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Does non-exercise activity thermogenesis contribute to non-shivering thermogenesis?

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Abstract

We wanted to examine if spontaneous physical activity contributes to non-shivering thermogenesis. Ten lean, healthy male subjects wore a physical activity, micro-measurement system while the room temperature was randomly altered at two hourly intervals between thermoneutral (72 °F), cool (62 °F) and warm (82 °F) temperatures. Physical activity measured during the thermoneutral, cooling and warming periods was not significantly different. Cooling increased energy expenditure above basal and thermoneutral values 2061 ± 344 kcal/day ($p < 0.01$). Thus, the increase in energy expenditure associated with short-term environmental cooling in lean, healthy males does not appear to be due to increased spontaneous physical activity or fidgeting.

Keywords: Environmental temperature changes; Non-shivering thermogenesis; Spontaneous physical activity; Non-exercise activity thermogenesis; Resting energy metabolism

1. Introduction

Non-shivering thermogenesis is documented to occur in humans, whereby energy expenditure (EE) increases with body cooling(Paolone and Paolone, 1995; Haman et al., 2002; van Ooijen et al., 2005). However, the mechanism of non-shivering thermogenesis is unknown. Spontaneous physical activity also increases EE (Levine et al., 2000) and is a component of non-exercise activity thermogenesis (NEAT) (Levine et al., 1999). We wanted to examine if spontaneous physical activity contributes to the non-shivering thermogenesis of cooling and if spontaneous physical activity decreases with warming.

We designed experiments to address the hypothesis that short-term environmental cooling increases spontaneous physical activity and NEAT in lean, healthy males. Our second hypothesis was that short-term environmental warming decreases spontaneous physical activity and NEAT in lean, healthy males.

2. Subjects and methods

2.1. Subjects

Ten lean, healthy men (24.7 ± 5.1 years, BMI 22.1 ± 1.8 kg/m^2) were recruited. Subjects were excluded if they were on any medications, smoked, abused alcohol, had any acute or chronic illness or reported unstable body weight (<2 kg fluctuation for the 3 months before the study). Subjects were asked not to consume caffeine-containing products or alcohol for 12 h before the study.

2.2. Measurement of physical activity

These measurements were made using a physical activity micro-measurement system (Figs. 1 and 2). This suit consists of four three-axis accelerometers and 11 dual-axis inclinometers. The accelerometers are positioned on the index fingers and dorsum of the wrist. The inclinometers are positioned on the lateral mid thighs, feet, forehead, upper and lower anterior trunk, and just above the ankles and elbows. This system thereby measures human movement for 23 axes of measurement, and the data are binned

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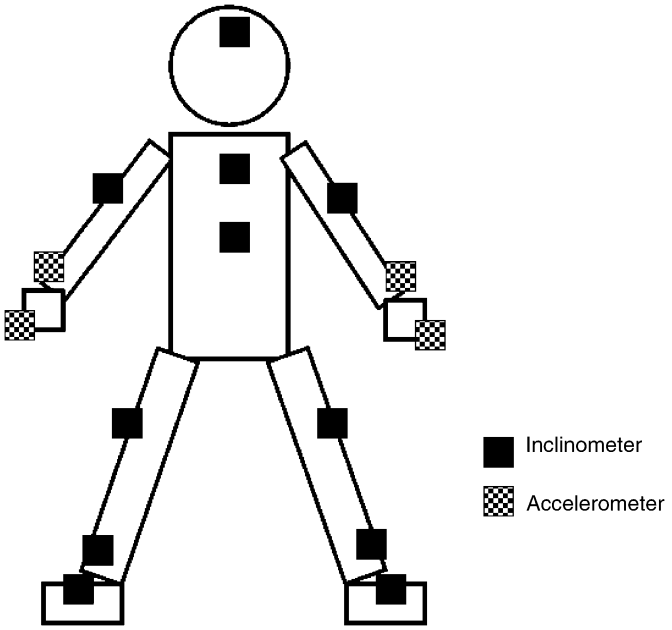

Fig. 1. Diagrammatic representation of the multisensor physical activity micro-measurement system. The blocked boxes represent inclinometers and the checked boxes accelerometers.

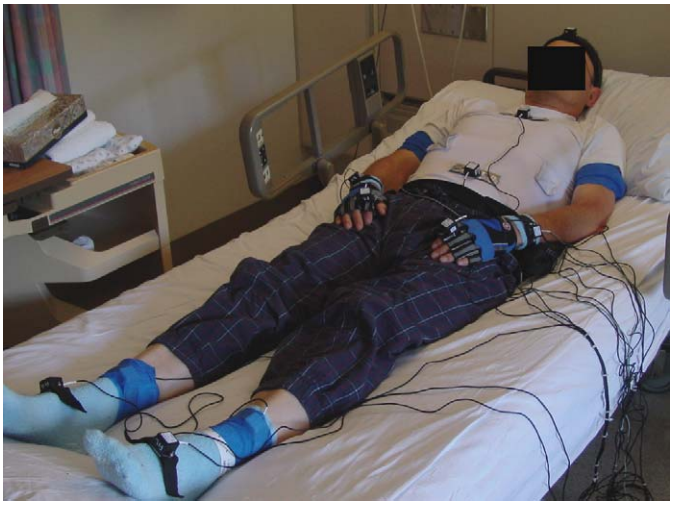

Fig. 2. The multisensor physical activity micro-measurement system on a participant.

four times per second. The data collected from the sensors results in 331,200 data points per hour.

2.3. Measurement of EE

EE was measured repeatedly throughout the protocol as described below. For each measurement the calorimeter (Deltatrac; SensorMedics, Yorba Linda, CA) was calibrated using gases of known composition. Subjects were awake, lightly clothed and in thermal comfort (68–74 °F). Measurements were performed for 25 min during which time subjects were not allowed to talk. For independent calorimeter validation alcohol burns were performed 2-weekly.

2.4. Experimental protocol

Subjects presented to the testing facility at 06:30 (Fig. 3). All subjects were fasting from 21:00 the evening before the study and for the duration of the study. Thermo-equilibrated water was offered to subjects between each study phase. The physical activity micro-measurement system was worn against the subject's skin and cotton clothing was worn on top of the sensors in order to maintain dignity.

First, the subjects rested for 20 min and then BMR was measured for 30 min while the subjects were awake, lightly clothed and in thermal comfort (68–74 °F).

Subjects then proceeded through four 2 h phases:

- thermoneutral (72 °F or 22 °C),
- warm (82 °F or 28 °C),
- thermoneutral again, and
- cool (62 °F or 17 °C) environments.

Subjects were randomized to proceeded through the cooling or warming phase initially (Fig. 3).

The investigator read the same script to the participant at the beginning of each 2 h phase, "during this period of the study, which will last 2 h, you will be asked to watch PG [parental guidance] rated videos. During this time you are not allowed to get off the couch or stand. You can move freely though, as you would normally do whilst watching a video or television at home. We ask that you do not talk with the study coordinator, unless you need some assistance."

We used three adjacent thermoregulated (±0.2 °C) rooms for this study, one at 62 °F, one at 72 °F and one at 82 °F. This permitted subjects to be moved between the rooms in a wheelchair by laboratory personnel so that the

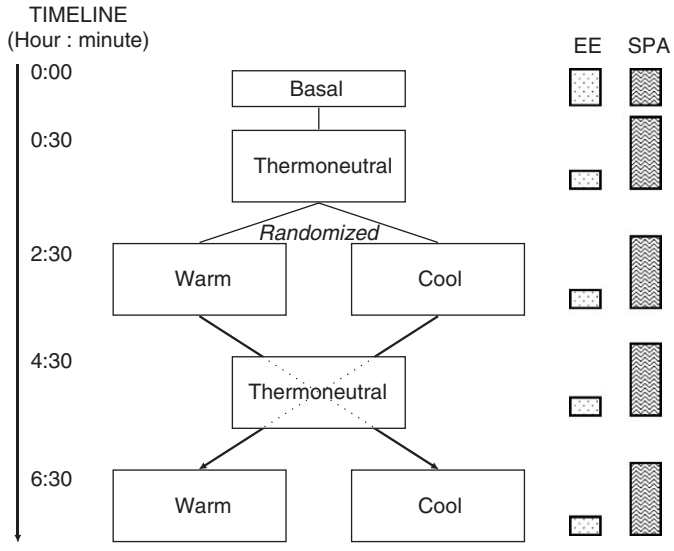

Fig. 3. Schematic representation of the study protocol. The subjects were randomized to undergo the cooling or the warming phase initially. EE—energy expenditure, SPA—spontaneous physical activity.