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Solar radiation reduces endurance exercise performance in a hot environment

Environmental conditions have a large influence on the development of fatigue during physical activity and exercise. High ambient temperature reduces endurance exercise performance compared with moderate and low ambient temperature. Moreover, in a hot environment, endurance exercise performance falls progressively as relative humidity increases and air velocity decreases. Despite awareness of the importance of solar radiation for endurance exercise performance in a hot environment, however, there has been no systematic study to confirm and quantify this effect.

Therefore, the present study investigated the influence of variations in solar radiation on endurance exercise capacity and thermoregulatory responses in a hot environment.

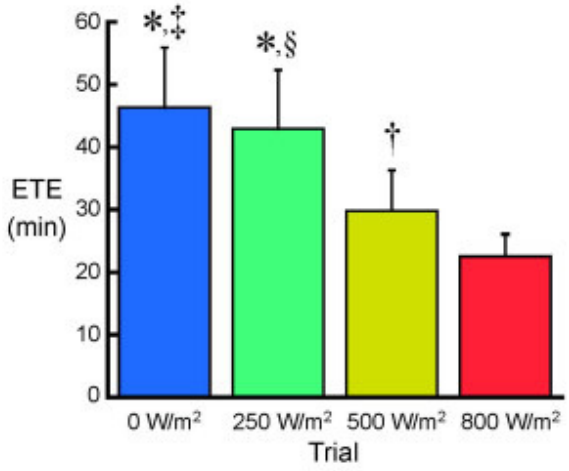

Fig. 1 Effect of the solar radiation on exercise time to exhaustion (ETE). *P < 0.001 and †P < 0.05 denote a significant difference from the 800 W/m2 trial. ‡P < 0.01 and §P < 0.05 denote a significant difference from the 500 W/m2 trial.

In this study, eight healthy young male volunteers performed four cycle exercise trials at 70% maximum oxygen uptake until exhaustion in an environmental chamber maintained at 30°C, 50% relative humidity and <0.3 m/s air velocity. Volunteers were tested under four solar radiation conditions in randomized order: 800 W/m^2, 500 W/m^2, 250 W/m^2 and 0 W/m^2. The intensity of solar radiation of 800 W/m^2 is equivalent to direct solar radiation on the Earth's surface at around noon under a clear sky in summer in the British Isles (latitude 50°N) and Japan (latitude 36°N). Metal halide lamps (67 × 360 Watts) were used as a ceiling-mounted solar simulator.

Endurance exercise capacity fell progressively as solar radiation increased. Time to exhaustion was 23 ± 4 (mean ± standard deviation) min on the 800 W/m^2 trial, 30 ± 7 min on the 500 W/m^2 trial, 43 ± 10 min on the 250 W/m^2 trial and 46 ± 10 min on the 0 W/m^2 trial, respectively, and was significantly less on the 800 W/m^2 trial than the other trials and was also less on the 500 W/m^2 trial than the 250 W/m^2 and 0 W/m^2 trials

(Fig. 1). During exercise, there were no significant differences between trials in sweating rate, heart rate, skin blood flow, blood pressure and changes in plasma volume. Solar radiation also had little effect on core temperature throughout exercise, and volunteers reached exhaustion at a constant core temperature (mean 38.5 ± 0.3°C; range 38.0-39.4°C), independent of the different exercise times. Solar radiation affected lower body (thigh and calf) skin temperatures but did not affect upper body (chest and upper arm) skin temperatures during exercise.

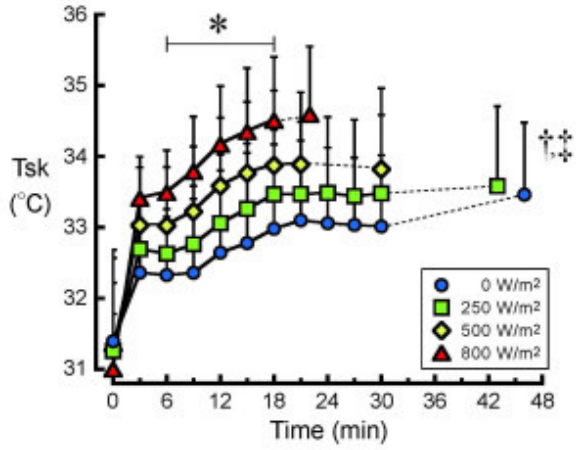

Fig. 2. Response of mean skin temperature (Tsk) to exercise with different solar radiation. *P < 0.05 denote a significant trial by time interaction between the 800 and 0 W/m2 trials. †P < 0.005 denote a significant main effect of trial between the 800 and 250 W/m2 trials. ‡P < 0.005 denote a significant main effect of trial between the 500 and 0 W/m2 trials.

There was a progressive increase in mean skin temperature as solar radiation increased. Mean skin temperature, which is the mass-weighted average surface temperature of the skin, was higher on the 800 W/m^2 trial than the 250 W/m^2 and 0 W/m^2 trials and also on the 500 W/m^2 trial than the 0 W/m^2 trial (Fig. 2). The temperature gradient between the body core and the skin at the point of exhaustion was narrower on the 800 W/m^2 trial than the 250 W/m^2 and 0 W/m^2 trials (800 W/m^2 3.6 ± 1.0°C, 500 W/m^2 4.6 ± 1.0°C, 250 W/m^2 5.1 ± 1.3°C, 0 W/m^2 5.2 ± 0.9°C).

In conclusion, the present study demonstrates that endurance exercise performance in a hot environment falls progressively as solar radiation increases. This early fatigue on the higher solar heat load trials is accompanied by a higher skin temperature and a narrower temperature gradient between the body core and the skin, with no apparent differences in sweating and cardiovascular responses or plasma volume to exercise. These findings suggest that solar radiation is a key consideration for individuals exercising in a hot environment

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