Alteration in thermal sensation and thermoregulation registered in skin physiology toward temperature and moisture transients

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Keywords: Climatic chamber, indoor environmental control, step change, dermal, comfort

1 Introduction

Air conditioning is frequently used as a means of adjusting indoor microclimate and promoting thermal comfort in hot-and-humid areas such as Taiwan. However, when entering an air-conditioned building from the ambient environment, people may experience temporary thermoregulatory shocks if the instantaneous change in air temperature (temp) or relative humidity (RH) exceeds the thermoregulatory capacity. de Dear et al. (1989) studied the impact of humidity on thermal comfort during step changes between 20 and 80% RH, and found that the subject's thermal sensation changed as influenced by the transient absorption and desorption of moisture in clothing. Tsutsumi et al. (2007) examined the effect of moisture transient, and reported that, when people transitioned from a temp of 30^{o}C and RH of 70% to a SET* of 25.2^{o}C, a period of over 35 min was required in thermally adapting to the new environment. Here we present a study that investigated the adaptation of thermal perception and thermoregulation to step change in either temp or RH. The gender as a factor was also evaluated.

2 Materials/Methods

Three temperature steps (down-stepping from 32/28 to 24^{o}C and up-stepping from 20 to 24^{o}C; RH maintained at 60%) and two moisture steps (RH down-stepping from 70 to 60% and up-stepping from 50 to 60%; temp maintained at 24^{o}C) were created in a climatic chamber consisting of twin microclimate-controlled rooms, simulating the thermal transient people experienced in Taiwan when entering from the ambient environment (i.e. the outdoor chamber) into an air-conditioned building (the indoor chamber). In the experiment, the subjects (8 males and 8 females) in *t*-shirt and long pants first stayed in sedentary position in the outdoor chamber for 30 min to acclimate, and then moved swiftly to the indoor chamber. The subject's sensational and thermoregulatory responses to the change in thermal environment were evaluated at 0, 1, 2, 3, 4, 5, 6, 10, 20 min following their entry into the indoor chamber. The thermal perception was gauged using the 7-grade thermal sensation vote (TSV) developed by the ASHRAE (ASHRAE, 2004), and the thermoregulatory responses were examined by measuring distinct stages of thermoregulation as manifested in skin physiology, including the change in skin capillary blood flow (SCBF), skin moisture, transepidermal water loss (TEWL), and skin temp. The variation in each indicator between groups of temp or moisture step was compared using the student's *t*-test.

3 Results and Discussion

As Figure 1 shows, a significant change in all physiological indicators occurred in the first 2 min after the subjects experienced a temp down-step from 32 to 24^{o}C. A cold sensation overshot was observed in the TSV, SCBF, TEWL, and skin temp in 1 min after the transient occurred. The change in TEWL revealed that the males required a longer period to adapt than the females did (p<0.05). The effect of temp transient was less noticeable when the step change was limited to 4^{o}C. The effect of moisture step was the most significant when the subjects experienced a RH increase from 50 to 60% (Figure 2); the SCBF, skin moisture, TEWL peaked approximately 5-6 min after the moisture transient occurred. When challenged by a temp down-step, the males physiologically adapted to the environment via increase in the skin moisture and TEWL, both resembling an invisible stage of sweating, whereas the females

dissipated excess body heat primarily via SCBF acceleration. Approximately 6 min into the thermal transition thermoregulatory feedback appeared among the subjects, possibly compensating for an over-regulation occurring when the subjects first entered the indoor chamber.

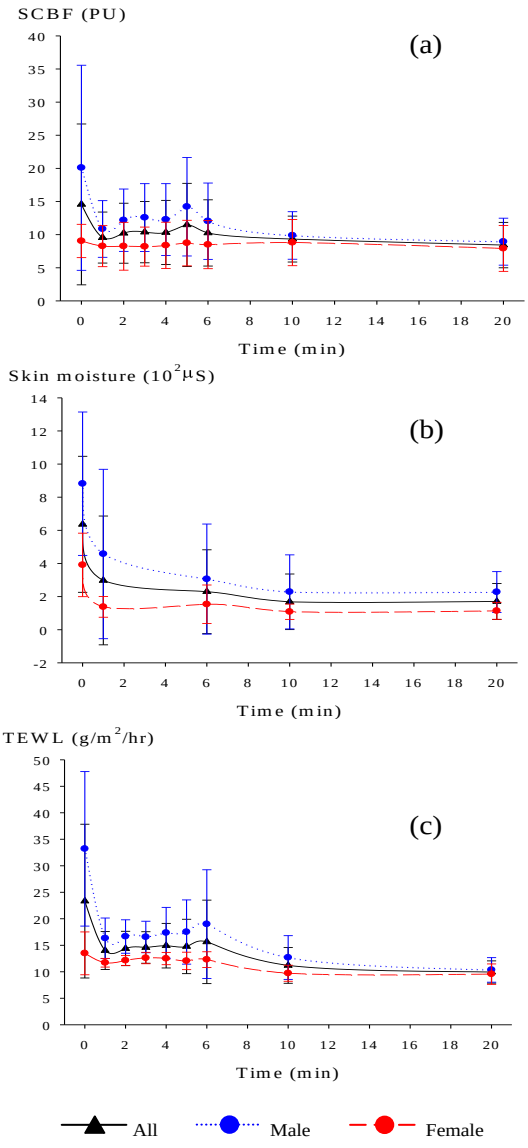

Figure 1: Change in (a) SCBF, (b) skin moisture and (c) TEWL over time in response to a temperature step from 32 to 24°C.

4 Conclusions

The study findings suggest that the disruption in thermal comfort and thermoregulation due to thermal transient may be adequately controlled when the instantaneous change in the thermal environment is limited to a step of 4°C in temp or 10% in RH. People who have to constantly move across a transient should take action (e.g. clothing adjustment) in the first 10 min of acclimation to reduce potential thermal stress.

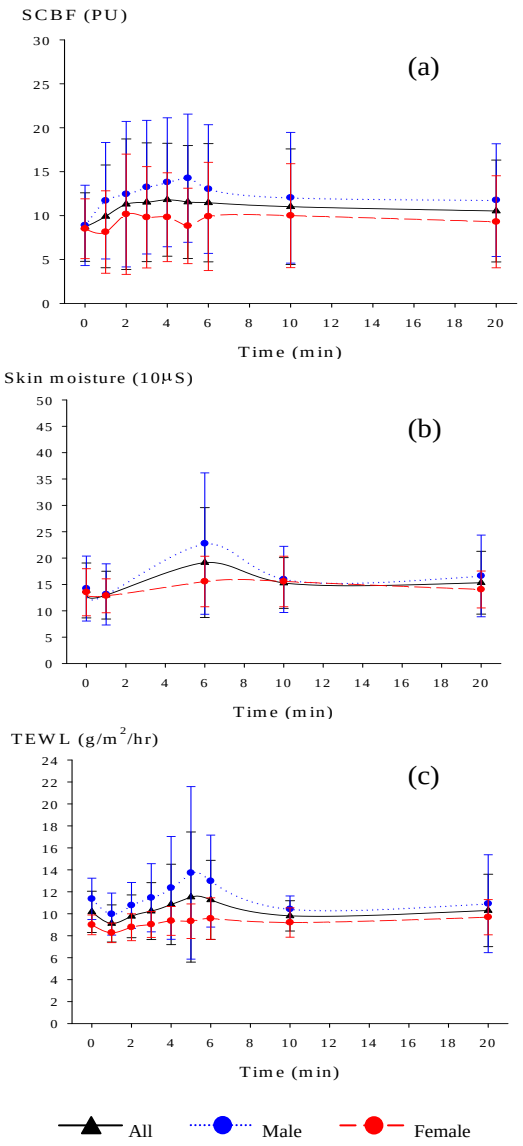

Figure 2: Change in (a) SCBF, (b) skin moisture and (c) TEWL over time in response to a moisture step from 50 to 60%.

5 References

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