

Is it hot in here? Thermoregulation and homeostasis through an exercise activity

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HOMEOSTASIS, the control of an internal environment to maintain stable, relatively constant conditions, is a key concept in physiology (1). In endothermic species, including humans (*Homo sapiens*), the control of body temperature is fundamental to the control of a suitable internal environment. To help regulate core body temperature, the body has a number of different responses. For example, under warm conditions by initiating processes such as peripheral vasodilation and sweating, heat is dissipated via the skin's surface to maintain a constant core temperature.

This activity seeks to illustrate the difference between thermal perception (how warm or cold individuals “feel”) and core body temperature by monitoring changes in both during exercise. Using exercise, the activity can change thermal perception quickly, although core temperature will remain relatively stable. While homeostasis remains a core theme in physiology, many aspects of it are difficult to illustrate in a noninvasive activity (e.g., ion concentrations). Temperature can be more easily manipulated to demonstrate the concept, and the presence of the carotid artery, just behind the ear, ensures that core body temperature is easy to measure.

This activity was developed for use in The Physiological Society's stand at the Big Bang Fair, a science festival that attracts >50,000 school children and families over 4 days. Subsequently, it was adapted for use at the Cheltenham Science Festival and public activities at the International Union of Physiological Sciences Congress (in Birmingham, United Kingdom) for a wider public audience.

This activity seeks to provide, in an informal environment, four key learning objectives for participants and observers. At the end of the activity, participants should be able to 1) describe their results and state whether they met their predictions before the activity, 2) compare the variability of skin surface temperature and temperature perception with that of core body temperature, 3) explain why core body temperature must be kept relatively constant, and 4) Explain the physiological mechanisms used by the body to maintain a relatively constant core body temperature.

Materials

This activity can be tailored, depending on the audience, theme, and space and equipment available. The core equipment required is an aural thermometer, which is easily available from pharmacy stores, and a thermal perception scale (Fig. 1) (2). Additional

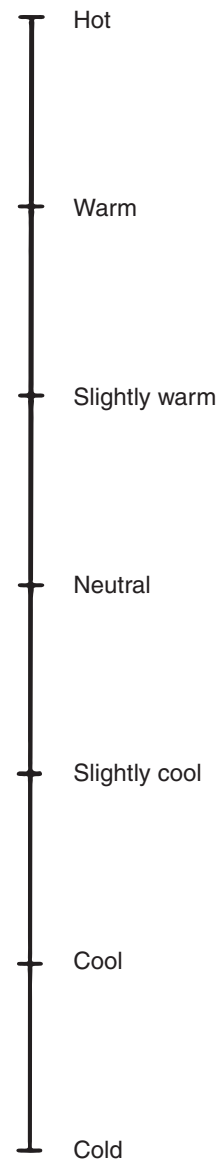


Fig. 1. Thermal perception scale used in the activity for participants to self-report how warm they are feeling.

equipment can be used to facilitate the exercise aspect of the activity. The activity has been run using a cross-trainer and a step, although the activity can be carried out without the use of exercise equipment (see *Activity Procedures*).

Depending on the theme of the activity, there can be additional props used. For example, at the Big Bang Fair, as the

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theme of the stand was extreme environments, outdoor jackets were supplied to participants to wear during the exercise. This served to exaggerate the thermal response to physical activity.

Ethical Considerations

Potential participants were provided with a brief explanation of the activity and were asked about preexisting medical conditions that would exclude their participation in light physical activity. For those under 18 yr old, the adult responsible for them was also consulted.

Mainstream exercise ergometers have minimum height requirements, which are contained within the manufacturer's instructions; thus, the height of participants informed what exercise they were asked to carry out. Children who were too small carried out jumping jacks (star-jumps) or ran on the spot as their physical activity. This worked particularly well if the volunteers running the activity also carried out the exercise alongside young children.

As the activity involves exercise, for some events it may be appropriate for organizers to gain ethics approval through an Institutional Review Board or equivalent. If the activity is being run through a science festival, this may be covered in the application.

Activity Procedures

Visitors who wished to take part in the activity were given a quick briefing (see *Ethical Considerations*). Core body temperature was then measured using the aural thermometer; volunteers could use this opportunity to ask participants about core body temperature (e.g., "do you know the core body temperature of a healthy person?"). Participants were asked to rate themselves on the thermal perception scale with a question, such as "how hot or cold do you feel right now?."

The participant was then asked to start exercising at a self-selected pace. Two minutes was used as the standard length of time for the exercise, although this was tailored to participants' fitness and how busy the event was. A volunteer supervised the exercise at all times. At ~1 min, the participant was asked once again to rate themselves on the thermal perception scale. If their perceived temperature had not increased, the intensity of exercise could be increased. During exercise, volunteers can talk with the participants about the reasons why extended exercise increases peripheral body temperature (such as muscles producing metabolic heat) and how the body regulates temperature during this time (redistribution of blood flow, sweating, and heat dissipation).

After the second minute of exercise, the participant again rated themselves on their thermal perception, and their core body temperature was measured once again using the aural thermometer. Participants were asked to guess how much their core body temperature had changed due to the exercise. Since

participants tended to "feel" hot after exercise, they regularly guessed that their core body temperature would have increased by several degrees Celsius, although it always remained within 0.5°C of the baseline temperature. This phenomenon can be used to initiate a discussion about homeostasis and thermoregulation, including the difference between changes in skin temperature and a relatively constant core temperature.

Summary

This activity is a simple, interactive task that can be used to illustrate homeostasis. In particular, it addresses the common misconception that core body temperature and skin temperature vary to the same extent. The results generated by the activity are often unexpected and hence have more impact on the participants, increasing the likelihood that it will be remembered. The core activity (measuring core body temperature and thermal sensation before and after exercise) is easy to carry out and requires very little equipment. Further items of equipment, such as a cross-trainer or step, can be used if there is budget and space.

This activity gives a simple demonstration of how the body maintains a constant internal temperature, despite changes in skin temperature (as perceived through thermal perception). By discussing changes, such as sweating and vasodilation, the processes of thermoregulation can be discussed and their effect (a constant core temperature) can be demonstrated.

As a relatively simple activity, with participation through exercise from the participant, this is ideal for science festivals and fairs and has the potential to be used as a quick demonstration in the classroom.

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DISCLOSURES

No conflicts of interest, financial or otherwise, are declared by the author(s).

AUTHOR CONTRIBUTIONS

Author contributions: L.G.D., A.B., and E.Z.R. conception and design of research; L.G.D. and A.B. performed experiments; L.G.D. interpreted results of experiments; L.G.D. prepared figures; L.G.D. drafted manuscript; A.B. and E.Z.R. edited and revised manuscript.

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