

TESTING THE WATERS: HIGHLIGHTING THE SAFETY OF OPEN WATER SWIMMERS

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OPEN WATER SWIMMING: AN UNPREDICTABLE ENVIRONMENT

By definition, open water swimming (OWS) includes any event not contested in a swimming pool. The last 3 decades have seen a proliferation of swimming competition in lakes, rivers, reservoirs and ocean courses, with the advent of 'marathon' swimming competition and the increasing popularity of triathlons. The international federations for swimming (Federation Internationale de Natation, FINA) and triathlon (International Triathlon Union, ITU) continue to collaborate with the support of the International Olympic Committee (IOC) to highlight athlete safety through research-informed rules for competition and event management.

Physicians are increasingly involved in the medical supervision of the challenging

discipline of the open water environment. This is particularly so in temperate regions where water and ambient temperatures are more conducive to OWS. However, events in some parts of the world seriously challenge athletes not habituated to swimming in colder water. Today, a better understanding of the physiological demands of OWS enables coaches and athletes to prepare for an environment in which water and ambient temperatures, as well as radiant heat exposure pose major risks. While professional events including Olympic competition involve limited fields in relatively sheltered water, the majority of OWS events, including the swim leg of triathlons, frequently involve mass-participation by athletes of widely varying experience and physical capability. Athletes frequently find themselves at the mercy of

the elements, with unpredictable winds, tides and currents among the challenging variables.

SWIMMING INFLUENCES ON CORE BODY TEMPERATURE

The normal core body temperature is approximately 37°C. However, the potential for hyperthermia is amplified by high-energy expenditure in any prolonged aerobic sport. When exercise-induced hyperthermia occurs during terrestrial activities, almost all heat losses occur through the combined evaporation of sweat and respiratory water, heat radiation and convection from the skin (Figure 1).

But during swimming, regular mechanisms of heat dissipation are significantly impaired by water immersion, with the potential for 'heat stress'. The

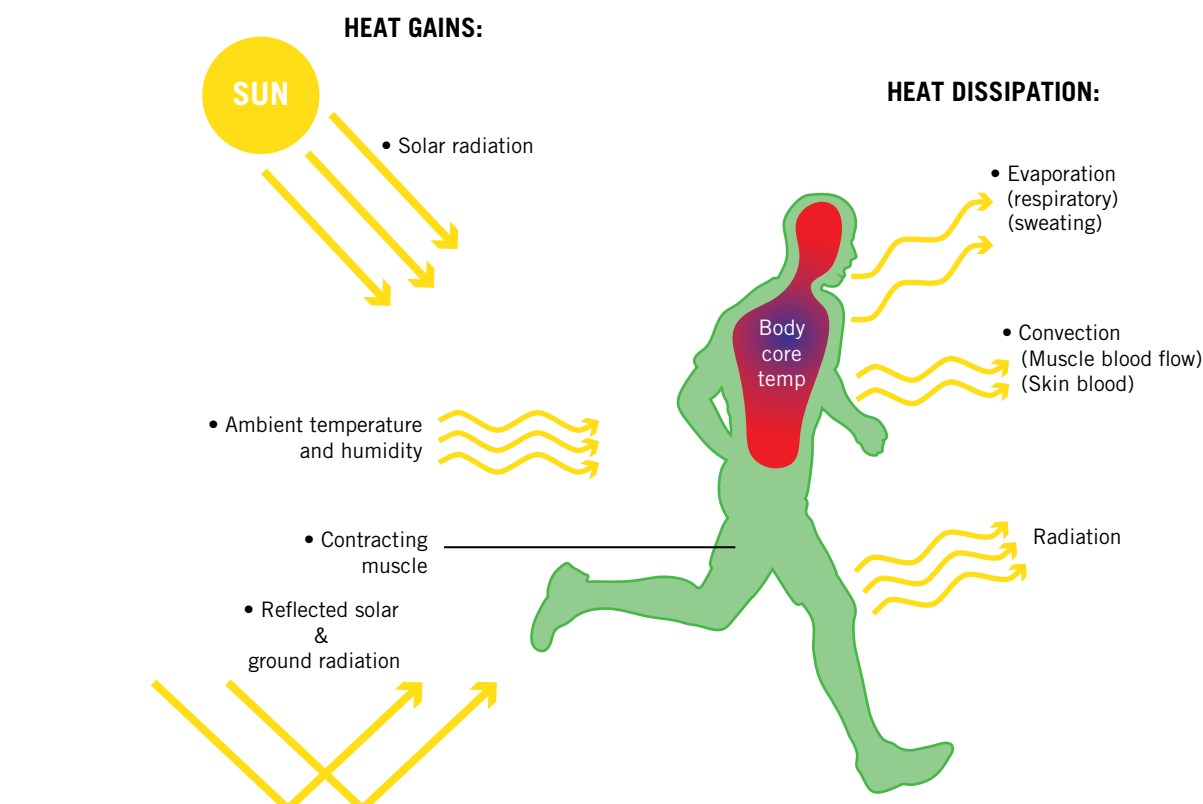


Figure 1: Normal mechanisms of heat loss from the body during terrestrial sports (adapted from Powers and Howley).

10 km open water swim event has often been described as the aquatic equivalent of the marathon run. In terms of duration, sustained energy requirements, heat production and other physiological demands, there are valid comparisons. However as already stated, swimmers are limited in their reliance on recognised innate mechanisms of cooling in order to maintain thermal steady state.

Therefore the critical challenge to all aquatic athletes is the maintenance of thermal neutrality, in a setting of total body immersion. The immersion of the body in water impedes the dissipation of body heat, generated through energy expenditure, which is further influenced by water ambient temperatures and solar heat loading.

Given the diversity of OWS venues, it has yet to be established how hot or cold swimmers get in water ranging from 20 to 32°C high ambient temperatures and solar heat. Questions have been raised over swimmers' reliability to subjectively recognise 'stress' and fatigue and their ability to report these accurately. Characteristic early signals of impending distress in

swimmers are critical to intervention and possible retrieval by event officials.

GENERAL REGULATIONS IN OWS EVENTS

Open water, endurance-trained swimmers pit themselves against challenging environments. No two venues are ever the same and the conditions prevailing on any given day will always differ.

Those charged with the responsibility of event planning must consider critical variables when designing courses, ensuring adequate on-water supervision of all participants. Table 1 provides a checklist of major issues for those charged with the organisation, safety and medical supervision of OWS events. These apply equally to triathlon, notwithstanding the different distances of the two Olympic events (1.5 km triathlon swim and 10 km marathon swim).

OWS competition demands consideration of the following risk factors:

- Aquatic hazards, e.g. flora and fauna, currents, waves, pollution, water quality and temperature.

- Venue, e.g. saltwater ocean and bays or fresh-water lakes and rivers.
- Environmental influences, e.g. extremes of water-ambient temperature, humidity, solar radiation, rain and wind. Additionally, in triathlon, environmental conditions during the swimming leg have been shown to negatively influence cycling and running performance.

The Medical Committees of the ITU and FINA jointly agree that the safety and health of athletes is their priority. The IOC Medical Code clearly stipulates standards for competition and training venues, accounting for the ambient and water temperatures and exposure to radiant heat. Some contemporary venues present significant challenges and therefore adherence to safety guidelines, including water quality, is critical.

International Federations and race organisers are legally required to provide a safe event and disclose all known risks to participants. The combined effects of water and ambient temperatures are considered the most significant variables for athlete safety. As already discussed, the ability

of swimmers to dissipate heat through ‘normal’ physiological means, is affected by immersion in water. This issue, with particular reference to heat stress, will be addressed later in greater detail.

FINA has a designated Open Water Swimming Committee that collaborates closely with the FINA Sports Medicine Committee to ensure that athlete safety remains their priority. Similarly, the ITU through its Medical Committee, ensures that minimum safety standards are mandatory. OWS rules in both International Federations stipulate the appointment of specified race officials and predetermined protocols for athlete on-water retrieval and resuscitation as necessary. These will be described later. Regulations also stipulate the provision of access to secondary and tertiary medical care, more particularly relevant in marathon swimming.

MINIMISING HEAT-RELATED INJURY: LESSONS FROM TRIATHLON

Mindful that heat loss in water is approximately 2 to 5 times that in air of the same temperature, thermoregulation during swimming requires the consideration of factors including:

- Water temperature
- Intensity of swimming
- Duration of exposure
- Athlete somatotype (subcutaneous fat thickness)
- Ratio of body surface area to mass
- Wetsuit use (in triathlons only).

Exertional heat stress (EHS) is defined by a core body temperature > 40°C, with central nervous system disturbances and potential multiple organ system failure. Extreme environmental conditions combined with prolonged physical exertion may induce dehydration. When combined with an elevated core temperature, this may potentiate tachycardia, dysrhythmia, hypotension and diminished cardiac stroke volume.

Considering the direct relationship between EHS, rising ambient temperature and relative humidity, the risk of EHS during the running segment of a Sprint or Olympic distance triathlon may be mitigated by:

- The timing of events to avoid extreme heat and humidity, informed by historical local weather data.

TABLE 1: SAFETY CHECKLIST	
1.	<i>Knowledge of water and ambient temperatures.</i>
2.	<i>Water quality and potential pollution.</i>
3.	<i>Influence of tides, currents or other natural hazards.</i>
4.	<i>Presence of natural flora and fauna (freshwater/sea).</i>
5.	<i>Effect of local water traffic (sea lanes).</i>
6.	<i>Course design (triangular, out-and-back, linear).</i>
7.	<i>Safe start/finish area.</i>
8.	<i>Need for feeding pontoons (marathon swimming).</i>
9.	<i>Sufficient on-water safety craft and medical support.</i>
10.	<i>On-shore medical triage, support and evacuation services.</i>
11.	<i>Availability of secondary medical support services.</i>

Table 1: Checklist for open water swimming events.

- The provision of competition shelters (tents, awnings, umbrellas) for athletes and officials in the field.
- The contingency for event modification or rescheduling in extreme weather conditions.
- The provision of adequate on-water medical support to identify and assist distressed athletes.

EHS in triathletes is of particular importance at the start of the running leg and has stimulated significant research. Quite clearly, adequate hydration and energy repletion are critical.

APPLIED RESEARCH IN OPEN WATER SWIMMING

While major triathlon swim competitions have been held in a water temperature range of approximately 13 to 32°C, FINA has determined a temperature range of 16 to 31°C for its sanctioned OWS events. There has been a small body of historical research determining the influence of water temperatures on core body temperatures and swimming performance, and establishing optimal water temperatures for competition (25.5 to 28°C) as an index of risk management. However, by design, these studies

did not answer questions relating to contemporary OWS competition at the elite level.

To specifically examine the effect of heat stress on endurance swimming performance and to study the observable signals of altered thermoregulation as markers of acceptable tolerance and athlete safety, FINA, the ITU and the IOC collaborated in research into thermal stress applicable to open water swimming.

This was undertaken in 2013 at the University of Otago, New Zealand, using a swimming flume and environmental chamber to simulate the OWS environment and establish competition parameters, principally to determine:

- a safe upper limit of water temperature for training and competition,
- the influence of selected environmental variables,
- objective signs of early exertional heat illness,
- the validity of self-perceived body temperature.

The study involved 24 competitive swimmers and triathletes in a flume-based study across a total of 190 self-paced swims. Participants swam for durations of 20, 60 and 120 minutes, as surrogates

for swims of 1500 metres 5 km and 10 km respectively. These were completed in water temperatures of 20, 27, 30 and 32°C in 50 to 70% humidity, with ambient air close to water temperature and a simulated radiant heat load of 400 to 800 W/m².

During these swims, participants had the following measurements taken:

- core temperature via a rectal thermistor,
- heart rate and ventricular depolarisation via a chest strap transmitter,
- blood glucose, lactate, haematocrit and haemoglobin levels, pre- and post-exercise,
- 'self-perception' of thermal discomfort, body temperature, exertion,
- swimming 'fitness' and anthropometry.

Rectal temperature was supplemented with oesophageal thermometry in a few participants able to tolerate this procedure. Every 20 minutes, a drinks break was provided to replicate the feeding station of a marathon swim. An underwater viewing window displayed feedback of the distance covered and psychophysical perception scales at 20-minute intervals, recorded by a numbered scale called out by the swimmer during the breathing phase.

After each trial, a venous blood sample was taken and participants' recovery was monitored to ensure their core temperature returned toward baseline levels. Measures of psychophysical perception scales were made 5 and 10 minutes after exiting the water. Participants were then weighed to

provide a measure of body mass. A post-exercise urine sample was used to calculate any change in body weight and hydration status.

ANSWERING THE RESEARCH QUESTIONS

1. During this study, involving more than 100 trials in a water temperature of 30°C or greater, no swimmer recorded a core temperature exceeding the ethically-approved upper limit of 40°C. Also, while most participants felt 'hot and uncomfortable', no one voluntarily stopped or displayed any visible signs of distress.
2. From the recorded objective data, it appeared that no participant was unduly affected by the range of water and ambient temperatures to which they had been exposed.
3. While measures of elevated core temperature and subjective responses to psychophysiological 'stress' were recorded, these were not accompanied by any consistent characteristic changes in stroke mechanics. Although there was a suggestion that an increased stroke rate might be a useful indicator, this finding was considered unreliable in isolation.
4. The psychophysiological responses reflected a strong positive correlation with objective measures, suggesting the reliability of the swimmers' perceptions of thermal status and their ability to adjust accordingly.

TRANSLATING SCIENCE INTO PRACTICE

This study was conducted primarily to inform measures for the safety of all open water swimmers. In particular, it extended our scientific knowledge of the response of the athlete to prolonged energy expenditure combined with immersion in water of varying temperatures. In addition, analyses of blood samples from participants are expected to test the widely-held clinical opinion that athletes in the convalescent phase of systemic illness are advised not to return to training or competition until they demonstrate signs of complete recovery.

The rules of both the ITU and FINA reflect these research findings and demonstrate a desire to enhance elite competition, while respecting the safety of participating athletes. However, despite this research-informed approach, it is clear that no single number, regulation, arbitrary guideline or objective measure of environmental conditions will ever be a substitute for the combined vigilance of the coach and OWS race officials. Swimmer safety remains an important collegial responsibility to be borne by all race officials and coaches.

IMPLEMENTATION OF FINA RULES

There are several existing FINA rules relating to the safe and effective conduct of OWS events. The most significant of these rules include regulations to address:

- water temperature between 16 and 31°C checked officially on race-day 2 hours



open water swimming stresses athletes in an unforgiving environment where mechanisms of thermoneutrality are influenced by total water immersion and impaired heat dissipation





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before the start, mid-course at a depth of 40 cm.

- the appointment of a Safety Officer to monitor environmental conditions during the race.
- the development of a FINA Safety Manual for marathon swimming.
- a pre-approved site-specific Safety Plan.
- the authority of the Chief Referee to postpone or modify any event for safety reasons.
- medical services for retrieval, triage and clinical management of swimmers.
- the post-event assessment of all competitors.

IMPLEMENTATION OF ITU RULES

By comparison, the ITU regulations focus on a number of safety issues relating to athlete oversight in the swim leg, plus the subsequent transition to cycling and running disciplines. For example:

- at water temperatures of 32°C or greater, the swim leg is cancelled, while, for temperatures between 31 and 31.9°C, the swim distance is reduced to 750 m.
- the water temperature is recorded 1 hour prior to the event at three sites, at a depth of 60 cm, the lowest temperature

is considered the official temperature.

- a pre-approved Emergency Action Plan including a designated Water Safety Team.
- the ability of technical and medical delegates to adapt limits of the swim leg or adopt wetsuit use as weather conditions dictate.

As discussed earlier, precipitants of exertional heat illness remain a challenge and medical guidelines have been established to minimise such risks in triathlon. These include guidelines for fluid replacement in accordance with the World Anti-Doping Agency (WADA) International Standards and the use of the wet bulb globe temperature to estimate the risk of heat-related illness. This system is converted to a coloured flag system to signal the risks of current weather conditions to athletes.

It is not within the scope of this article to discuss clinical criteria for heat illness or the specific management of athletes. However, those responsible for the medical supervision of ITU-sanctioned events must be aware of the signs of heat stress and the immediate management including emergency cooling procedures and fluid replacement within the scope of WADA

regulations relating to intravenous fluid administration. Given the potential life-threatening consequences of extreme heat stress, immediate triage, assessment and evacuation are essential in the provision of medical support at all events.

OWS AT THE SUMMER OLYMPICS: A BRIEF HISTORY

The triathlon made its Olympic debut in Sydney (2000). On that occasion, the swim leg took place in the waters of Sydney Harbour, over a triangular course in front of the Sydney Opera House. Simon Whitfield (Canada) and Brigitte McMahon (Switzerland) were the winners of that inaugural event, which has continued successfully in Athens (2004), Beijing (2008) and London (2012).

The 10 km marathon swim was introduced to the Olympic programme at the Beijing Games of 2008 in the Shunyi Olympic Rowing-Canoeing Park. Events for men and women hosted fields of 25 competitors. Maarten van der Weijden (The Netherlands) and Larisa Ilchenko (Russia) were the respective winners. Despite safety concerns in water temperatures between 28 and 31°C, only one male and

one female competitor failed to complete the course.

At the 2012 London Olympics, the Olympic triathlon and the marathon swim shared the same venue for the first time, a 2.5 km circular course in the Serpentine lake, in London's Hyde Park. In water temperatures between 19 and 21°C, only two female competitors withdrew from the marathon swim for indeterminate reasons. Neither swimmer required post-event medical intervention.

The proposed course for both the triathlon swim and the 10 km marathon swim event at the 2016 Rio de Janeiro Olympics is Copacabana Beach. Although early conjecture regarding water quality has been reported, recent test events have been successfully concluded at this venue with no swimmers reporting any health-related issues. Both the ITU and FINA have accepted bacteriological standards for water quality at competition venues in Rio with strong advocacy for WHO minimum requirements. These standards have also been agreed by the IOC Medical Commission. The IOC and local health authorities will continue to monitor this venue.

CONCLUSIONS

OWS stresses athletes in an unforgiving, unpredictable environment. Accepted physiological mechanisms to establish thermoneutrality are significantly influenced by total water immersion and impaired heat dissipation. These effects are compounded by physical exertion and fatigue, even in the best-conditioned athletes.

The ITU and FINA, the International Federations responsible for the safe management of the 10 km marathon swim and the Olympic-distance triathlon, have adopted research-informed guidelines to minimise the risk to all athletes.

In particular, regulations for an acceptable range of water temperatures have been adopted for all sanctioned events. Race organisers and host committees remain obligated to apply these and other safety rules at every FINA- or ITU-sanctioned event. However, once again it must be stressed that no rule or set of regulations will ever be a substitute for the vigorous surveillance of all competitors by coaches and race officials.

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