BODY FAT AFFECTS CALORIMETRICALLY MEASURED BODY HEAT STORAGE ONLY DURING COLD STRESS

Jan W. Snellen[1], Michel B. Ducharme[2] and John Frim[2]
[1] Faculty of Medicine, Memorial University, St.John, Nfld, CANADA, A1B 3V6
[2]Human Protective Systems Division, Defence & Civil Institute of Environmental Medicine
North York, Ontario, CANADA, M3M 3B9

INTRODUCTION

The thermal insulation of the body has multiple "in-series" components including the skin, the subcutaneous fat and the underlying tissues. It is well accepted that both the subcutaneous fat (1) and the constricted non-fatty tissues (2) provide significant thermal protection against body cooling during cold exposures. Gygax et al. (3) reported, however, that no relationship could be found between the change in body heat storage and the subcutaneous fat thickness of the subjects during exposure near thermal neutrality in air. The objective of the present study was to investigate for a large range of air temperatures (from 12 to 35°C) the contribution of body fat to the changes in body heat storage measured by direct calorimetry.

MATERIALS AND METHODS

Six male subjects between 20 and 33 years of age (mean ± SE: 23.8 ± 2.1 years) were exposed one week apart to six calorimeter air temperatures (Tcalor = 12, 16, 20, 24, 29, and 35°C) for three hours while wearing only shorts. Before the exposures the subjects were seated for an hour at 22°C and wrapped in a blanket to maintain their thermal comfort. Every minute after entry into the calorimeter the sum of the metabolic heat production ($\dot{M}$), sensible heat exchange (R + C, radiative and convective), and evaporative heat loss (E) was determined and converted to heat loss or gain in kilojoules (kJ). These values were summated minute by minute and divided by body mass times specific heat to obtain the change in mean body temperature ($\Delta\bar{T}$bcal) for the whole exposure period. The conventional value for specific heat ($3.47\ kJ \cdot kg^{-1} \cdot °C^{-1}$) is only valid for a person with 13-14% body fat (BF) (4). Since the subjects in the present study ranged in %BF from 11.3 to 27.6, their individual specific heat was calculated as follows: a) body density was calculated with the equation given by Durnin and Womersley (5); b) %BF was obtained by inserting body density in the equation given by Siri (6); c) specific heat was obtained using the equation given by Minard (7). The technical details of the whole-body human calorimeter have been published elsewhere (8). That description is still valid but the measurement of $\dot{M}$ has been changed into a continuous recording system.

RESULTS

Every subject showed a significant linear relationship ($0.96 \leq r \leq 0.99$) between calorimeter temperature and $\Delta\bar{T}$bcal corrected for the DuBois surface area (A_D) at the end of the three hour exposure. From this relationship, it was observed that at the lowest temperatures the leanest subject had the largest drop in $\Delta\bar{T}$bcal and the most obese subject the smallest. At higher temperatures, however, similar observation was not found. Figure 1 shows the relationship between $\Delta\bar{T}$bcal and %BF for every Tcalor tested.

CONCLUSIONS

At colder Tcalor of 12 and 16 there is a significant ($p < 0.05$) protection against body cooling proportional to %BF. At 20°C the effect is still present but at the 7% level. At higher temperatures, 24, 29 and 35°C, %BF does not play a significant role in the changes of body heat storage. This can possibly be explained by the relatively large contribution of the non-fatty tissue to the body insulation during exposures at Tcalor > 20°C for