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Change in Skin Temperature, Stratum Corneum Water Content and Transepidermal Water Loss During Cycling Exercise

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Abstract

The study investigated the skin temperature (T_{sk}) at sixteen points, Stratum Corneum Water Content (SCWC) and Transepidermal Water Loss (TEWL) at fourteen points over the ventral and dorsal surfaces, during submaximal cycling exercise in an ambient temperature of 25 °C, and a relative humidity of 60%. Nine healthy competitive males completed a 20 min rest on the cycle and 5-min warm-up, followed by a 30 min of cycle exercise at 70% maximal heart rate and 30 min recovery. Average mechanical power output and pedaling rate were 150 W and 70 rpm. The results showed that the ventral and dorsal skin temperatures were significantly decreased from a minimum of 0.68 °C up to 3.48 °C than those measured at rest before cycling. In accordance with the regions of declines in skin temperatures, the values of SCWC and TEWL almost attained 120 A.C.U. and 40∼60 g/h.m^2. Meanwhile, the subjects produced 0.45 L/h sweating throughout the experiment. The distribution state of T_{sk}, SCWC and TEWL could be visualized directly by a novel color mapping of human body. The results obtained suggest that during the submaximal cycling exercise, the reduction of skin surface temperature is associated with the evaporative heat loss due to skin sweat.

Keywords: Skin Temperature; Stratum Corneum Water Content; Transepidermal Water Loss; Skin Sweat; Cycle Exercise

1 Introduction

Stratum corneum water content (SCWC) is considered to maintain proper function of the skin as a barrier and transepidermal water loss is commonly ascribed to be a measure of skin barrier function at baseline [1, 2]. The studies of various methods have found that the SC hydration state was increased rapidly after increase of the environmental relative humidity (RH) and temperature (T) [3-7] or logarithmic relationship was demonstrated between SC water contain and RH [4]. Increase of the SC hydration state increases the permeability of stratum corneum, leading to TEWL elevation [8]. Increasing the skin surface temperature increases the rate of TEWL, and

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increase of skin temperature by 7°-8 °C doubled the rate of TEWL [8]. A recent study reported that the higher moisture absorption capacity and lower thermal diffusivity of the clothing material can remain the higher level of SCWC in the skin [9, 10]. However, despite considerable research suggesting the effects of the temperature/humidity of skin/environment on the stratum corneum water content, transepidermal water loss in near windstill conditions, studies have not assessed simultaneously the change of skin temperatures, SCWC and TEWL and interaction among them with higher air velocities in cycling exercise.

In competitive cycling, excellent cyclists ride at speeds ranging from 20 to 50 km/h and thus generate an equivalent facing windspeed, which may increase the extent of heat loss by both convection and evaporation [11]. Adams et al. [12] showed that subjects reached higher rectal and oesophageal temperatures when they exercised in windstill conditions compared with a facing air velocity of 12.6 km/h. Saunders et al. [18] observed that the skin temperature in 0.2 km/h increased significantly with time and was significantly greater compared with the other three conditions (9.9, 33.3 and 50.1 km/h) from 10 to 50 min. Kwon et al. [13] further found the skin temperature became abruptly lower when exposed to a wind velocity of 5.4 km/h compared with the near windstill condition.

Above studies suggested that during dynamic exercising, skin temperature reduced [14-16]. The sweating rate and evaporative heat loss due to skin sweat markedly increased as an increase of workload [17, 18]. The trends in SCWC and TEWL are currently unknown if the human body is in the dynamic exercising state and sweating is not inhibited. Therefore the purpose of this study is to investigate skin temperature, SCWC, TEWL distributions and analyze the involved reasons in cycling subjects when the environmental values of RH and T are kept in the thermo-neutral level. A novel color mapping of human body would be plotted to visualize directly the distribution state of skin temperature, SCWC and TEWL.

2 Methods

2.1 Subjects

Nine healthy male competitive collegiate sportsmen were recruited as subjects. Age, height, body weight, and Dubois body surface area [19] were 21.6 ± 1.6 yr, 172.8 ± 6.4 cm, 61.7 ± 7.6 kg and 1.74 ± 0.13 m^2, respectively. Average maximal heart rate was 198.4 ± 1.5 beats/min. Before testing, each subject signed a consent form approved by the Human Subjects Ethics Sub-Committee of the Hong Kong Polytechnic University.

2.2 Measurements

Ventral infrared thermograms of the subjects were scanned using an infrared (IR) thermographic system (Nikon Thermal Vision, LAIRD-S270, Nikon Corperation). A total of 85 ventral thermograms were obtained from each subject (1 min Rec interval). The temperature-resolving power of the Thermoviewer was ± 0.1 °C. The infrared thermogram was digitized and saved on a floppy diskette using a thermographic data converting program (FAI-Controller, Nikon Corperation). The data from the thermograms were analyzed with an image processing system (FAI-Analyzer, Nikon Corperation). Ventral skin temperatures in chest, abdomen, under arm, upper arm, fore-