The potential use of new cooling technologies during Tokyo 2020 Olympics and associated ethical dilemmas

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Background

The environmental conditions during Tokyo Summer Olympics are expected to be comparable to previous years [1] with air temperatures and relative humidity in excesss of 30ºC and >70%, respectively [2]. A previous consensus statement highlighted the main considerations for prevention, recognition and treatment of exertional heat illnesses [3], while the impact of extreme heat on athletic performance is examined elsewhere [4]. Cooling strategies applied before and during exercise in the heat have been shown to help athletes better maintain their performances [5] by lowering body heat storage and core body temperature [6]. The Tokyo Games have also encouraged the development of wearable technologies that could also be used for prevention, diagnosis and real-time monitoring of skin and core temperature and will be trialled during competition in Tokyo 2020. Here we aim to highlight the potential application of those novel technologies and the associated ethical dilemmas regarding their effectiveness, the use of athlete biodata and predictive algorithms.

Development of Portable Cooling Technologies

Recently, manufacturers have developed new cooling wearables that have the potential to reduce exertional heatstroke (EHS) risk and to reduce the decline in athletic performance in hot environments, with the most novel summarised in Table 1. Here the focus is not on cooling strategies for medical treatment of EHS but on cooling technologies for EHS prevention and their potential to protect the health and performances of athletes in the heat. However, the cooling effectiveness of this new technology during sporting events in hot and humid conditions remains to be determined.

[INSERT TABLE 1 HERE]

Potential Ethical Issues with Wearable Technology Validation

The rapid introduction of cooling wearables and the lack of external validity testing hinders the process of selecting the most effective devices. As we recently discussed [7], there is concern that the unregulated use of this technology and without rigorous quality control procedures, poses a threat, be that perceived or real, that athletes could use these

technologies to gain an unfair advantage over their competitors if this technology is not available to all before its true effect is fully understood. For example, the current technical regulation of World Athletics, states that athletes are allowed to use *"any kind of personal safeguard (e.g., bandage, tape, belt, support, wrist cooler, breathing aid, etc.) for protection and/or medical purposes […]"* (Rule 6.4.3) [8]. There is no requirement for the technology to be scientifically tested or to be available to all. There is a need for cooling wearables that impact performance in hot environments to be regulated in all sports on the basis of external validations and publicly available data.

We present two matters that urgently need to be addressed: (1) the requirement for wearable technology to undergo validity testing to demonstrate their cooling effectiveness, and, (2) the need to assess whether any advantage gained by the use of technology is fair within sport and available to all athletes in competition. In order to address the first issue, the International Federation of Sports Medicine (FIMS) established a central resource at the University of Zaragoza, Spain, to guide wearable technology providers in achieving quality control and data standardization, with the cooling wearables described in Table 1 already under validation. In a similar way, the International Organisation for Standardisation (ISO) provides standards for meteorological measurements so that the data is comparable and reliable for the users. This model would enable wearable companies to perform validation tests, receive certification and enable governing bodies of sport and athletes to make informed decisions when selecting the most appropriate devices for their specific needs. Governing bodies and competition organisers would be assured that the certified wearables have been through a validation process and have access to this publically available validity data.

Potential Ethical Issues with Athletes Biodata Recording during Competition

Having access to real-time biodata monitoring (e.g., core temperature [9] or sweat [10]) during competition raises the conundrum related to the potential decision to withdraw athlete/s from competition on medical grounds. For example, should the medical race director or/an athlete support team withdraw a marathon runner showing signs of EHS (i.e., very high core temperature and an asymmetrical gait) at the final stages of a race or let the

athlete attempt to finish potentially causing the athlete life threatening health issues? Such ethical dilemmas will become more commonplace give the advent of real-time technology in elite sport, hence the need for considered regulation. It is inevitable that real-time technology of some sort (e.g., connected mouth guards) will soon appear in sports such as boxing and rugby to either stop a fight by the corner or even the referee or justify the removal and return to play of a suspected concussed rugby player. Creative solutions will need to be sought, such in the case of the marathoner above, establishing the critical level of core temperature during acclimation/acclimatisation without EHS symptoms prior to competition to provide the athlete with adequate individual protection against unnecessary measures during competition. More accurate diagnosis of conditions such as EHS, and therefore protection against too drastic measures, will also be achieved by the simultaneous monitoring of physiological, biomechanical and perceptual data [9]. Of paramount importance are also the requirements 1) to ensure implementation of any technology that uses biophysical data of athletes is in strict accordance with data protection rules, and 2) to develop encryption technology to avoid any anauthorised access of the athletes personal/biometric data.

Resolving the numerous efficacy and ethical concerns raised here with data and evidence-based and transparent recommendations would ensure a fair and appropriate implementation of essential wearable technology. This discussion and necessary action is urgently needed given the threat of rising summer temperatures due to global warming, combined with the timing of major sporting events such as Tokyo 2020, Paris 2024 and LA 2028 Olympics.

Declarations

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Technology	Information
Pocket Air Conditioners	Wireless devices that, when in contact with one's skin through a shirt, can potentially cool the local microenvironment on the body surface.
Neck coolers	Wearable devices fitted on the shoulders of the individual and adapted around the neck. This wearable cooling device has a thermal cooling plate that assists with the collection of humid air and transforms it into cool air.
Wrist coolers	These bracelet-like wearables contain a thermostat and cools down or warm up at the press of a button. Manufacturers claim that wearers perceive whole-body cooling when they are submitted to this localised wrist cooling stimulus.
Cooling Fabrics and Patches	This technology is claimed to pull moisture away from the skin and disperse it throughout the fabric along channels on the surface of the threads. Novel fabrics containing thermoconductive, moisture-permeable, and superhydrophobic nanofibrous membranes have shown to effectively cool down when compared to other fabrics.

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