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ORIGINAL ARTICLE

# Effects of three different water temperatures on dehydration in competitive swimmers

## *Effets de trois différentes valeurs de température de l'eau sur la déshydratation chez des nageurs de compétition*

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Open water;
Swimming;
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Performance;
Rectal temperature

**Summary**
*Aims.* — The purpose of this study was to evaluate the effects of three different water temperatures on physiological responses (dehydration, sweat rate, urine output, rectal temperature and plasma electrolytes) of competitive athletes during a ''simulated'' race of 5 km in an indoor swimming pool.
*Methods.* — Nine male competitive master swimmers swam 5 km with the water at temperatures of 23, 27 and 32 °C. Immediately before (Pre) and after (Post) each trial, samples of blood and urine were collected, body weight was recorded and rectal temperature was measured. The dehydration percentage and sweat rate were the highest at 32 °C and the lowest at 23 °C (23 °C: −0.9 ± 0.5; 27 °C: −1.3 ± 0.6; 32 °C: −2.2 ± 0.7% and 23 °C: 0.48 ± 0.28; 27 °C: 0.76 ± 0.36; 32 °C: 1.25 ± 0.37 l/h). The Post urine volume output was not significantly different in the three trials (23 °C: 122.6 ± 62.4; 27 °C: 78.2 ± 24.9; 32 °C 81.4 ± 37.0 mL). The 27 and 32 °C water increased the rectal temperature (Pre: 37.0 ± 0.3; Post: 37.9 ± 0.5 °C—Pre: 36.9 ± 0.4; Post: 38.0 ± 0.4 °C, respectively).

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*Results*. — This study shows that dehydration, sweat rate and body temperatures simultaneously increase with the rise of water temperature during the shortest open water swimming event distance (5 km) performed at race intensity.


**MOTS CLÉS**
Natation ;
Taux de sudation ;
Équilibre ;
Hydroélectrolytique ;
Performance ;
Température rectale

**Résumé**
*Objectifs*. — Évaluer les effets de trois températures différentes de l'eau sur les réponses physiologiques (déshydratation, sudation, volume urinaire, température rectale et électrolytes plasmatiques) chez des athlètes de compétition, à l'issue d'une course « simulée » de 5 km dans une piscine couverte.
*Méthodes*. — Neuf nageurs de compétition (masculins) ont nagé 5 km dans une eau à des températures respectivement de 23, 27 et 32 °C. Immédiatement avant (Pre) et après (Post) chaque épreuve, des échantillons de sang et d'urine ont été prélevés, la masse corporelle et la température rectale ont été mesurées. Le pourcentage de déshydratation et le taux de sudation étaient le plus élevés dans l'eau à 32 °C et le plus bas dans l'eau à 23 °C (23 °C : $-0,9 \pm 0,5$ ; 27 °C : $-1,3 \pm 0,6$ ; 32 °C : $-2,2 \pm 0,7$ % et 23 °C : $0,48 \pm 0,28$ ; 27 °C : $0,76 \pm 0,36$ ; 32 °C : $1,25 \pm 0,37$ L/h). Le volume urinaire mesuré après l'effort (Post) n'était pas significativement différent dans les trois cas (23 °C : $122,6 \pm 62,4$ ; 27 °C : $78,2 \pm 24,9$ ; 32 °C $81,4 \pm 37,0$ mL). L'eau à 27 et 32 °C a augmenté la température rectale (Pre : $37,0 \pm 0,3$ ; Post : $37,9 \pm 0,5$ °C—Pre : $36,9 \pm 0,4$ ; Post : $38,0 \pm 0,4$ °C, respectivement).
*Résultats*. — Cette étude montre que la déshydratation, le taux de sudation et la température corporelle augmentent simultanément avec la température de l'eau, au cours de la plus courte des distances parcourues lors de compétitions de nage en eau libre, effectuée avec un effort d'intensité comparable à celui d'une course.


## 1. Introduction

Open water swimming is defined, by the Fédération Internationale de Natation (FINA), as any swimming event that takes place in a body of water such as rivers, lakes or oceans [1]. Open water swimming world championships are performed on distances of 5, 10 and 25 km. During the shortest (5 km) distance events swimmers are not permitted to consume food and drink. Open water swimmers perform races in a wide range of environmental conditions, such as cold/hot water temperature, high/low water salinity, high/low altitudes and high/low wave height. Hypothermia and dehydration are the most common medical problems during open water events [2,3]. Open water swimming is a widespread aquatic sport performed also by the master swimmers globally [4].

Exercise in cold water results in a rapid cooling of the body, because thermal conductivity is approximately 25 times more than in air [5], and in a raised oxygen uptake as a consequence of shivering thermogenesis effect [6]. The increase of water temperature and exercise intensity induces a rise of body temperature [7], although, the heat exchange occurs mainly via conduction and convection, substantial amounts of fluid may be lost as sweat during water sport [8]. Soler et al. [9] reported that during a typical interval training (9 km) in an outdoor pool (water temperature: 27 °C), the magnitude of fluid losses (1.8 kg, i.e. 2.5% of body weight) was sufficient to compromise convective thermoregulation because of the decreased plasma volume (10.5%), although the swimmers drank *ad libitum*. Therefore, if a negative body fluid balance compromises the thermoregulatory and physiological response during swimming training, this effect may be emphasized during an endurance swimming event. The hypothesis of the present study was that athletes, swimming the shortest open water swimming world championship event distance (5 km) without food or drink supplementation as indicated by FINA rules, may have severe negative body fluid balance in warm water.

The purpose of this study was to evaluate the effects of three different water temperatures (23, 27 and 32 °C) on physiological responses (dehydration, sweat rate, urine output, rectal temperature, plasma electrolytes and fluid balance) to a ''simulated'' race of 5 km in competitive athletes in an indoor swimming pool (25 m long).

## 2. Methods

### 2.1. Subjects

Nine volunteer male competitive master swimmers, ranked in the top 5 of category in open water (1.5—10 km) Italian races, were studied (age: $34.6 \pm 14.4$ years, height: $172.1 \pm 9.8$ cm, mass: $72.7 \pm 8.5$ kg, body fat: $12.7 \pm 3.5$%, body surface area: $1.86 \pm 0.16$ m$^2$). The subjects trained five to six times per week (3—8 km per training session) in 25- and 50-meter swimming pools (water temperature about 27 °C). Participants were informed of the experimental procedures and associated risk before having to provide a written informed consent form. This study was approved by the institutional review board for the protection of human subjects of the University of Palermo.

### 2.2. Protocol

During this study, subjects completed three experimental trials, separated by 7 days, in a 25-meter indoor swimming pool; they swam 5 km with water at the temperatures of 23,