerobic fitness should be progressively increased with football-specific high intensity drills (Bangsbo & Mohr, 2014; Fransson et al., 2018; laia et al., 2009) with players training at social distance. This may enable players to prepare to the casual intermittent high-intensity activity that they will face ahead during matches.

The forced confinement and associated difficulties to perform high-intensity training sessions such as small-sided games are expected to affect high-intensity performance during match-play. However, main concerns should be on the expected match congestion for the 2–3 months to resume the season. The resulting bio-physiological load will be relevant and magnified by the limited time available to

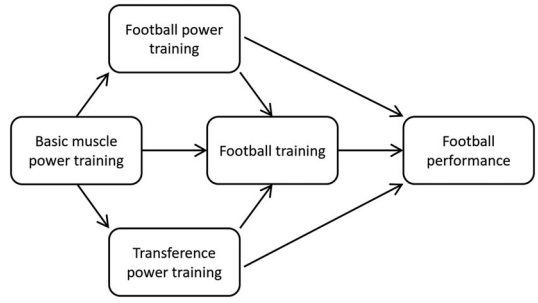

Figure 1. The figure shows the interactions between power training caregories in elite football. Basic football power training is the fundament that impacts the quality of both transference and football power training, which are necessary to get full outcome of the training in the gym and translate it into football performance. Also, basic power training improves the quality of the normal football training, which again improves performance. The figure is modified from Bangsbo and Andersen (2015).

Table 2. Example of a pre-season basic power training program for elite football players.

	1	2	3	4	5	6
		2 times per week			1.5 times per week	
Squats	3 × 10	4 × 8	4 × 8	5 × 6	4 × 6	3 × 6
Bulgarian split squats	3 × 10	4 × 8	4 × 8	5 × 6	4 × 6	3 × 6
Lunges	3 × 10	4 × 8	4 × 8	5 × 6	4 × 6	3 × 6
Romanian deadlift	3 × 10	4 × 8	4 × 8	5 × 6	4 × 6	3 × 6
Legpress	3 × 10	4 × 8	4 × 8	5 × 6	4 × 6	3 × 6
Knee extension	4 × 8	4 × 8	4 × 8	4 × 8	4 × 6	3 × 6
Hamstring curl	4 × 10	4 × 8	4 × 8	4 × 8	4 × 8	3 × 6
Eccentric hamstring curl	2 × 4	2 × 4	3 × 4	3 × 4	2 × 4	2 × 4
Nordic hamstring	3 × 8	3 × 8	3 × 8	3 × 8	3 × 8	3 × 8
Hip extensions	3 × 12	3 × 12	3 × 12	3 × 12	3 × 12	3 × 12
Bridging	3 × 12	3 × 12	3 × 12	3 × 12	3 × 12	3 × 12

Strength training in elite football. The table shows an example of a training program for the lower extremites that can be performes during a normal 6 week preseason. The program includes exercises, as well as the number of sets and repitions. It is suggsted that the program is performed twice a week during the first four weeks (which could be the individual or group training period during the corona crisis) and 1–2 times weekly during the team training preparation (last two weeks) (Modified from Bangsbo & Andersen, 2015).

build up appropriate aerobic fitness. Post-match residual fatigue should be monitored using various markers like creatine kinase and delayed onset of muscle soreness to optimize players recovery (Mohr et al., 2016a; Silva et al., 2018). Proper sleep and rest strategies, the use of compression garments, and a carbohydrate enriched diet are efficient and safe recovery strategies. Attention to hygiene issues should be given to contrast baths, which are also used regularly for recovery. With the aim to protect players' health, temporary changes in the Laws of Football should be discussed in the attempt to lower match acute and residual fatigue (e.g. increasing the number of substitutions during matches as proposed by FIFA and/or reducing playing time to 70–75 min).

What can coaches and players do?

To prepare the players for the complex match demands in football, fitness coaches must ensure appropriate training on football-specific actions and drills that mimic the football match demands (Nassis et al., 2019), also on individual basis. Training strategies should follow three major rules: (1) progressiveness of loading, (2) specificity of actions and speeds, and (3) preparation for the worst-case scenario.

Progressiveness might prevent sharp increases and spikes in workload (Lolli et al., 2019a, 2019b, 2020; Nieman & Wentz, 2019). This increase should be planned around the total distance covered, the distance covered in high intensity running and sprinting, as well as accelerations and decelerations. We acknowledge there may be more variables of external workload associated with neuromuscular load and injuries and the multifactorial complexity of injuries (Nassis & Gabbett, 2017), but progressive overloading should be a priority in injury risk management (Lolli et al., 2019b), as well as performance enhancing strategies.

To improve muscle power, a combination of basic and transference power training with inclusion of football-specific actions (football power; see Figure 1) should be preferred (Bangsbo & Andersen, 2015; Silva et al., 2015). To speed-up endurance adaptations, intensified training using small-sided games and especially speed endurance production training is highly recommended (Fransson et al., 2018; Bangsbo & Mohr, 2014; Paul et al., 2019, see also Table 1).

Players should be prepared to be ready to compete in congested fixtures (see for example Mohr et al., 2016a). While sprinting has been associated with hamstring injuries, the lack of adequate speed training during the preparatory period may be a risk factor for injury as well

(Malone et al., 2018). Therefore, training should include adequate speed training. To counteract the effect of fatigue, coaches should consider scheduling power training towards the end of training sessions (Paul et al., 2014) or in the mornings on training days with afternoon training. Lower extremity muscle power and balance exercises should be of priority (Brunner et al., 2019; see Table 2), and micro-dosing power training should be considered.

An integrated approach taking into consideration external and internal workload monitoring, as well as wellness and readiness assessments is recommended to guide better decisions during this sensitive period (Lolli et al., 2019b). Thus, when external workload is low, but players still perceive it as highly stressful, workload should be lowered. In contrast, a relatively high external workload in combination with good level of wellness and readiness should be taken as a positive sign and may indicate a lower risk of non-contact injury (Gabbett et al., 2017; Lolli et al., 2019b).

Conclusion

We conclude that the COVID-19 crisis and its consequence on the football ecosystem has created a myriad of challenges for the elite game, including returning optimally and safely to competitive football competitions. During this extraordinary preseason we recommend a progressive build-up of aerobic high-intensity, speed endurance and power training. Players' fitness level and health situation should be monitored closely, and high emphasis should be given on optimal recovery protocols including a high focus on nutrition and injury prevention strategies. Football clubs should be aware of that these are special circumstances and be prepared for a future unlike anything experienced before.

Disclosure statement

No potential conflict of interest was reported by the author(s).

ORCID

Magni Mohr http://orcid.org/0000-0002-1749-8533
George P. Nassis http://orcid.org/0000-0003-2953-3911
Joao Brito http://orcid.org/0000-0003-1301-1078
Morten B. Randers http://orcid.org/0000-0002-0192-8981
Carlo Castagna http://orcid.org/0000-0002-8320-6404
Dan Parnell http://orcid.org/0000-0001-5593-0633
Peter Krustrup http://orcid.org/0000-0002-1461-9838

References

Bangsbo, J., & Andersen, J. L. (2015). *Power training in football*. Bangsbosport.

Bangsbo, J., Iaia, F. M., & Krustrup, P. (2008). The Yo-Yo intermittent recovery test – A useful tool for evaluation of physical performance in intermittent sports. *Sports Medicine*, *38*(1), 37–51. https://doi.org/10.2165/00007256-200838010-00004

Bangsbo, J., & Mohr, M. (2014). *Individual training in football*. Bangsbosport.

Bangsbo, J., Mohr, M., Poulsen, A., Perez-Gomez, J., & Krustrup, P. (2006). Training and testing the elite athlete. Review. *Journal of Exercise Science and Fitness*, *4*(1), 1–14.

Bengtsson, H., Ekstrand, J., Waldén, M., & Hägglund, M. (2018). Muscle injury rate in professional football is higher in matches played within 5 days since the previous match: A 14-year prospective study with more than 130 000 match observations. *British Journal of Sports Medicine*, *52*(17), 11160–11122. https://doi.org/10.1136/bjsports-2016-097399

Brunner, R., Friesenbichler, B., Casartelli, N. C., Bizzini, M., Maffiuletti, N. A., & Niedermann, K. (2019). Effectiveness of multicomponent lower extremity injury prevention programmes in team-sport athletes: An umbrella review. *British Journal of Sports Medicine*, *53*(5), 282–288. https://doi.org/10.1136/bjsports-2017-098944

Carling, C., McCall, A., Le Gall, F., & Dupont, G. (2016). The impact of short periods of match congestion on injury risk and patterns in an elite football club. *British Journal of Sports Medicine*, *50*(12), 764–768. https://doi.org/10.1136/bjsports-2015-095501

Christensen, P. M., Krustrup, P., Gunnarsson, T. P., Kiilerich, K., Nybo, L., & Bangsbo, J. (2011). VO_2 kinetics and performance in soccer players after

intense training and inactivity. *Medicine and Science in Sports and Exercise*, *43*(9), 1716–1724. https://doi.org/10.1249/MSS.0b013e318211c01a

Deloitte. (2017). *Ahead of the curve: Annual review of football finance*. Sport Business, Deloitte Sport Business Group.

Eirale, C., Bisciotti, G., Corsini, A., Baudot, C., Saillant, G., & Chalabi, H. (2020). Medical recommendations for home-confined footballers' training during the COVID-19 pandemic: From evidence to practical application. *Biology of Sport*, *37*(2), 203–207. https://doi.org/10.5114/biolsport.2020.94348

Ekstrand, J., Spreco, A., Windt, J., & Khan, K. M. (2020). Are elite soccer teams' preseason training sessions associated with fewer in-season injuries? A 15-year analysis from the union of European football associations (UEFA) elite club injury study. *The American Journal of Sports Medicine*, 1–7. https://doi.org/10.1177/0363546519899359

Folgado, H., Duarte, R., Marques, P., & Sampaio, J. (2015). The effects of congested fixtures period on tactical and physical performance in elite football. *Journal of Sports Sciences*, *33*(12), 1238–1247. https://doi.org/10.1080/02640414.2015.1022576

Fransson, D., Nielsen, T. S., Olsson, K., Christensson, T., Bradley, P. S., Fatouros, I. G., Krustrup, P., Nordsborg, N. B., & Mohr, M. (2018). Skeletal muscle and performance adaptations to high-intensity training in elite male soccer players: Speed endurance runs versus small-sided game training. *European Journal of Applied Physiology*, *18*(1), 111–121. https://doi.org/10.1007/s00421-017-3751-5

Gabbett, T. J., Nassis, G. P., Oetter, E., Pretorius, J., Johnston, N., Medina, D., Rodas, G., Myslinski, T., Howells, D., Beard, A., & Ryan, A. (2017). The athlete monitoring cycle: A practical guide to interpreting and applying training monitoring data. *British Journal of Sports Medicine*, *51*(20), 1451–1452. https://doi.org/10.1136/bjsports-2016-097298

Hammami, A., Harrabi, B., Mohr, M., & Krustrup, P. (2020). Physical activity and coronavirus disease 2019 (COVID-19): specific recommendations for home-based physical training. *Managing Sport & Lesire*. https://doi.org/10.1080/23750472.2020.1757494

Hull, J. H., Loosemore, M., & Schwellnus, M. (2020). Respiratory health in athletes: Facing the COVID-19 challenge. *Lancet Respiratory Medicine*. https://doi.org/10.1016/S2213-2600(20)30175-2. [Epub ahead of print] No abstract.

Iaia, F. M., Rampinini, E., & Bangsbo, J. (2009). High intensity training in football. *International Journal of Sports Physiology and Performance*, *4*(3), 291–306. https://doi.org/10.1123/ijspp.4.3.291

Krustrup, P., Bradley, P. S., Christensen, J. F., Castagna, C., Jackman, S., Connolly, L., Randers, M. B., Mohr, M., & Bangsbo, J. (2015). The Yo-Yo IE2 test: Physiological response for untrained men vs trained soccer players. *Medicine and Science in Sport and Exercise*, *47*(1), 100–108. https://doi.org/10.1249/MSS.0000000000000377

Krustrup, P., Mohr, M., Nybo, L., Jensen, J. M., Nielsen, J. J., & Bangsbo, J. (2006). The Yo-Yo IR2 test: Physiological response, reliability, and application to elite soccer. *Medicine and Science in Sport and Exercise*, *38*(9), 1666–1673. https://doi.org/10.1249/01.mss.0000227538.20799.08

Krustrup, P., Ortenblad, N., Nielsen, J., Nybo, L., Gunnarsson, T. P., Iaia, F. M., Madsen, K., Stephens, F., Greenhaff, P., & Bangsbo, J. (2011). Maximal voluntary contraction force, SR function and glycogen resynthesis during the first 72 h after a high-level competitive soccer game. *European Journal of Applied Physiology*, *111*(12), 2987–2995. https://doi.org/10.1007/s00421-011-1919-y

Lolli, L., Batterham, A. M., Hawkins, R., Kelly, D. M., Strudwick, A. J., Thorpe, R., Gregson, W., & Atkinson, G. (2019a). Mathematical coupling causes spurious correlation within the conventional acute-to-chronic workload ratio calculations. *British Journal of Sports Medicine*, *53*(15), 921–922. https://doi.org/10.1136/bjsports-2017-098110

Lolli, L., Batterham, A. M., Hawkins, R., Kelly, D. M., Strudwick, A. J., Thorpe, R. T., Gregson, W., & Atkinson, G. (2019b). The acute-to-chronic workload ratio: An inaccurate scaling index for an unnecessary normalisation process? *British Journal of Sports Medicine*, *53*(24), 1510–1512. https://doi.org/10.1136/bjsports-2017-098884

Lolli, L., Batterham, A. M., MacMillan, G., Gregson, W., & Atkinson, G. (2020). A comment on "does mathematical coupling matter to the acute to chronic workload ratio? A case study from elite sport". *International Journal of Sports Physiology and Performance*, *15*(5), 600. https://doi.org/10.1123/ijspp.2019-0949

Malone, S., Owen, A., Mendes, B., Hughes, B., Collins, K., & Gabbett, T. J. (2018). High-speed running and sprinting as an injury risk factor in soccer: Can well-developed physical qualities reduce the risk? *Journal of Science and Medicine in Sport*, *21*(3), 257–262. https://doi.org/10.1016/j.jsams.2017.05.016

Mohr, M., Draganidis, D., Chatzinikolaou, A., Barbero-Alvarez, J. C., Castagna, C., Douroudos, I. I.,

Avloniti, A., Margeli, A., Papassotiriou, I., Flouris, A. D., Jamurtas, A. Z., Krustrup, P., & Fatouros, I. G. (2016a). Muscle damage, inflammatory, immune and performance responses to three football games in 1 week in competitive male players. *European Journal of Applied Physiology*, *116*(1), 179–193. https://doi.org/10.1007/s00421-015-3245-2

Mohr, M., & Iaia, F. M. (2014). Physiological basis of fatigue resistance training in competitive football. *Sports Science Exchange*, *27*, 1–9.

Mohr, M., Thomasen, M., Racinais, S., Grantham, J., & Nybo, L. (2016b). Muscular variables of importance for football match performance. *European Journal of Applied Physiology*, *116*(2), 251–262. https://doi.org/10.1007/s00421-015-3274-x

Mujika, I., Halson, S., Argus, C., & Krustrup, P. (2013). *Recovery from training and matches, in Science and soccer*. Edited by Williams, M.A. Routledge.

Nassis, G., & Gabbett, T. (2017). Is workload associated with injuries and performance in elite football? A call for action. *British Journal of Sports Medicine*, *51*(6), 486–487. https://doi.org/10.1136/bjsports-2016-095988

Nassis, G. P., Brito, J., Figueiredo, P., & Gabbett, T. J. (2019). Injury prevention training in football: Let's bring it to the real world. *British Journal of Sports Medicine*, *53*(21), 1328–1329. https://doi.org/10.1136/bjsports-2018-100262

Nieman, D. C., & Wentz, L. M. (2019). The compelling link between physical activity and the body's defense system. *Journal of Sport and Health Science*, *8*(3), 201–217. https://doi.org/10.1016/j.jshs.2018.09.009

Parnell, D., Spracklen, K., & Millward, M. (2017). Sport management issues in an era of austerity. *European Sport Management Quarterly*, *17*(1), 67–74. https://doi.org/10.1080/16184742.2016.1257552

Parnell, D., Widdop, P., Bond, A., & Wilson, R. (2020). COVID-19, networks and sport. *Managing Sport & Leisure*. https://doi.org/10.1080/23750472.2020.1750100

Paul, D. J., Brito, J., & Nassis, G. P. (2014). Injury prevention training in football: Time to consider training under fatigue? *Aspetar Sports Medicine Journal*, 578–581.

Paul, D., Marques, J., & Nassis, G. (2019). The effect of a concentrated period of soccer specific fitness training on physical fitness in youth players. *Journal of Sports Medicine & Physical Fitness*, *59*(6), 962–968. https://doi.org/10.23736/S0022-4707.18.08547-X

Purdam, C., Drew, M., Blanch, P., Chapman, D., Gabbett, T., Gore, C., Hughes, D., Kelly, T., Mitchell, J., Rice, T., & Raysmith, B. (2015). *Prescription of training load in relation to loading and unloading phases of training*. Australian Institute of Sport.

Rago, V., Krustrup, P., Martin-Acero, R., Rebelo, A., & Mohr, M. (2019). Training load and submaximal heart rate testing throughout a competitive period in a top-level male football team. *Journal of Sports Sciences*, *26*, 1–8. https://doi.org/10.1080/02640414.2019.1618534

Silva, J., Nassis, G. P., & Rebelo, A. (2015). Strength training in soccer with a special focus on highly trained players. *Sports Medicine – Open*, *1*(1), 17. https://doi.org/10.1186/s40798-015-0006-z

Silva, J. R., Brito, J., Akenhead, A., & Nassis, G. P. (2016). The transition period in soccer: A window of opportunity. *Sports Medicine*, *46*(3), 305–313. https://doi.org/10.1007/s40279-015-0419-3

Silva, J. R., Rumpf, M. C., Hertzog, M., Castagna, C., Farooq, A., Girard, O., & Hader, K. (2018). Acute and residual soccer match-related fatigue: A systematic review and meta-analysis. *Sports Medicine*, *48*(3), 539–583. https://doi.org/10.1007/s40279-017-0798-8

Thomassen, M., Christensen, P. M., Gunnarsson, T. P., Nybo, L., & Bangsbo, J. (2010). Effect of 2 wk intensified training and inactivity on muscle Na+-K+ pump expression, phospholemman (FXYD1) phosphorylation, and performance in soccer players. *Journal of Applied Physiology*, *108*(4), 898–905. https://doi.org/10.1152/japplphysiol.01015.2009

Varley, M. C., Di Salvo, V., Modonutti, M., Gregson, W., & Mendez-Villanueva, A. (2018). The influence of successive matches on match-running performance during an under-23 soccer international tournament: The necessity of individual analysis. *Journal of Sport Sciences*, *36*(5), 585–591. https://doi.org/10.1080/02640414.2017.1325511