

Protective guidelines and mitigation strategies for hot conditions in professional football: starting 11 Hot Tips for consideration

Vincent Gouttebarga ^{1,2,3,4}, Rob Duffield,⁵ Steve den Hollander ¹, Ron Maughan⁶

To cite: Gouttebarga V, Duffield R, den Hollander S, *et al.* Protective guidelines and mitigation strategies for hot conditions in professional football: starting 11 Hot Tips for consideration. *BMJ Open Sport & Exercise Medicine* 2023;**9**:e001608. doi:10.1136/bmjsem-2023-001608



© Author(s) (or their employer(s)) 2023. Re-use permitted under CC BY-NC. No commercial re-use. See rights and permissions. Published by BMJ.

¹Football Players Worldwide (FIFPRO), Hoofddorp, Netherlands

²Amsterdam UMC location University of Amsterdam, Department of Orthopedic Surgery and Sports Medicine, Meibergdreef 9, Amsterdam, Netherlands

³Amsterdam Collaboration on Health & Safety in Sports (ACHSS), IOC Research Center, Amsterdam, Netherlands

⁴Section Sports Medicine, University of Pretoria, Pretoria, South Africa

⁵School of Sport, Exercise and Rehabilitation, Faculty of Health, University of Technology Sydney, Sydney, New South Wales, Australia

⁶School of Medicine, St Andrews University, St Andrews, UK

Correspondence to

Prof. Vincent Gouttebarga;
v.gouttebarga@amsterdamumc.nl

ABSTRACT

Elevated heat, humidity and solar load combined with low air movement independently and additively impair performance, increase the perception of effort and the risk of heat-related illnesses. For the specific context of professional football, the Fédération Internationale de Football Association (FIFA) heat guidelines are often used as the default policy. Still, these seem less protective than guidelines in other sports or from countries traditionally exposed to extreme hot conditions. Following several high-profile international and continental competitions played in hot conditions (eg, 2014 FIFA World Cup Brazil), a series of cross-sectional studies showed that national team players and their managers unanimously mentioned that the hot and humid conditions during these matches made it difficult as a team to perform. Such a concern is likely to be relevant for the upcoming 2026 FIFA World Cup that will be held in the traditional June–July window across 16 host cities in Canada, Mexico and USA. Therefore, to better protect players' health and performance during training and match play in hot conditions, we present our starting 11 Hot Tips that should be considered and facilitated by governing bodies, competition organisers, clubs, staff members and players.

INTRODUCTION

The human body's core temperature functions within thermoregulatory limits, especially in extreme environmental temperatures.¹ When athletes, including professional footballers, train or compete, high rates of metabolic heat production must be balanced by increased heat loss, mainly through sweating.¹ There is good evidence from laboratory studies that both independently and additively, even moderately elevated heat, humidity and solar load, especially in combination with low air movement, can impair performance and increase the perception of effort.^{2–7} These conditions also increase the risk of heat-related illnesses.⁸

Many football competitions (eg, World Cup, Champions League qualifying round) occur or start during the year's hottest

WHAT IS ALREADY KNOWN ON THIS TOPIC

- ⇒ Elevated heat, humidity and solar load combined with low air movement independently and additively impair performance, increase the perception of effort and the risk of heat-related illnesses.
- ⇒ Mitigation strategies, including acclimation, hydration, cooling strategies and breaks, can prevent the effects of hot conditions and better protect players' health and performance.

WHAT THIS STUDY ADDS

- ⇒ Based on a critical analysis of the available heat guidelines (ie, policies) and evidence in professional football, this article provides a starting 11 Hot Tips for consideration to guide future improvement to current practice.
- ⇒ Heat guidelines in football should refer to thresholds for Wet Bulb Globe Temperature (WBGT) (especially in elite professional football) and ambient (in case a WBGT measurement device is unavailable) temperature to increase their understanding and global implementation across all levels of professional football.
- ⇒ Football stakeholders (international, continental, national) and television broadcasting companies should consider the national and local weather forecast to avoid scheduling matches during hot conditions.
- ⇒ Heat mitigation strategies that are effective and easy to implement must be developed. In contrast, if necessary, modifying the game's laws and heat acclimation/acclimatisation could be considered to protect the players' health.

months, while hot conditions are increasingly challenging in many continental and national competitions due to global warming. Over the past decades, guidelines for protecting athletes competing in hot conditions have been developed, offering strategies to mitigate the risk of heat-related illnesses.⁹ For the specific context of professional football, the Fédération Internationale de Football Association (FIFA) heat guidelines are often used



as the default policy.¹⁰ However, questions remain about whether these are protective enough and whether they are systematically implemented. Even more, although prior heat acclimation improves performance and reduces the risk of heat illnesses, this is seldom possible for professional footballers from temperate climates who must play matches in the heat.^{9 11} This article reflects on professional football's heat guidelines (ie, policies) and related concerns for past and future high-profile competitions. In turn, we aim to present considerations to better protect players' health and performance during training and match play in the heat.

HEAT GUIDELINES IN PROFESSIONAL FOOTBALL

Guidelines for exercise in hot conditions generally rely on the Wet Bulb Globe Temperature (WBGT), a composite temperature measurement calculated from ambient temperature, humidity and sun exposure. These guidelines use thresholds of WBGT values to advise on the potential risk of heat-related illnesses, whether and how training and competition should continue, and whether mitigation strategies (eg, precooling, hydration) should be introduced.^{9 11 12}

The FIFA heat guidelines indicate that a WBGT value above 32°C results in extreme risk of thermal injury, and therefore, cooling breaks at approximately 30 min in each half of a match should be implemented as a mitigation strategy, or the match should be delayed or postponed.¹⁰ Although the FIFA guidelines are guiding principles in the professional football industry for many continental confederations and national leagues, they have not been updated in nearly 20 years. Further, they seem less protective than guidelines in other sports or from countries traditionally exposed to extreme hot conditions (table 1).^{13–17} In addition, the single cooling break over 45 min might be suboptimal to enable players to hydrate or cool adequately, while the delay or postponement of matches is rather non-committal, and there have been instances where competition organisers have not implemented this.

In contrast, the heat guidelines adopted by the Australian Professional Leagues, Football Australia

and FIFPRO (Football Players Worldwide) member Professional Footballers Australia represent more conservative WBGT and ambient temperature thresholds for match-day policies.¹⁵ Referring either to WBGT or ambient temperature, these indicate that (1) a match can proceed as scheduled when WBGT is below 26°C or ambient temperature is below 31°C, (2) a cooling break in each half of a match is implemented when WBGT is between 26°C and 27.9°C or the ambient temperature is 31°C or above and (3) a match is delayed or postponed when WBGT is 28°C or above or the ambient temperature approaches 40°C or above.¹⁵

HOT CONDITIONS DURING HIGH-PROFILE FOOTBALL COMPETITIONS

Implications of playing in the heat have been under scrutiny for many years, especially during high-profile international, continental and national competitions for matches with (early) afternoon kick-off times due to broadcasting contracts. During the 1994 FIFA World Cup USA and 2014 FIFA World Cup Brazil, matches were played with WBGT \geq 30°C. Hot conditions were the reason why the 2022 FIFA World Cup Qatar was moved from the traditional June–July window (WBGT reaching up to 35°C) to the unusual November–December window (WBGT \approx 20°C–25°C). To qualify for this 2022 FIFA World Cup Qatar, the Asian Football Federation held matches in May and June 2021 in Kuwait, Bahrain, Saudi Arabia, Qatar and the United Arab Emirates, with afternoon and evening WBGT reaching 36 and 31°C, respectively. These examples highlight the increasing presence of hot conditions in many competitions. Further, global warming and associated heat waves mean many national competitions are also being more regularly exposed to the heat. Hence, players have voiced concerns over playing in the heat, while those conditions are expected to become increasingly common.

VIEW OF PLAYERS AND MANAGERS ABOUT HOT CONDITIONS

FIFPRO conducted a series of cross-sectional electronic surveys to explore the views of national team players

Table 1 Comparison of few heat guidelines across sports and countries with regard to the risk of heat-related illnesses

Risk category	FIFA	ACSM	SMA	Football Australia	BOKSMART	US soccer		
	WBGT (°C)	WBGT (°C)	WBGT (°C)	WBGT (°C)	WBGT (°C)	WBGT (°C)		
						CAT 1	CAT 2	CAT 3
Low	<24	<22	<28	<26		<24	<27	<28
Moderate	24–29	22–25	28–30*	26–28*		25–29	27–30*	28–31*
High	30–32	26–28	31–33		>28*	29–30	31–32	32–33
Extreme	>32*†	>28†	>33†	>28†		>30*†	>32†	>33†

*Recommendation to introduce mandatory drinks breaks.

†Recommendation to cancel game.

ACSM, American College of Sports Medicine; CAT, category (CAT 1, 2 and 3 in US Soccer guidelines grouped by geographical location of venue); FIFA, Fédération Internationale de Football Association; SMA, Sports Medicine Australia; WBGT, Wet Bulb Globe Temperature.

(captains) and managers on the hot conditions during the aforementioned high-profile football competitions.¹⁸ Players and managers unanimously mentioned that the hot and humid conditions during these matches made it difficult as a team to perform. Around half of the players stated that cooling breaks at approximately 30 min into the run-of-play in both halves of the matches were adequate to hydrate sufficiently, while only a minority were in favour of more cooling breaks, given the effect on increased stoppage times. Also, only a minority of the national team managers considered the weather when selecting either their starting 11 players or their tactical plan. Despite the qualitative approach of these surveys and potentially limited generalisability, their findings confirm that heat guidelines in professional football should be reviewed and updated.

CONCERN FOR THE UPCOMING 2026 FIFA WORLD CUP CANADA, MEXICO USA

The 2026 FIFA World Cup will be held in the traditional June–July window across 16 host cities in Canada, Mexico and the USA, where weather conditions can be challenging. Weather estimations for the main parameters (eg, ambient temperature, humidity, sun exposure, wind) were obtained based on a statistical analysis of historical hourly reports

and model reconstruction. WBGT values were calculated for all 16 host cities.^{19 20} As indicated in table 2, afternoon (15:00–18:00 hours) WBGT is estimated to range from 30°C to 35°C in six host cities (Atlanta, Dallas, Houston, Kansas City, Miami and Monterrey), which is classified as extreme (high) risk of heat-related illnesses in Australian and USA guidelines. In six other host cities (Guadalajara, Los Angeles, Mexico City, New York, Philadelphia, San Francisco), afternoon (15:00–18:00 hours) WBGT is estimated to be associated with (very) high risk of heat-related illnesses with afternoon (15:00–18:00 hours) WBGT ranging from 27°C to 30°C. These estimations for the 2026 FIFA World Cup and other competitions played in hot conditions justify the need for a series of tips that aim to protect players' health and performance better when exposed to hot conditions. This is even more cognisant for the 2026 FIFA World Cup, which will be the largest and the longest in the tournament's history, with 48 teams playing 104 matches over 40 days across three countries.

OUR STARTING 11 HOT TIPS FOR CONSIDERATION

To better protect players' health and performance during training and match play in hot conditions, we present our starting 11 Hot Tips that should be considered and

Table 2 Estimating the risk of heat-related illnesses during the 2026 FIFA World Cup Canada, Mexico, USA

Host city	Afternoon (15:00–18:00 hours)						Evening (18:00–21:00 hours)					
	Temperature			WBGT*			Sunset	Temperature			WBGT†	
	Min	Max	Humidity	Min	Max	Min		Max	Humidity	Min	Max	
Atlanta	20°C	29°C	60%	22°C	30°C	20:45	17°C	25°C	73%	15°C	23°C	
Boston	14°C	24°C	70%	18°C	26°C	20:20	12°C	20°C	78%	11°C	18°C	
Dallas	23°C	33°C	56%	19°C	33°C	20:30	21°C	29°C	67%	18°C	26°C	
Guadalajara	18°C	30°C	49%	20°C	29°C	20:36	15°C	28°C	68%	13°C	25°C	
Houston	23°C	32°C	77%	26°C	34°C	20:20	22°C	28°C	82%	21°C	26°C	
Kansas City	18°C	28°C	68%	16°C	30°C	20:45	14°C	24°C	77%	13°C	22°C	
Los Angeles	16°C	26°C	60%	19°C	27°C	20:00	15°C	20°C	78%	13°C	18°C	
Mexico City	13°C	26°C	60%	16°C	27°C	19:33	11°C	23°C	71%	9°C	21°C	
Miami	24°C	32°C	69%	26°C	33°C	20:08	22°C	28°C	79%	20°C	26°C	
Monterrey	27°C	36°C	51%	27°C	35°C	20:28	21°C	29°C	67%	18°C	26°C	
New York/New Jersey	17°C	26°C	67%	14°C	28°C	20:23	12°C	21°C	80%	11°C	20°C	
Philadelphia	17°C	27°C	64%	20°C	28°C	20:24	14°C	24°C	81%	13°C	22°C	
San Francisco Bay Area	13°C	25°C	67%	17°C	27°C	20:28	9°C	20°C	80%	8°C	19°C	
Seattle	12°C	21°C	69%	16°C	24°C	21:11	9°C	18°C	76%	8°C	16°C	
Toronto	12°C	23°C	62%	15°C	25°C	20:53	7°C	19°C	77%	6°C	17°C	
Vancouver	11°C	19°C	63%	15°C	21°C	21:20	9°C	17°C	79%	8°C	16°C	

Estimates based on average environmental data recorded in June between 2012 and 2021.

WBGT risk categorised according to Football Australia guidelines; green: low risk, yellow: moderate risk and red: extreme risk.

WBGT was calculated using the formula provided by <https://www.climatechip.org/excel-wbgt-calculator>.

*Under the assumption of full sunshine (990 w/m² of solar radiation) and light wind (1.5 m/s).

†Under the assumption of light wind (1.5 m/s).

FIFA, Fédération Internationale de Football Association; max, maximum; min, minimum; WBGT, Wet Bulb Globe Temperature.

facilitated by governing bodies, competition organisers, clubs, staff members and players:

- Heat guidelines should be adopted and respected by football stakeholders, clubs and national teams for matches and training and embedded within regulations (eg, Minimum Medical Requirements, Laws of the Games, Collective Bargaining Agreement for national competitions; FIFA competition regulations, Social Dialogue).
- Heat guidelines should refer to thresholds for WBGT (especially in elite professional football) and ambient (in case a WBGT measurement device is unavailable) temperature to increase their understanding and global implementation across all levels of professional football.
- A WBGT above 26°C (or ambient temperature above 30°C) should warrant cooling breaks during matches (eg, at approximately 30 min in each half of a match).
- A WBGT above 28°C (or ambient temperature above 36°C) should lead to the delay or postponement of matches until conditions for players and officials (and fans) are safer.
- WBGT (and/or ambient temperature) should be measured on-site before each match and training session (eg, 2 hours), and consultation between key stakeholders (eg, players, coaches, match officials, team physicians) about potential risks should occur.
- National and local weather forecasts should monitor the weather conditions (eg, at least 5 days before each match) and estimate potential hot conditions to schedule matches (and training) optimally and provide players with a safe environment.
- Next to additional cooling breaks, other mitigation strategies (eg, heat acclimation/acclimatisation, cooling methods, easy availability of cool drinks all around the football field) should be planned and used for matches and training, with responsibility for their implementation resting with teams and individuals involved.
- Stakeholders (international, continental, national) and television broadcasting companies should not schedule matches at the hottest time of day, that means avoiding mid-day or afternoon matches (ie, full sunshine) where high WBGT is most likely.
- A (inter)national registry of heat-related collapses and/or deaths should be developed to assess their prevalence, explore the underlying contributing factors, and improve existing guidelines and mitigation strategies.
- While players' responses (eg, physiological, cognitive) when exercising in hot conditions have been extensively studied, more research is needed to understand (1) how thresholds (WBGT and/or ambient temperature) in heat guidelines could evolve, (2) how mitigation strategies, including potential modification of the laws of the game and heat acclimation/acclimatisation, could be optimally implemented and enforced in practice

and (3) how new technologies might enable the assessment of personal factors (eg, metabolic rate, thermoregulatory function) and contribute to the prediction of the risk of heat-related illnesses.

- Particular attention should be given to female and youth players with regard to individual responses when exercising in hot conditions or when it comes to avoiding television broadcasts of their matches at mid-day or in the afternoon (ie, full sunshine).

Twitter Vincent Goutteborge @VGoutteborge and Steve den Hollander @steve_dh1

Contributors VG conceptualised and wrote the initial version of the manuscript. All authors critically commented on all versions of the manuscript and read and approved the final manuscript.

Funding The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests None declared.

Patient consent for publication Not applicable.

Provenance and peer review Not commissioned; externally peer reviewed.

Open access This is an open access article distributed in accordance with the Creative Commons Attribution Non Commercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited, appropriate credit is given, any changes made indicated, and the use is non-commercial. See: <http://creativecommons.org/licenses/by-nc/4.0/>.

ORCID iDs

Vincent Goutteborge <http://orcid.org/0000-0002-0126-4177>

Steve den Hollander <http://orcid.org/0000-0002-6064-038X>

REFERENCES

- Périard JD, Eijsvogels TMH, Daanen HAM. Exercise under heat stress: thermoregulation, hydration, performance implications, and mitigation strategies. *Physiol Rev* 2021;101:1873–979.
- Galloway SDR, Maughan RJ. Effects of ambient temperature on the capacity to perform prolonged cycle exercise in man. *Med Sci Sports Exerc* 1997;29:1240–9.
- Maughan RJ, Otani H, Watson P. Influence of relative humidity on prolonged exercise capacity in a warm environment. *Eur J Appl Physiol* 2012;112:2313–21.
- Otani H, Kaya M, Tamaki A, et al. Effects of solar radiation on endurance exercise capacity in a hot environment. *Eur J Appl Physiol* 2016;116:769–79.
- Otani H, Kaya M, Tamaki A, et al. Air velocity influences thermoregulation and endurance exercise capacity in the heat. *Appl Physiol Nutr Metab* 2018;43:131–8.
- Otani H, Kaya M, Tamaki A, et al. Exposure to high solar radiation reduces self-regulated exercise intensity in the heat outdoors. *Physiol Behav* 2019;199:191–9.
- Otani H, Kaya M, Tamaki A, et al. Combined effects of solar radiation and airflow on endurance exercise capacity in the heat. *Physiol Behav* 2021;229:113264.
- Nybo L, Flouris AD, Racinais S, et al. Football facing a future with global warming: perspectives for players health and performance. *Br J Sports Med* 2021;55:297–8.
- Racinais S, Hosokawa Y, Akama T, et al. IOC consensus statement on recommendations and regulations for sport events in the heat. *Br J Sports Med* 2023;57:8–25.
- Fédération Internationale de Football Association (FIFA). *Football Medicine Manual*. Zurich: Fédération Internationale de Football Association, 2009.
- Périard JD, Racinais S, Sawka MN. Adaptations and mechanisms of human heat acclimation: applications for competitive athletes and sports. *Scand J Med Sci Sports* 2015;25 Suppl 1:20–38.
- Lee JKW, Shirreffs SM, Maughan RJ. Cold drink ingestion improves exercise endurance capacity in the heat. *Med Sci Sports Exerc* 2008;40:1637–44.
- Sports Medicine Australia (SMA). *Extreme heat policy*. Sydney: Sports Medicine Australia, 2021.
- Roberts WO, Armstrong LE, Sawka MN, et al. ACSM expert consensus statement on exertional heat illness: recognition,

- management, and return to activity. *Curr Sports Med Rep* 2021;20:470–84.
- 15 Jones M. *Football Australia Heat Policy*. Sydney South: Football Australia, 2020.
 - 16 Readhead C, Viljoen W, Suter J. *Safety in the Playing Environment*. Cape Town: BokSmart, 2023.
 - 17 Soccer US. *Recognize to Recover - Heat Guidelines*. Chicago: U.S. Soccer Federation, 2023.
 - 18 Gouttebarga V. Health and safety at Fifpro - from science to practice. Proceedings of the Conference on Promoting the Well-Being of Athletes; Sofia, Bulgaria, October 4, 2016
 - 19 National Oceanic and atmospheric Administration (NOAA). Available: <https://noaa.gov/> [Accessed 13 Mar 2023].
 - 20 Environment Canada. Available: https://weather.gc.ca/index_e.html [Accessed 13 Mar 2023].