PHYSIOLOGICAL AND BEHAVIOURAL TEMPERATURE REGULATION IN MEN SUPPRESSING AUSTRALIAN SUMMER BUSHFIRES WITH HAND TOOLS

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Bushfire fighters undertake prolonged strenuous work, usually in hot summer weather, on fires that liberate great quantities of heat. How do they cope? Four seven-man crews were studied by reliable standard methods over three summers in Australian eucalypt forests while they attempted to suppress bushfires of intensities commonly faced by hand-tool crews (Budd *et al*., 1997). They were men of age (mean and range) 26 (18-45) yr and body mass 71 (52-105) kg; they wore light cotton or wool coveralls, or trousers and shirt, together with boots and hard hat; and they experienced air temperature 29 (19-35)°C and mean radiant temperature 66 (33-96)°C, with low humidity and windspeed.

Physiological temperature regulation: Firefighters' physiological responses averaged (mean ± s.d.) energy expenditure (EE) 516 ± 100 W, heart rate (HR) 152 ± 14 beats min^{-1}, rectal temperature (Tre) 38.2 ± 0.2°C, thigh skin temperature 34.5 ± 1.7°C, and sweat rate 1,144 ± 373 g h^{-1}. They considered the work 'somewhat hard' (Rating of Perceived Exertion (RPE) 13.6 ± 1.7) and they felt 'just too warm'. No burns or heat disorders were observed. HR and Tre were not changed by a sixfold variation (36-217 min) in work duration, showing that their heat load was completely dissipated and they were in thermal equilibrium. Nor were HR or Tre changed by variations of 406-630 W in energy expenditure; of 15-34°C in Wet-bulb Globe Temperature (WBGT) — as much as 9°C above recommended limits; of 7-27% in body fat content; or of 31-63 ml min^{-1} kg^{-1} body mass in maximum oxygen uptake, except for an attenuated effect on HR. These unchanged responses while firefighting are contrary to the results of numerous laboratory studies, and also to the firefighters' own responses in formal work tests. Effects of fire were negligible except for a 356 g h^{-1} increase in sweat rate, showing that the results are also applicable to other hot and/or strenuous occupations. Behavioural temperature regulation: The stability of HR and Tre during firefighting despite wide variations in work, weather, and fire, and in the firefighters' fitness, fatness, and age, is explained by (1) unrestricted evaporation of sweat and (2) firefighters' self-regulation of their work rate, radiant-heat exposure, and other work behaviour, guided by negative feedback from their physiological and subjective responses. Despite head-fire intensities as high as 3,280 kW per metre of fire front, firefighters' work practices reduced their radiant-heat exposure to an intensity (1.6 kW m^{-2}) little greater than that of sunlight, which could readily be blocked by clothing light enough to let sweat evaporate at rates of 1-2 l h^{-1}. The average metabolic heat load was more than twice the combined heat load from fire and weather, showing that the main task for bushfire fighters' clothing is not to keep heat out but to let it out.

Conclusions: Behavioural regulation and appropriate clothing allowed firefighters to maintain their physiological and subjective responses at safe and sustainable levels over a wide range of job demands and personal factors. These findings highlight the limitations of laboratory studies for predicting physiological responses in the workplace.

Budd, G.M., Brotherhood, J.R., Hendrie, A.L., Cheney, N.P., Dawson, M.P., 1997. Special Issue: Project Aquarius. Stress, strain, and productivity in wildland firefighters. International Journal of Wildland Fire 7(2): 69-218.

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