LIMITS TO PHYSICAL PERFORMANCE UNDER BOTH HOT AND COLD THERMAL EXTREMES

J. González-Alonso, The Copenhagen Muscle Research Centre, Rigshospitalet, Copenhagen, Denmark.

It is well established that physical performance is hindered under both extreme hot and extreme cold thermal conditions. The physiological factors limiting performance in either environment will depend on the subjects' training status, as well as type, duration and intensity of exercise. Recent evidence in trained subjects indicates that endurance performance in hot and very cold environments is closely linked to critically high or low body temperature, respectively. In opposition to this hypothesis of a critical level of body temperature, there are reports indicating that some subjects fatigue during light exercise in extreme hot and cold conditions with body temperatures of ~37-38°C. Therefore, exhaustion in extreme environments should be conceived as a complex phenomenon most likely resulting from the interaction of body temperature, as well as metabolic and circulatory factors. Nevertheless, there will be exercise conditions where one of these variables will be the most important. For instance, during prolonged exercise in hot environments, trained cyclists have been found to rapidly fatigue at strikingly similar body temperature (~40°C), when its initial value (36.0, 37.4 or 38.4°C) and rate of rise (0.10 vs. 0.05°C/min) are systematically manipulated. This volitional fatigue (i.e., inability to sustain the same workload) can be acutely reversed by perfusing the skin with cold water. Conversely, during prolonged exercise in the cold with continuous exposure to rain and wind, some people fatigue when reaching a critical level of hypothermia (~35°C). Together, these findings suggest a pivotal role of body temperature on the etiology of fatigue in trained people. Critically high or low temperature could directly alter the function of vital organs such as the brain and heart (e.g. diminishing central command and cardiac contractility, respectively) or indirectly impair tissue circulation and metabolism. During prolonged exercise in less extreme hot environments the elevation in body temperature is accompanied by marked reductions in cardiac output, skeletal muscle blood flow and skin blood flow, and altered skeletal muscle metabolism, as indicated by the greater glycogen utilization and lactate production and declining skeletal muscle oxygen uptake at exhaustion. These metabolic alterations are accentuated during maximal exercise, encompassing significant reductions in systemic and skeletal muscle O_2 delivery and uptake. During maximal exercise in hot environments, diminished skeletal muscle ATP production might instead be the main factor causing fatigue.

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jga@cmrc.dk