Heat risks associated with synthetic athletic fields

It is well known that humans can suffer adverse health effects when exposed to elevated temperatures. These include heat stress, heat exhaustion, heat stroke, Rhabdomyolysis, heat syncope and acute burns, among others. The impact of synthetic fields on increasing temperatures has been studied and it has been shown that synthetic fields can reach temperatures that are far in excess of natural turf fields. In some studies, the temperatures are high enough to cause acute skin burns (first to third degree) depending on the exposure duration. But also, these elevated temperatures can, in turn affect local air temperatures, essentially a localized 'urban heat island'. Consequently, there can be risks to both athletes and spectators, especially those who may be more at risk to elevated temperatures.

The physical mechanism that leads to higher temperatures is clear. A high solar absorptivity of artificial fields, combined with a lack of water evaporation are primary factors. Low thermal capacity of the artificial turf may also play a role. Regardless, the providing of useful guidelines for athletic organizations is an important role for the scientific community. In fact, athletic organizations may not be aware of the potential heat risks.

Currently, some organizations rely upon weather forecasting services (such as the National Weather Service) that issue heat advisories. Heat advisories based on air temperature and humidity levels are useful because they partially account for the human body's ability to control core temperature (through sweating). The combined effects of temperature and humidity are incorporated into the so-called wet-bulb temperature. This is a thermodynamic quantity that represents the adiabatic water saturation temperature of the air; this quantity is also useful for assessing risk.

But research has shown that forecast wet-bulb temperature measurements do not necessarily reflect local temperatures at specific fields [1]. In addition, turf surface temperatures can rise to very high levels, particularly in direct sunlight, that cause an added concern that is not captured by a heat advisory or wet bulb temperature. Very high surface temperatures have been found in multiple scientific studies. From the initial studies, the impact of turf on surface temperature was acknowledged. For instance, Buskirk et al. [2] measured temperatures for 24 d on artificial turf, natural grass and in air. They found turf temperatures that were ~50 F higher than natural grass temperatures and reach 70 F hotter than the air temperatures. In 2005, a study reported surface temperatures of 93 C (200 F) – values well in excess of those required to cause third-degree burns [3]. In a review article, Claudio [4] reported surface temperatures that were approximately 60 F warmer than the surrounding air temperature and above levels that can cause skin burns. Later, Lim and Walker [5] made measurements of turf temperature and found them to be much hotter than the local temperature. These conclusions were supported by a more recent study [6] where synthetic turf temperatures of 86.4 C (188 F) were recorded. Again, these values were significantly higher than the local environmental air temperature. Research has also been carried out that shows all artificial turfs, regardless of brand, exceed temperatures of natural turf [7].

What has become evident is that artificial turf can approach natural fields in terms of mechanical performance and safety, but there has been very little progress in reducing the thermal risks [8]. These theoretical risks have resulted in cases of studies that provide cause for concern. For instance, following a burn claim by a collegiate athletic coach, researchers at BYU measured turf temperatures and found them to be 87 F hotter than natural grass [9]. There was an inverse correlation with humidity and a positive relation with air temperature. Measurements at the University of Missouri showed elevated air temperatures (138 F) and elevated turf temperatures (173 F) – while adjacent natural turf temperatures were 105 F and local air temperatures were 98 F [10]. But this relationship between air temperature and turf temperature is not always seen. Measurements of the wet-bulb and synthetic turf temperatures taken after a heat-related death showed very little, if any relation between the two quantities [11]. The conflicting results of these studies are made more challenging by the lack of information provided in references. Consequently, it is not possible to quantify, at this time, how artificial turfs impact local air temperatures. It is likely that the influence varies depending on the specific situation. However, it is certain that elevated risk of heat stress can stem from infrared heating from the ground, regardless of the air temperature. A reasonable response, in the absence of such information, is two-fold. First, emphasis should be placed on the actual temperatures measured at specific fields; forecast temperatures do not necessarily represent field-specific temperatures. Second, a greater level of caution is warranted for athletes playing or practicing on artificial fields, even if the air temperature is not at an otherwise unsafe level.

These risks are acknowledged in some administrations of guidelines, for instance, the NY Department of Health cites the above-referenced study in guidance documentation [12,13]. While there have been some reports of synthetic-turf harm [9–11,14,15], to the best knowledge of the author there have been no epidemiological studies on the prevalence of heat stress episodes associated with synthetic turf, compared with natural turf. Such a study could help answer the questions posed here, regarding dangers associated with elevated surface temperatures.

These values should give pause to the use of synthetic turf in warm and sunny situations. Reliance upon regional
weather reporting or the wet bulb temperature does not provide a full picture of the threat of heat on synthetic athletic fields. Fortunately, low-cost temperature instruments (e.g., infrared temperature sensors) can be used to measure synthetic turf temperatures and this information can inform rational decisions. More study is needed on this issue and for the development of a science-based guideline for athlete care.

Disclosure statement
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References
[1] Pryor JL, Pryor RR, Grundstein A, et al. The heat strain of various athletic surfaces: a comparison between observed and modeled wet-bulb globe temperatures. J Athl Train. 2017;52:1056–1064.
[2] Buskirk ER, McLaughlin ER, Loomis JL. Microclimate over artificial turf. J Health, Phys Educ Recreat. 1971;42:29–30.
[3] McNitt AS. Synthetic turf in the USA – trends and issues. Int Turfgrass Soc Res J. 2005;10:27–33.
[4] Claudio L. Synthetic turf: health debate takes root. Environ Health Perspect. 2008;116:A116–A122.
[5] Lim L, Walker R. An assessment of chemical leaching, releases to air and temperature at crumb-rubber infilled synthetic turf fields, New York State Department of Environmental Conservation. New York (NY): New York State Department of Health; 2009.
[6] Thomas AW, Brosnan JT, Zidek JM, Sorochan JC. Models for predicting surface temperatures on synthetic turf playing surfaces. Proc Eng. 2014;72:895–900.
[7] McNitt AS, Petrunak D. Evaluation of playing surface characteristics of various in-filled systems, Published at Penn State Extension, Department of Crop and Soil Sciences. November 2010. Available from: https://extension.psu.edu/evaluation-of-playing-surface-characteristics-of-various-in-filled-systems#section-26
[8] Villacanas V, Sanchez-Sanchez J, Garcia-Urnanue J, et al. The influence of various types of artificial turfs on football fields and their effects on the thermal profile of surfaces. J Sports Eng Technol. 2016;231:21–32.
[9] Williams CF, Pulley GE. Synthetic surface heat studies. Provo (UT): Brigham Young University; 2002. Available from: https://aces.nmsu.edu/programs/turf/documents/brigham-young-study.pdf. Accessed March 2019.
[10] Adamson C. Synthetic turf fields present unique dangers. Columbia (MO): University of Missouri- Columbia College of Agriculture, Food, and Natural Resources; 2007. Available from: http://agebb.missouri.edu/news/ext/showall.asp?story_num=3521&iln=8. Accessed March 2019.
[11] Walters R. An independent evaluation of procedures and protocols related to the June 2018 death of a University of Maryland football student-athlete. Report prepared by Walters Inc. Consultant in Sports Medicine, September 21, 2018. Available from: https://www.usmd.edu/newsroom/Walters-Report-to-USM-Board-of-Regents.pdf
[12] New York Department of Health. Information about crumb-rubber infilled synthetic turf athletic fields. 2019. Available from: https://health.ny.gov/environmental/outdoors/synthetic_turf/crumb-rubber_infilled/fact_sheet.htm. Accessed March 2019.
[13] New York City Department of Health and Mental Hygiene. A review of the potential health and safety risks from synthetic turf fields containing crumb rubber infill. May 2008. Available from: http://agebb.missouri.edu/news/ext/showall.asp?story_num=3521&iln=8. Accessed March 2019.
[14] USA Today. October 30, 2018. Available from: https://usatodayhss.com/2018/va-high-school-soccer-player-sues-school-ad-soccer-coach-for-near-fatal-heat-stroke
[15] ESPN, Sources: Maryland OL Jordan McNair showed signs of extreme exhaustion. Available from: http://www.espn.com/college-football/story/_/id/24343021/jordan-mcnair-maryland-terrapins-died-heatstroke-team-workout. Accessed March 2019.

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