Research questions:

The primary research question guiding this project is:

1. Are fans and/or skin-wetting effective in decreasing the physiological strain experienced by elderly during a simulated hot, humid heatwave (38°C and 60% relative humidity)

Research hypotheses:

The research hypotheses going into this study are:

1. In the hot and humid condition all interventions will result in improved cooling compared to the control (no-fan) trial. With fan and skin-wetting (FSW) being the most effective, then no fan and skin-wetting (NFSW), then fan (F), and finally, the control, no-fan (NF).

Participant characteristics

To complete this study 56 (greater than or equal to 60 years) adults will be recruited from previous participants who have consented to being contacted for future studies and through the distribution of recruitment fliers at both the Cumberland and Camperdown campuses at The University of Sydney.

The sample size computation is based on comparison of the primary endpoint (change in rate pressure product from baseline to the end of a 3 hour simulated heatwave exposure to 38°C and 60% RH) between the 4 conditions of control, fan use alone, skin wetting alone, fan use + skin wetting. This preliminary data from young healthy participants was provided by Nate Morris, a former PhD student from within our laboratory. A non-repeated measures ANOVA on this data demonstrates 20% (eta squared of 0.2) of the variability was due to the intervention. Using GPower 3.1.9.2 software an ANCOVA: Fixed effects, main effects and interactions f-test was performed using an alpha of 0.05, a beta of 0.1 and an effect size of 0.5 in order to determine a total sample size of 45 is needed to obtain sufficient statistical power. To account for an approximately 20% loss to follow-up rate, 56 participants will be included in the study. Of the 56 participants, 14 will be healthy older females, 14 will be healthy older males, 14 will be older healthy females taking antihypertensive medication, and 14 will be older males taking antihypertensive medication.

Inclusion criteria:

For overall cohort: Non-smokers or ex-smokers (greater than or equal to 1y since quitting), fluent/have no difficulty understanding and speaking English, and age of greater than or equal to 60 y. Age will be matched across all groups.

Additional criteria for HTN-Rx group: Diagnosed as hypertensive and taking antihypertensive medication.

Exclusion criteria:

For overall cohort: Body mass index greater than or equal to 35. No history/signs/symptoms of coronary artery disease or heart failure. Currently undertaking hormone replacement therapy. Currently taking a medication known to cause hyper- or hypo-hidrosis (except those taken for hypertension). Currently taking a beta-blocker. Evidence of current fluid and electrolyte disorders, anemia, abnormal thyroid function, arrhythmias, diabetes, renal disease, liver disease, cerebrovascular disease, significant pulmonary disease, endocrine abnormalities, uncontrolled hypertension (180/110 mmHg), significant cognitive impairment, psychiatric disorder, substance abuse, degenerative neurological condition or any other medical condition deemed to pose risk during the proposed testing or experiments, or preclude them from completing the screening stress test.

Data collection protocol

The preliminary session and the 4 experimental sessions (with the option of doing an additional four experimental trials) will take place at The University of Sydney, Cumberland Campus. The time involvement will be approximately 1 hour for the preliminary session and 4 hours for each of the experimental sessions. This involves a total time commitment of approximately 17 hours.

We are recruiting participants for four experimental sessions that will take place in the hot, humid condition.

Pre-screening and preliminary sessions

Participants will be initially screened over the phone using a standardized phone screen based on the inclusion and exclusion criteria of our study. If the participants pass the phone screen they will be invited in for a preliminary session.

The preliminary session involves a complete medical history, physical examination and cardiac stress test. This screening will be carried out by geriatrician Maria Fiatarone Singh, MD. During the second preliminary session the participant will be asked to arrive fasted and their body composition. The preliminary session is important to further determine their eligibility for the study and deem them safe to participate. The following equipment and techniques will be used:

• Cardiac Stress Test: The participant will undergo a physician-supervised graded exercise test on a treadmill while undergoing ECG and blood pressure monitoring. Both are described below.

If the participant agrees to participate in this study, they will undergo testing at the Cumberland Campus of the University of Sydney for approximately three hours on 4 separate occasions. Each experimental session will be separated by at least 72 hours. Participants will be asked to abstain from alcohol and caffeine, avoid strenuous exercise in the 12 h prior to each experimental session, and will be instructed to consume a light meal and 0.5L of water ~2 h before arriving at the lab. They will be provided with a standardized singlet and shorts to wear and will undergo 20-min of baseline rest (seated) in a thermoneutral room (~24°C), where they will be instrumented using the equipment described below. After 20-min, they will then enter a climate-controlled chamber, where they will be seated unrestrained in a standard armchair for the remainder of the 3-hour experimental protocol. This protocol will consist of the participant sitting in a 38ºC and 60% relative humidity room. During each session the participant will undergo one of the following four conditions: no cooling intervention, use of an electric fan, skin-wetting with a sponge, or use of an electric fan while skin-wetting with a sponge. Additionally, in all trials they will be given cold (~18ºC) water equivalent to 1ml per kg every 20 minutes in all trials. In all fan trials they will be seated 1.25 m from an 18” diameter fan set to the highest setting. The following equipment and techniques will be used:

• Rectal temperature sensor: The participant will be asked to insert a flexible sensor 10-12cm into their rectum. A marker is placed on the sensor using sterile surgical tape. The participant will insert the sensor until the tape reaches their anal surface. The insertion of the sensor may cause some mild discomfort and minor irritation; however, this sensation soon passes. The participant will receive proper instruction regarding the placement of the sensor to ensure their safety and comfort. The participant will be responsible for the insertion of this sensor. It will provide the researcher with an indication of the amount of heat stored in their body and will be tracked throughout the entirety of each experimental session

• Skin temperature sensors: Four skin sensors will be taped to the participants skin surface with hypoallergenic tape. Some hair may need to be shaved (by the use of disposable razors) in order to secure the sensors adequately. These sensors give an indication of skin temperature and heat loss from the skin and will be recorded throughout the entirety of each experimental session.

• Blood pressure: An automated blood pressure monitor will be strapped to the participants arm and blood pressure will be taken every 20 minutes during the experimental protocol and will be used by researchers to calculate RPP (heart rate x systolic blood pressure) and mean arterial pressure . Blood pressure will also be taken three times during the orthostatic intolerance test described below.

• ECG monitoring: 12 soft electrodes will be stuck to the participants torso and will measure the electrical signals of their heart. This will produce signals on a display that will be continuously monitored to ensure the participants safety throughout the cardiac stress test during the first preliminary session and each experimental session.

• Heart rate: Heart rate will be measured using the ECG monitoring.

• Skin blood flow: A flexible laser probe will measure skin blood flow non-invasively at the upper back and forearm during the entirety of each experimental session. This measurement device does not result in any discomfort or residual medical effects.

• Ventilated sweat capsules: A small plastic capsule connected to plastic tubing will be placed on the participants upper back and forearm. Dry air is passed through this capsule and a humidity sensor will pick up humidity from the skin and provides a measurement of local sweat rate throughout each experimental session.

• Cognitive test: The participant will be asked to complete a short-form of the Stroop Colour and Word Test (SCWT) immediately before and at the completion of the heatwave exposure. This test involves them looking at various words and identifying which color the words are shown in.

• Whole-body sweat loss: The participant will be weighed on a platform scale immediately before and at the completion of the heatwave exposure in order to compare whole-body sweat losses.

• Rating of thermal comfort and sensation: The participant will be asked to rate how warm they feel and how uncomfortable the heat makes them on two separate visual analogue scales every fifteen minutes during each experimental session.

• Nausea and lightheadedness scale: The participant will be asked to rate how much (if any) nausea or lightheadedness they are experiencing and tick if they are experiencing any other symptoms (including paleness, muscle cramps, tiredness, weakness and headache) every fifteen minutes during each experimental session.

• Orthostatic hypotension: At the completion of the heatwave exposure the participants blood pressure will be taken. They will then be asked to stand up and their blood pressure will be taken after 1 minute of standing and then again after 3 minutes of standing. This test is carried out to see if there is evidence of postural hypotension (a drop in blood pressure within 3 minutes of standing from a seated position).

Statistical Analysis

The primary research outcomes for this study are rectal temperature (Tre) and rate pressure product (RPP).

Secondary outcomes to be compared are; heart rate (HR), blood pressure (BP), thermal sensation (TS), thermal comfort (TC) and pre to post trial whole-body sweat losses (WBSL). skin temperature (TSk), skin blood flow (SkBF), local sweat rate (LSR), cognitive performance, rating of nausea and light headedness (NL), and evidence of orthostatic hypotension (OH).

All data will be compared between all four interventions and both conditions (very hot and dry, and hot and humid).

To assess the primary and secondary outcome variables, pre to post trial changes as well as the means of the dependent variables will be analyzed using one-way repeated measures ANOVAs with the repeated factor of cooling intervention (four levels: no fan (NF), fan (F), fan and skin-wetting (FSW), and no fan and skin-wetting (NFSW)) will be employed.

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 Holm-Bonferroni correction.

All statistical analyses will be performed with GraphPad Prism (version 6.0, GraphPad Software, La Jolla, CA).

We intend that this research study helps to develop beneficial and informed public health guidelines for this vulnerable population (older adults) in heatwaves.