THE EFFECT OF BODY COMPOSITION ON REWARMING FROM IMMERSION HYPOTHERMIA

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INTRODUCTION

Several studies have addressed the effects of subcutaneous fat and body composition on body cooling during cold exposure (1, 2), however none have quantified the effects of body composition on core temperature changes during the rewarming period. Instead mean results, calculated from a heterogeneous subject pool, are often applied to all individuals in the general population. There are several reasons to believe that body composition affects, not only the cooling, but the rewarming process as well.

We have previously shown that, compared to shivering and external heat, exercise causes a dramatic increase in the rewarming rate but also a core temperature afterdrop three times in magnitude (3). We attributed these results to differences in endogenous heat production and the convective effects of blood flow through cold previously hypoperfused peripheral tissue. Secondary analysis indicated that differences between treatments were attenuated in thinner subjects and exaggerated in those with greater subcutaneous fat (4). These findings, if confirmed, could be due to greater relative convective effects in groups with increased subcutaneous fat.

In a second related study *(5)* we found that upon immersion in 40°C water, following ~60 min of exercise or shivering treatment for immersion hypothermia, the initial rate of rewarming was significantly reduced (with a second afterdrop occurring in 40% of the trials); the effect being greater following shivering than exercise. These results were also attributed to convective effects of peripheral blood flow.

This study was designed to evaluate differences in treatment responses between groups possessing different body composition characteristics. Specifically we felt that differences in initial afterdrop and rewarming parameters, as well as the attenuation of the initial rewarming rate subsequent to warm water immersion, would be greater in subjects with increased subcutaneous fat. If confirmed, these findings would have important implications for treatment of accidental hypothermia.

METHODS

Twelve subjects (mean±SD; age 27.2±6 yrs) were assigned to low and high fat groups (sum of 4 skinfolds 33.3±2 and 74.8±12 mm; mass 74.8±3.7 and 82.5±7.7 kg; height 179.2±5.2 and 173.7±5.1 cm respectively). Esophageal temperature (T_{ES}) was used as an indicator of core temperature. On each of 3 occasions subjects were immersed to the neck in stirred cold water (8°C) to a T_{ES} as low as 33°C (low fat group) or 35°C *(high* fat group). After exiting the cold bath each subject was initially rewarmed by: 1-shivering in a supine position inside a sleeping bag (SH); 2-application of an external heating pad (HEATPAC) while in the sleeping bag (HP); and 3-treadmill exercise increasing from 1.1-5.6 km/hr (EX). After ~55 min, subjects then entered warm (40°C) water where they remained until T_{ES} rose to pre-immersion values.

Calculations: initial and secondary (if applicatble) afterdrop amount and length; the rate of T_{ES} increase during the initial treatment (R1); rate of T_{ES} change over the early warm water immersion period (R2); and the rate of rewarming during the remainder of the warm bath immersion (R3).

RESULTS

Combined rewarming data were in agreement with our previous study (3) (Fig 1). The initial afterdrop was greater during EX than both SH and HP in the high fat group ($P<0.01$) but only greater than HP in the low fat group ($P<0.01$). Similar relationships existed for afterdrop length. The EX rewarming rate was greater than both SH and *HP* in the high fat group ($P<0.01$) while no difference was seen in the low fat group (Fig 1&2). In all cases the initial rate of rewarming was significantly attenuated upon warm water immersion ($P<0.01$)(Fig. 2). In both groups a second afterdrop occurred following SH and HP but not EX.

FIG. 1

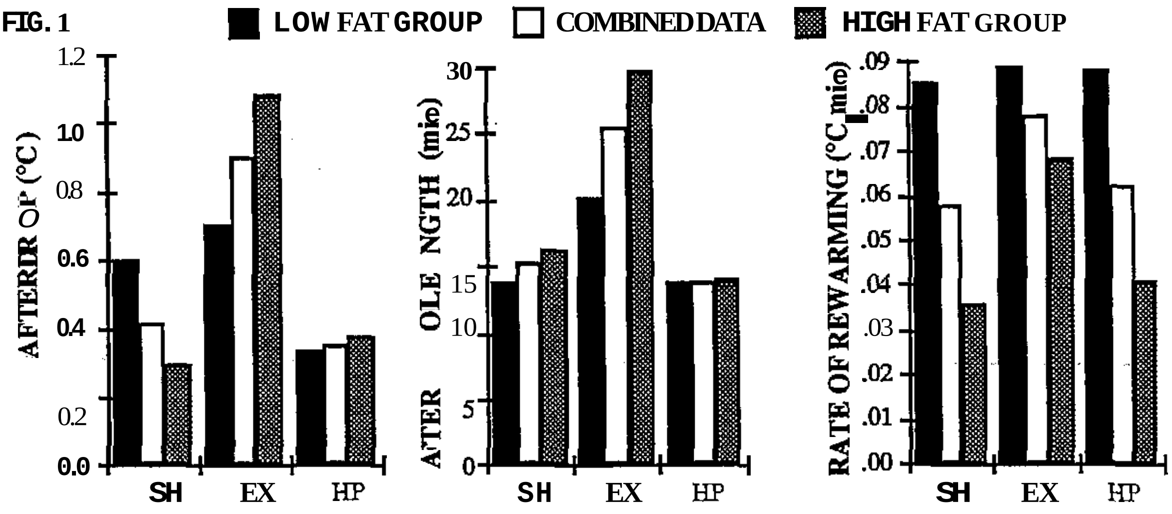
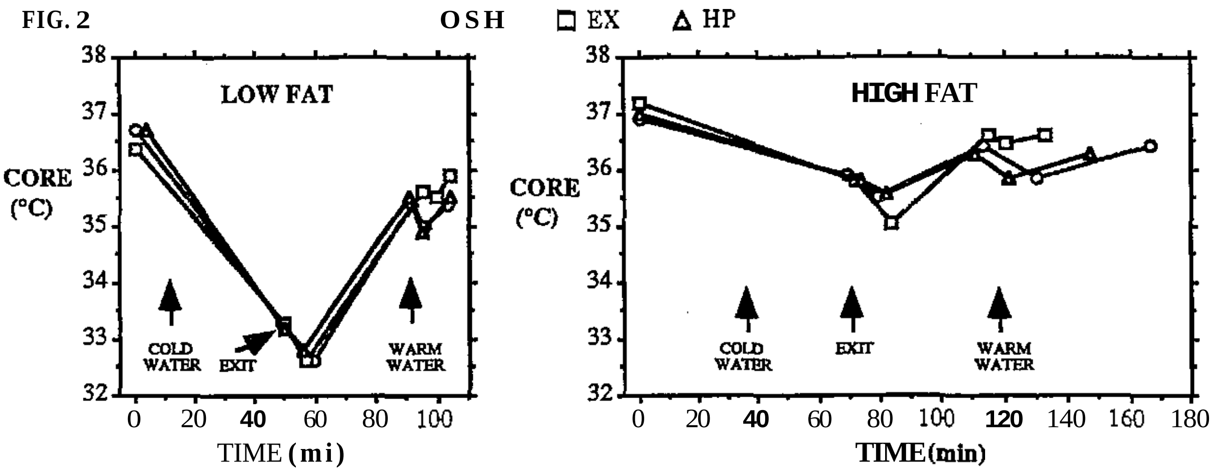


FIG. 2



CONCLUSIONS

The greater initial afterdmp of exercise is likely due to increased blood flow to a large mass of cold tissue in the exercising limb. Likewise, the second afterdrop following shivering and heating pad is probably due to the warm-induced increase in blood flow to previously hypoperfused cold peripheral tissue. Since leg muscles were already perfused during exercise, subsequent increase in blood flow following warm water immersion would be relatively less than following the other two treatments. Therefore no second afterdrop was seen following exercise, although the initial rate of rewarming was subsequently reduced ($P<0.03$) to zero. Since most of these effects are likely explained by perfusion of cold peripheral tissue, it is not surprising that the effects were exaggerated in subjects with greater subcutaneous fat. These results may have significant implications for treatment selection based on body composition, even long after removal from a cold stress.

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