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Physiological and perceptual responses in the elderly to simulated daily living activities in UK summer climatic conditions

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ABSTRACT

Objectives: The elderly population is at an increasingly significant health risk to heat-related illnesses and mortality when compared with younger people in the same conditions. This is due to an increased frequency and severity of heatwaves, attributed to climate change, and reduced ability of elderly individuals to dissipate excess heat. Consequently, most excess deaths and emergency visits during heatwaves occur in people aged more than 65 years. The aim of this investigation was to assess the physiological and perceptual responses of elderly people during exercise sessions equating to activities of daily living in UK summer climatic conditions.

Study design: Mixed-method, randomised research design.

Methods: Twenty-eight participants (17 males, 10 females and 1 transgender female) were randomly assigned into three experimental groups; 15°C, 25°C or 35°C, with 50% relative humidity. Participants completed one preliminary and three experimental trials within their assigned environment. The data from the preliminary incremental recumbent cycling test was used to calculate participant's individual exercise intensities equating to 2, 4 and 6 metabolic equivalents (METs) for the subsequent trials. During experimental trials, participants completed 30-min seated rest and 30-min cycling.

Results: No change was observed in thermal comfort ([TC] just uncomfortable in both trials), and only modest changes in ratings of perceived exertion (14 ± 2 vs 15 ± 2) at 6 METs in 25°C compared with those in 35°C were observed. In contrast, thermal strain markers did significantly increase ($P < 0.05$) across the same conditions, including change in rectal temperature (ΔT_{re}) during exercise (0.27 ± 0.17°C vs 0.64 ± 0.18°C) and peak skin temperature ([T_{skin}] 32.94 ± 1.15°C vs 36.11 ± 0.44°C).

Conclusion: When completing exercise that equates to activities of daily living, elderly people could have a decreased perceptual awareness of the environment even though physiological markers of thermal strain are elevated. Consequently, the elderly could be less likely to implement behavioural thermoregulation interventions (i.e. seek shade and/or remove excess layers) due to a decreased awareness of an increasingly thermally challenging environment.

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Introduction

It has been predicted that climate change will increase the risk of heat-related morbidity and mortality of elderly people (>65 yrs) in the UK.[1] There are ~2000 heat-related deaths per year in the UK with a predicted fivefold increase by 2080, equating to ~12,700 preventable deaths.[1] Furthermore, extreme heatwaves such as the 2003 European heatwave resulted in ~70,000 deaths,[2,3] the majority being elderly.[4] Elderly people also comprise the majority of the emergency and general practitioner (G.P) visits during heatwaves for heat-related illnesses.[5,6] In response to the extreme weather events, advice and governmental policy have been issued to the general public and health services, with the aim to decrease heat illness risk.[7,8] The information provided encourages people to increase fluid intake, seek shade, take cool showers and reduce physical activity.[7,8] Metabolic heat production ($\dot{H}_{prod}$) is decreased with decreased physical activity; consequently, less excess heat dissipation is required to maintain a thermal equilibrium.[9] However, advising less physical activity is a conflicting health message which can have serious health consequences. The UK Government recognises the benefits of exercise and conducts several health campaigns to encourage greater exercise participation including; One You,[10] Change4Life[11] and Couch to 5K.[12] These campaigns highlight the benefits of regular exercise which include: reducing the risk of diseases such as type 2 diabetes, heart disease, several types of cancer and stroke; reducing the incidence of obesity; and improving mental health. A more cohesive message of safe and effective exercise during periods of hot weather for the elderly will improve health messages across environmental and physical health services.

Current research into heat, exercise and elderly health has focused on comparing physiological responses to younger adults.[13–18] It is well established that elderly people have an attenuated ability to dissipate heat through their reduced cutaneous blood flow, physical fitness and sweat gland output, resulting in a decrease in sweat rate.[5] More recent research has advanced our understanding of when elderly people store greater amounts of heat than younger adults, therefore placing them at a greater risk of heat illness. Stapleton et al. found that when exercising at a fixed rate, $\dot{H}_{prod}$, in a 40°C environment, older people began to store greater amounts of heat than younger individuals, from 400 W $\dot{H}_{prod}$ (~47% of peak oxygen uptake during a near maximal incremental test [$\dot{V}O_{2peak}$][16]) in older men and from 325 W $\dot{H}_{prod}$ (~50% $\dot{V}O_{2peak}$) in older women.[17,18] However, the exercise intensities used in these previous studies are at a set $\dot{H}_{prod}$[16–18] and do not replicate activities of daily living for the elderly. Furthermore, the extreme environments >35°C and <20% relative humidity (RH) used in the aforementioned research do not simulate current UK summer environments. The average summer temperature for the UK is ~15°C, and the average hottest temperature experienced across the UK was 34.4°C, with 38.5°C being the hottest ever recorded temperature.[19] The RH in the UK is variable: during average summers, RH ranges from ~60% to 80%;[20] however, during periods of hot weather, RH is between 20% and 60%.[21,22] Consequently, the physiological and perceptual responses to activities of daily living of elderly people in UK summer environments remain unclear.

Metabolic equivalents (METs) are an easy way to quantify energy expenditure of activities of daily living[23] and are commonly used as an estimate of energy expenditure in elderly participants.[24] One MET, commonly referred to as resting metabolic rate (RMR), is the utilisation of 3.5 ml O_2/kg/min by a 70-kg individual, and consequently, 2 METs require 7.0 ml O_2/kg/min to complete. Activities equivalent to 2 METs include washing the dishes and cooking, 4 METs include gardening and painting and 6 METs include walking and dancing.[23]

The elderly population could benefit from advice on how to maintain healthy and active lifestyles during periods of hot weather to gain the health benefits of exercise while avoiding the risks of heat illness. Therefore, the aim of this study was to investigate the physiological and perceptual response of elderly people during exercise that equated to various activities of daily living in environmental temperatures associated with UK summer conditions. It was hypothesised that physiological and perceptual responses would increase with exercise intensity and environmental temperature.

Methods

Ethical approval

The experimental protocol was approved by the University of Brighton's ethics committee, and the experiment was conducted in accordance with the revised Declaration of Helsinki.[25] Before testing, participants provided their written consent and a medical questionnaire by which participants were excluded if they had prior or were currently being treated for cardiovascular or respiratory illnesses or they were taking medication that affected thermoregulation. In addition, the participants' G.Ps were informed of their patient's participation and gave their written consent for their patient to participate.

Participants

Twenty-eight (17 males, 10 females and 1 transgender female) habitually active participants volunteered for the study and were divided into three experimental groups. Participants were matched between groups for stature, body mass, body fat percentage and age (Table 1).

Preliminary testing

During the preliminary testing, anthropometric and baseline data were collected, followed by a graded exercise test (GXT). Stature (Detecto, USA) and body mass (0.01 kg) (Adam GFK 150; Adam Equipment Inc., USA) were recorded. Body fat percentage was determined from four skin folds[26] and the equations of Siri.[27] On completion, a 10-min supine 12-lead electrocardiogram (ECG) analysis was completed by a qualified technician to detect abnormalities in heart activity. Resting blood pressure was measured after ECG analysis to ensure participants were not hypertensive. If a heart