Water dousing on the skin surface during a very-hot-and-dry heatwave: impacts on fluid balance and thermal and cardiovascular strain

Protocol Summary

Each participant will undergo one four-hour simulated heatwave exposure in a climate chamber, undertaking one of three possible interventions:
1. Full fluid replacement, sham dousing (FFR-S) (comparator)
2. Quarter fluid replacement, sham dousing (QFR-S)
3. Quarter fluid replacement, frequent dousing (QFR-F)

They will be asked to sit in a thermally regulated environmental chamber at a temperature of 45°C and 15% relative humidity, with an electric fan stack on a low setting simulating a light breeze (~0.6 m/s).

Prior to exposure, predicted water loss due to sweat and respiration across the four hours will be calculated and used to determine the amount of fluid given to the participant to consume throughout. Briefly, this will be achieved using known thermoregulatory constants, the environmental conditions, and an assumed resting metabolic rate equal to one MET. The sweat loss required to achieve heat balance will be subsequently calculated, as will the respiratory water loss, and this will inform fluid consumption. In the FFR-S trial, participants will be given 100% of their predicted fluid losses, broken into four water drinks (~20°C). In the QFR-S and QFR-F trials the participant will receive only 25% of their predicted water losses, also broken into four drinks. These drinks will be of equal volume and delivered at the 35, 95, 155 and 215 minute time points.

In the two sham dousing trials (FFR-S and QFR-S) participants forearms will be doused with water once every five minutes using a spray bottle. This will be administered by the researcher. Each spray dispense 1.2ml of ~20 degrees Celsius water, for a total dousing in these two trials of 2.4ml per five minutes. In the optimal dousing trial (QFRO) participants will spray themselves a pre-determined number of times every two minutes. This number will also be based upon calculated fluid losses; 75% of the expected fluid losses across four hours will be calculated prior to exposure, and then broken down into two minute increments, then an allotted number of 1.2ml sprays will be determined. For a typical participant (75kg, 175cm) this will be equal to ~6 sprays (7.2ml) every two minutes. The participant will spray their forearms, legs, chest, abdomen and face. Adherence to the spraying routine throughout the QFR-F trial will be monitored by the researcher, who will offer reminders at each two minute time point.

Measurements Summary

Resultant dehydration

Nude body mass will be measured on a platform scale and changes in body mass will be considered losses in body water. Total body mass loss and baseline body mass will be used to determine the level of dehydration (% total body mass) and indicate the effectiveness of dousing in mitigating dehydration rates and reducing the amount of fluid that need be

consumed to maintain hydration status. The primary time point for this measure will be at the end of exposure.

Core temperature via ingestible telemetric pill

Participants will ingest a small telemetric pill ~6h prior to exposure. Throughout the exposure this will give an indication of intestinal temperature, an index of core temperature. Change in core temperature from baseline will indicate thermal strain caused by the exposure. The primary time point for this measure will be at the end of exposure.

Rate pressure product

An automated blood pressure cuff will be employed to determine blood pressure, and a chest strap heart rate monitor to measure heart rate. The product of systolic blood pressure and heart rate will be calculated as the rate pressure product and taken as an index of cardiovascular strain throughout the exposure. The primary time point for this measure will be at the end of exposure.

Thirst

Participants will be asked to rate their thirst, mouth dryness and how pleasant a drink of water would be on three separate visual analogue scales. These scales are each 100mm long and the participant may mark anywhere on the line, with a score between 0-100 being determined for each. These three scores will be taken as an indication of the participants level of thirst throughout the exposure. Baseline measurements will be taken at the beginning of the exposure (minute 0), and further measures taken every half an hour throughout the exposure (30, 60, 90,120, 150, 180, 210 minutes) as well as at the end of exposure (240 minutes).

Thermal comfort and sensation

Using two separate visual analogue scales participants will rate their level of thermal comfort (not uncomfortable, slightly uncomfortable, uncomfortable, very uncomfortable) and thermal sensation (very cold - very hot). These scores will indicate the thermal acceptability of the environment coupled with whatever exposure they are undertaking. Baseline measurements will be taken at the beginning of the exposure (minute 0), and further measures taken every half an hour throughout the exposure (30, 60, 90,120, 150, 180, 210 minutes) as well as at the end of exposure (240 minutes).

Skin temperature

Four temperature sensors will be taped to the participant's skin surface (chest, shoulder, thigh, and calf) and be used to estimate mean skin temperature. This will be used to estimate dry heat exchange for each participant throughout the exposure. These temperature sensors will record continuously throughout the whole exposure.

Orthostatic hypotension

Participants will be asked to stand immediately after a seated blood pressure, and a further blood pressure reading will be taken via an automated cuff after one minute of standing. This test is carried out to see if there is evidence of postural hypotension (a drop in BP following standing from a seated position). Baseline measurements will be taken at the beginning of the exposure (minute 0), and further measure taken at the mid-point (120 minutes) and end (240 minutes) of the trial.

Heart rate

Heart rate will be monitored via a chest strap/ECG. This will be monitored and logged continuously throughout the whole exposure.

Blood pressure

Baseline measurements will be taken in duplicate at the beginning of the exposure (minute 0), and further measures taken every half an hour throughout the exposure (30, 60, 90,120, 150, 180, 210 minutes) as well as at the end of exposure (240 minutes).

Participant Characteristics

A total of 108 participants (36 per intervention) will complete this study. All participants must fall into one of our three potential age categories; 18-40, 45-55 or 65+ years old. Exclusion criteria include:
1. Not within a specified age bracket
2. Currently taking medication that may impact thermoregulatory outcomes
3. Current respiratory, renal or metabolic disease/ disorder(s)
4. Current smoker
5. Recent (<12 months) stomach surgery
6. Pregnant

Statistical Analysis

Data for resultant dehydration core temperature, rate pressure product, thirst, orthostatic intolerance, skin temperature, thermal comfort, thermal sensation, heart rate and blood pressure will be analysed with a 3-way ANOVA with the repeated factor of time (5 levels: 0, 60, 120, 180 and 240 minutes), independent factor of condition (3 levels: FFR-S, QFR-S, QFR-F) and independent factor of age (3 levels: 18-40 years, 45-55 years, 65+ years).

If significant main effects or interactions are found, independent differences will be assessed using a two-tailed paired Student's t-tests while maintaining a fixed probability (5%) of making a type I error using a Sidak correction.

Data analysis will be blinded, with the key to unscramble the data only employed once a minimum of 6 participants from each age group have completed each condition (at least 54 participants completed). All further analysis beyond this point will remain blinded until all data collection has been completed.