Diabetes, Obesity and Metabolism 13: 92–93, 2011.

Hot fat in a cool man: infrared thermography and brown adipose tissue

To the Editor:

Brown adipose tissue (BAT) is a key regulator in energy balance and metabolism in animals [1]. It plays an important role in energy homeostasis, protecting animals against high fat diet-induced obesity and diabetes [2]. In adult humans, BAT has been considered unimportant. Located around the neck and the interscapular regions in newborns, it was believed to be lost after the first few years of life. Early studies in adult humans revealed the absence of BAT in the interscapular region, leading to the conclusion that BAT plays little role in metabolism in adults [3].

The emergence of metabolic imaging by Positron Emission Tomography (PET)–CT using ^{18}F- fluorodeoxyglucose, an analogue of glucose, has challenged this view [4]. PET–CT imaging revealed no evidence of BAT in the interscapular region, but identified substantial depots of adipose tissue with avid glucose uptake around the supraclavicular (SCV) areas in adult humans, confirmed to be BAT on histology [5]. The metabolic importance of BAT is supported by the finding that individuals with BAT have a lower body weight and fasting glucose [5,6].

Use of PET–CT as a tool to study BAT biology in humans is limited by cost/radiation exposure. The combined radiation

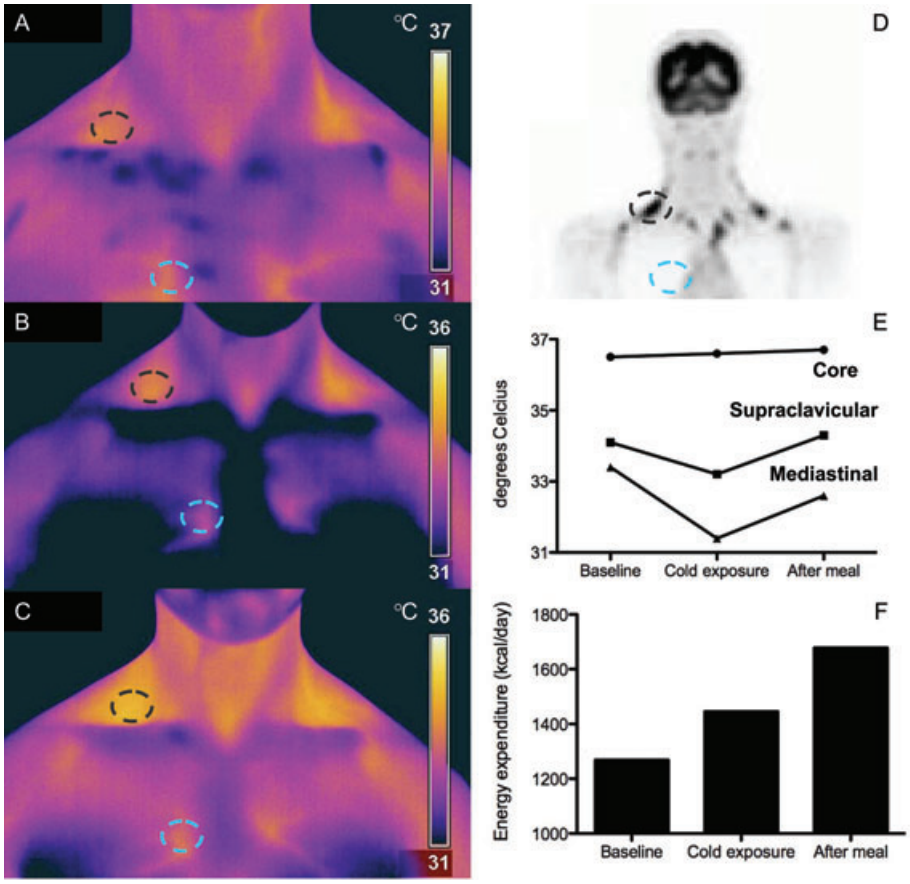

Figure 1. Infrared thermogram of a 32-year-old man before (A) and after 30 min of cold exposure (B), followed by a meal challenge (C), showing consistently higher temperatures in the supraclavicular fossa (grey circle) than the mediastinum (blue circle), as depicted graphically (E). The warmest area corresponded to brown fat on PET (grey circle) while the mediastinum contains no brown fat (blue circle) (D). Corresponding changes in energy expenditure were shown in (F).

from a PET–CT study is more than 20 mSv, which far exceeds the current safety guidelines in medical research. Given the expansion of human BAT research and its potential as a target for obesity and diabetes treatment, a practical alternative to PET–CT for undertaking BAT research in humans is highly desirable.

As BAT is a thermogenic organ, protecting infants from hypothermia and a major contributor to diet-induced thermogenesis [2], we hypothesized that (i) skin overlying BAT is warmer than skin elsewhere and (ii) skin temperature overlying BAT changes in response to cold exposure and meal challenge. Our aim is to investigate whether such skin temperature difference is detectable by thermo-sensing devices.

We tested infrared thermography (IRT) (FLIR Systems SC660, Victoria, Australia) in a 32-year-old man before and after stimulation of BAT activity by cold exposure (17 °C for 30 min) and a meal challenge (250 ml Ensure plus®). IRT was used to measure skin temperatures overlying the SCV fossae, where BAT depot is most commonly located [5], and a control area over the mediastinum which does not harbour BAT. The core temperature was measured at tympanic membrane. Changes in energy expenditure (EE) were measured by indirect calorimetry.

By IRT, the highest skin temperature was localized to the SCV fossae, which corresponds to the most common location of BAT on PET–CT (figure 1). Following cold exposure, SCV skin temperature reduced by 0.9 °C, in contrast to a reduction of 2.0 °C in the mediastinum, resulting in an increase in temperature difference from 0.7 °C to 1.8 °C. After the meal, SCV skin temperature rose to baseline (+0.1 °C), while mediastinal temperature did not (−0.8 °C) (figure 1E), resulting in a stable temperature difference of 1.7 °C. Cold stimulation resulted in an increase in EE by 14%, while that induced by the meal was 32% (figure 1E). The magnitude of EE increase was similar to those observed after cold activation of BAT detected by PET–CT in humans [7]. In both of these situations of enhanced EE, increased skin temperature differences were clearly showed between SCV and mediastinal regions, at 1.7 °C and 1.8 °C, respectively, while core temperature was unchanged.

To investigate the variability in skin temperature differences detected by IRT, we measured SCV and mediastinal skin temperatures in 87 individuals (31 ± 1 years old, 46 females). The mean skin temperature was significantly higher in the SCV compared to the mediastinal region (33.3 ± 0.1 vs. 32.5 ± 0.1 °C, $p < 0.01$).

In this study, IRT detected skin temperature difference between SCV and mediastinal regions, which diverged following classic BAT stimulation. One major limitation is the uncertainty of whether changes in skin temperature overlying the SCV fossae arise from increase in blood flow or from thermogenic response in BAT. However, we would propose the higher skin temperature observed in the SCV fossa arises from a local thermogenic response from activated BAT, which is absent in the mediastinum. Larger studies are warranted to validate the accuracy of IRT by PET–CT.

Our results support the feasibility of IRT as a promising novel non-invasive tool in BAT detection/monitoring in adult humans. As there is likely an expansion of interest in pharmacological interventions to stimulate BAT in future, IRT may be a novel method in monitoring BAT activity in response to treatments.

P. Lee* and K. K. Y. Ho
Pituitary Research Unit, Garvan Institute of Medical Research, Sydney 2010, New South Wales, Australia

P. Lee*, J. R. Greenfield and K. K. Y. Ho
Department of Endocrinology, St Vincent's Hospital, Sydney 2010, New South Wales, Australia

J. R. Greenfield
Diabetes and Obesity Program, Garvan Institute of Medical Research, Sydney 2010, New South Wales, Australia

**Department of Endocrinology, Pituitary Research Unit, Garvan Institute of Medical Research, 384 Victoria Street, Darlinghurst, Sydney 2010, New South Wales, Australia*
E-mail: p.lee@garvan.org.au

Acknowledgement

The authors thank Dr. Ingvars Birznieks for assisting with IRT and analysis.

Conflict of Interest

P. L. designed and conducted the study, collected and analysed the data, and wrote the original manuscript. J. G. and K. H. made substantial contributions in the design, analysis of the data and writing of the original manuscript. P. L. was supported by a postgraduate research scholarship from the National Health Medical Research Council. J. G. and K. H. have no conflicts of interest.

References

1. Farmer SR. Obesity: be cool, lose weight. Nature 2009; **458**: 839–840.
2. Cannon B, Nedergaard J. Brown adipose tissue: function and physiological significance. Physiol Rev 2004; **84**: 277–359.
3. Astrup A, Bulow J, Christensen NJ, Madsen J. Ephedrine-induced thermogenesis in man: no role for interscapular brown adipose tissue. Clin Sci (Lond) 1984; **66**: 179–186.
4. Nedergaard J, Bengtsson T, Cannon B. Unexpected evidence for active brown adipose tissue in adult humans. Am J Physiol Endocrinol Metab 2007; **293**: E444–452.
5. Lee P, Greenfield JR, Ho KK, Fulham MJ. A critical appraisal of prevalence and metabolic significance of brown adipose tissue in adult humans. Am J Physiol Endocrinol Metab 2010; **299**: E601–E606.
6. Lee P, Ho KK, Fulham MJ. The importance of brown adipose tissue. N Engl J Med 2009; **361**: 418. (Author reply 419–420)
7. van Marken Lichtenbelt WD, Vanhommerig JW, Smulders NM et al. Cold-activated brown adipose tissue in healthy men. N Engl J Med 2009; **360**: 1500–1508.