Laboratory 1: Basic thermal physiology laboratory skills

Aim/s of the session

To introduce you to the fundamentals of data collection techniques in thermal physiology

Learning outcomes

By the end of this session you should:

- Be competent at measuring the following (a range of measurements used in thermal physiology)
    1. Skin temperature (Station 1)
    2. Aural temperature (Station 1)
    3. Mean body temperature (Station 1)
    4. Skin blood flow (Station 2)
    5. Sweat loss (Station 3)
    6. Sweat rate (Station 3)
- Have a greater understanding of the background physiology relating to the measurement

If you do not have time to complete all of the calculations in the session please complete them in your own time

Station 1 – Skin, aural, and mean body temperature

Body temperature comprises of the internal (core) and external (shell) temperatures. There are a number of sites at which core body and skin temperature can be measured and the overall temperature recorded will depend on the site of measurement.

Today we will estimate **core body temperature** using an indirect measurement (aural cavity temperature) and measure **skin temperature** directly. These data can then be used to calculate **mean-weighted skin temperature** (MWST) and **mean body temperature** using the following equations:

Mean-weighted skin temperature = (0.3 x sternal notch skin temperature) + (0.3 x forearm skin temperature) + (0.2 x thigh skin temperature) + (0.2 x calf leg skin temperature) (Ramanathan, 1964)

Mean body temperature 1 = (0.64 x core body temperature) + (0.34 x mean-weighted skin temperature) (Burton, 1935)

Mean body temperature 2 = (0.80 x core body temperature) + (0.20 x mean-weighted skin temperature) (Stolwijk and Hardy, 1966)

Task:

1. Fix four skin thermistors to the relevant sites using dressings and hypoallergenic tape
2. Measure aural and skin (x4 site) temperatures while at rest
3. Use the data to calculate mean-weighted skin temperature, mean body temperature 1 and mean body temperature 2.

	Temperature (°C)
Aural Cavity	
Sternal notch	
Forearm	
Thigh	
Calf	
Mean-weighted skin temperature (Ramanathan, 1964)	
Mean body temperature 1 (Burton, 1935)	
Mean body temperature 2 (Stolwijk and Hardy, 1966)	

Notes *E.g. Definitions for the bold underlined terms; Measurement considerations; Strengths and weaknesses of the measurement; What are you actually measuring? Why do the two body temperature equations differ?*

Ramanathan N.L. (1964). A new weighting system for mean surface temperature of the human body. *Journal of Applied Physiology*. 19, 531-3.
Burton A.C. (1935). Human Calorimetry: The average temperature of the tissues of the body. *Journal of Nutrition*. 9, 261-280.
Stolwijk JA, Hardy JD. (1966). Partitional calorimetric studies of responses of man to thermal transients. Journal of Applied Physiology. 21(3):967-77.

Station 2 – Skin blood flow

When you exercise in a hot environment you may notice that your skin becomes flushed and red in colour, this usually indicates an increase in skin blood flow i.e. an increase in the amount of blood being redirected from the core to the periphery. Once sweating has been initiated, the increase in skin blood flow serves to deliver the heat from the core which can be removed when the sweat is evaporated.

Skin blood flow is regulated by two branches of the sympathetic nervous system:

1. While resting in temperate ambient conditions the cutaneous vasculature is predominantly controlled by the noradrenergic vasoconstrictor system and endothelial nitric oxide synthase
2. When core body temperature is increased (e.g. during exercise) the cholinergic active vasodilator system (regulated by neuronal nitric oxide synthase) takes over and accounts for 80 – 95% of the increased skin blood flow observed during passive heat stress.

Passive and active heating can both elevate cutaneous blood flow. Passive heating does so due to active vasodilation (controlled by neuronal nitric oxide synthase) whereas active heating does so due to endothelial nitric oxide synthase withdrawing vasoconstrictor tone.

Task:
1. Measure resting skin blood flow using the laser Doppler (resting skin temperature)
2. Measure resting skin blood flow using the laser Doppler (resting skin temperature 35°C)
3. Measure resting skin blood flow using the laser Doppler (skin temperature = 40°C)
4. Use the data to calculate the % increase at 35°C and 40°C

Measurement	**Skin temperature (°C)**	**Skin blood flow (AU)**	**% change from resting**
Resting skin temperature			N/A
Resting skin temperature 35°C	35°C		
Skin temperature = 40°C	40°C		

Notes *E.g. Definitions for the bold underlined terms; Measurement considerations; Strengths and weaknesses of the measurement; What are you actually measuring?*

Station 3 – Sweat loss and sweat rate

A number of physiological adjustments occur when we exercise in a hot environment. One of the most obvious is that we increase our sweat production in order to try and lose the extra heat stored. The increased sweat loss helps to regulate core body temperature but it can also compromise **<u>cardiac stability</u>** by reducing **<u>plasma volume</u>** and induce a state of **<u>hypohydration</u>**.

<u>Sweat loss</u> (L or ml): ((Body Mass pre – Body mass post) - urinary loss) + fluid consumed

<u>Sweat rate</u> (L·h^{-1} or ml·hr^{-1}): Sweat loss / exercise duration

Task:

1. Record a nude pre-exercise body mass (in privacy)
2. Cycle in the environmental chamber for 10 minutes (~90 W) – make a note of any fluid consumed
3. Record a nude post-exercise body mass (in privacy)
4. Calculate sweat loss and sweat rate

*Fluid can be consumed **<u>ad libitum</u>** but the volume must be recorded*

Body mass		Fluid out	Fluid in	
Pre	**Post**	**Urinary loss**	**Bottle mass pre**	**Bottle mass post**
___________	___________	↓	___________	___________

Pre - post | **Pre - post**

[___________ - ___________] + ___________

Sweat loss: ___________

Sweat rate : ________/10 = ________

Notes *E.g. Definitions for the bold underlined terms; Measurement considerations; Strengths and weaknesses of the measurement; What alternative approaches exist?*