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Skin Temperature, Stratum Corneum Water Content and Transepidermal Water Loss Distributions During Running

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Abstract

This study examined the trends in skin temperature, Stratum Corneum Water Content (SCWC), Transepidermal Water Loss (TEWL) and subjective sensations during running exercises. Ten healthy male subjects performed exercises wearing cotton briefs in a climate chamber controlled at an air temperature of 27∼28℃ and a relative humidity of 50%. Following a rest for 20 mins on a chair (Rest), subjects exercised on a motorised treadmill at 4 km/h walking speed for 20 mins (walk) followed by a 7.2 km/h (medium run) and 12 km/h (high run) running speed for 10 min, respectively. The SCWC and TEWL were measured at pre-exercise, end-walk, end-medium run and end-high run. Skin temperatures were obtained by infrared thermograms for every 5 mins. The main findings were summarized as follows: Skin temperature in chest, abdomen, under arm, upper arm, forearm, hand, ventral thigh and ventral leg were significantly lower during walk, medium & high run than at rest by 0.13∼0.73, 0.36∼1.78, 0.35∼2.24℃, respectively. Skin temperature in dorsal thigh, popliteal fossa was lower within 1℃ or higher by 0.11∼1.28℃ in dorsal leg and foot during exercises than at rest. In accordance with the regions of declines of skin temperatures, SCWC and TEWL doubled and elevated four times. Exercises were rated significantly higher for perception of humidity, heat and overall discomfort than rest. We discussed how dynamic exercises induce significantly different skin temperature, SCWC and TEWL on human body, which have profound influence on subjective perception of thermal factors, humidity and discomfort. The results of this study suggested that fall in skin surface temperature during dynamic exercising were related to thermal factors, such as evaporation due to skin sweat.

Keywords: Exercises; Stratum Corneum; Water Content; Transepidermal Water Loss; Subjective Sensations

1 Introduction

Stratum Corneum Water Content (SCWC) is considered to maintain proper function of the skin as a barrier and Transepidermal Water Loss (TEWL) is commonly ascribed to be a measure of skin barrier function at baseline [1, 2]. Previous studies have demonstrated that the stratum

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Corneum hydration state is closely related with the environmental values of relative humidity (RH) and temperature (T) [3-7]. Rising ambient humidity increases the permeability of the stratum corneum by increasing its water content, leading to TEWL elevation [8]. Increasing the skin surface temperature increases the rate of TEWL, and increase of skin temperature by 7°-8 ℃ doubled the rate of TEWL [8]. These experiments were conducted in the near still condition when sweating was abolished. And the observations mainly focus on the effects of the environmental values of RH and T on SCWC and TEWL. However, the studies found that during dynamic exercising, the skin temperature reduced [9-11]. The trends in SCWC and TEWL are currently unknown if the human body is in the dynamic exercising state when skin temperature falls, where sweating is not inhibited and the environmental values of RH and T are maintained at a thermo-neutral level. Therefore the purpose of this study is to investigate the trends in SCWC and TEWL in exercising subjects with different intensities in thermo-neutral environments. Furthermore, we also determine whether skin temperature falls and analyze the involved reasons, and whether the subjective perception of thermal factors, humidity and discomfort has profound effect, as well as explore the relationship between SCWC, TEWL and subjective sensations. 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

Ten healthy male subjects were recruited. Age, height, body weight, and Dubois body surface area [12] were 22.25±0.97 yr, 175.69±3.06 cm, 70.24±13.34 kg and 1.86±0.13 m^2, respectively. 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, and Nikon Corporation) (1 min Rec interval). The temperature-resolving power of the Thermoviewer was ± 0.1 ℃. The infrared thermogram was digitized and saved on a floppy diskette using a thermographic data converting program (FAI-Controller, Nikon Corporation). The data from the thermograms were analyzed with an image processing system (FAI-Analyzer, Nikon Corporation). Ventral skin temperatures in head, chest, abdomen, under arm, upper arm, forearm, hand, ventral thigh and ventral leg were estimated by IR. IR provided temperatures from 270,000 pixels on average from the ventral body surface. The mean temperature from thermography (Tsk-IR) was taken as an arithmetic mean of these points. Dorsal skin temperatures were measured with thermistors (Nikkiso-YSI, Japan) and taped at eight sites: upper back, lower back, dorsal thigh, popliteal fossa, dorsal calf and foot. All temperatures were recorded continuously and temperature readings were stored in the data logger LT-8A (Nikkiso-YSI, Japan) every 2s, and then sampled by a computer though a converter.

Measurements of SCWC were performed on the ventral areas (head, chest, abdomen, armpit, upper arm, forearm, hand, ventral thigh and ventral leg) and dorsal areas (upper back, lower back, dorsal thigh, popliteal fossa, dorsal calf and foot) with a Corneometer CM825 (Courage