INHALATION OF WARM MOIST AIR INHIBITS SHIVERING THERMOGENESIS

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INTRODUCTION

The benefits of inspiring warm humidified oxygen in rewarming hypothermic patients was initially proposed by Lloyd *et al.* (1, 2). The enhancement of core temperature rewarming rate is attributed primarily to the reduction of respiratory heat loss, rather than to the donation of heat. The numerous studies evaluating this method of rewarming, have not agreed on the efficacy of the method in terms of core temperature rewarming rate (cf. 3, 4). In an earlier study (4), we postulated that, whereas inhalation rewarming may benefit non-shivering subjects, it may be of limited benefit in enhancing the rate of rewarming of shivering hypothermic subjects. Our reasoning was that, in mildly hypothermic subjects, inhalation rewarming may inhibit shivering by heating the nasopharyngeal region and most likely the hypothalamic region. Thus, should the inhibition of endogenous heat production exceed the amount of heat donated exogenously by the inhalation rewarming device, then no benefit may be incurred in terms of rewarming rate in shivering subjects.

The present study tests the hypothesis that inhalation rewarming inhibits shivering.

METHODS

Five healthy male subjects participated in the study. They completed two head-out immersions, separated by at least one week. The subjects were immersed in water at 10°C, either inspiring room air, or warm (43°C) humidfied air (RH=100%). Immersions were terminated once core temperature attained 35°C, or decreased by 2°C from pre-immersion values. Subjects were aware that they could request termination of the experiement at any time.

Core temperature was monitored with a YSI (Yellow Springs Instruments) rectal thermistor (Tre) inserted 12 cm. Inspiratory minute volume was measured with a Dry Gas Ventilation Meter (Parkinson Cowan), and the O_2 and CO_2 content of mixed expired gas with an Applied Electrochemistry Oxygen Analyzer and a Statham Godart Capnograph, respectively.

The Tre and VO_2 responses during normal air breathing were compared to the responses observed with the inhalation of warm humidified air with an ANOVA.

RESULTS

Fig. 1 shows the response of one subject during immersion in water when inspiring either room air or warm humdified air. Inhalation of warm saturated air enhanced the rate of Tre cooling, and attenuated the oxygen uptake, assumed to reflect shivering thermogenesis.

The magnitude of the suppression of shivering varied between subjects, as did the effect of the warm humidified inhalate on the rate of Tre cooling. Nevertheless, a two-way analysis of variance revealed that warm humidified air significantly ($p<0.05$) reduced Tre compared to the condition where subjects inspired room air, and also significantly ($p<0.05$) attenuated the VO_2 response.

CONCLUSIONS

Inhalation of warm moist air significantly attenuated the shivering response, as reflected in the oxygen uptake, despite inducing a greater Tre cooling rate, and therefore presumably a greater core drive for shivering thermogenesis.

These results have some relevance to the discussion regarding the efficacy of inhalation rewarming therapy. Ideally, the shivering response of mildly hypothermic subjects should be examined during the rewarming period, with the subjects inspiring either room air or warm humidified air. However, due to the increasing skin temperature and core temperatures, VO_2 decreases quite early and rapidly in the rewarming period *(5)*. It was therefore considered less appropriate to assess the effect of inspiring warm moist air on VO_2 during the rewarming period. In the present study, skin temperature was clamped at a level slightly above water temperature, and together with the declining Tre, provided a stimulus for a progressive shivering response.

A consensus regarding the efficacy of inhalation rewarming therapy appears, as yet, not to have been reached. Judging from the present results, our postulation from an earlier study (4), that it may be inappropriate to extrapolate the results derived with mildly hypothermic shivering subjects to severely hypothermic subjects, which are no longer shivering, would appear valid. Namely, in the case of shivering subjects, the endogeneous heat is adequate to reinstate their body heat content, assuming they are adequately insulated. A rewarming therapy such as inhalation of warm moist air, in fact, provides local heating to the hypothalamic region, resulting in a suppression of shivering. Should the amount of heat production suppressed equal or exceed the amount donated, then the therapy would not offer any benefit in terms of core temperature rewarming rate.

It is important to emphasize that it is unwarranted to disqualify inhalation rewarming as a means of rewarming hypothermic individuals. Certainly it may be of limited value in shivering individuals, but its benefit in donating heat to severely or moderately hypothermic non-shivering patients should not be disputed.

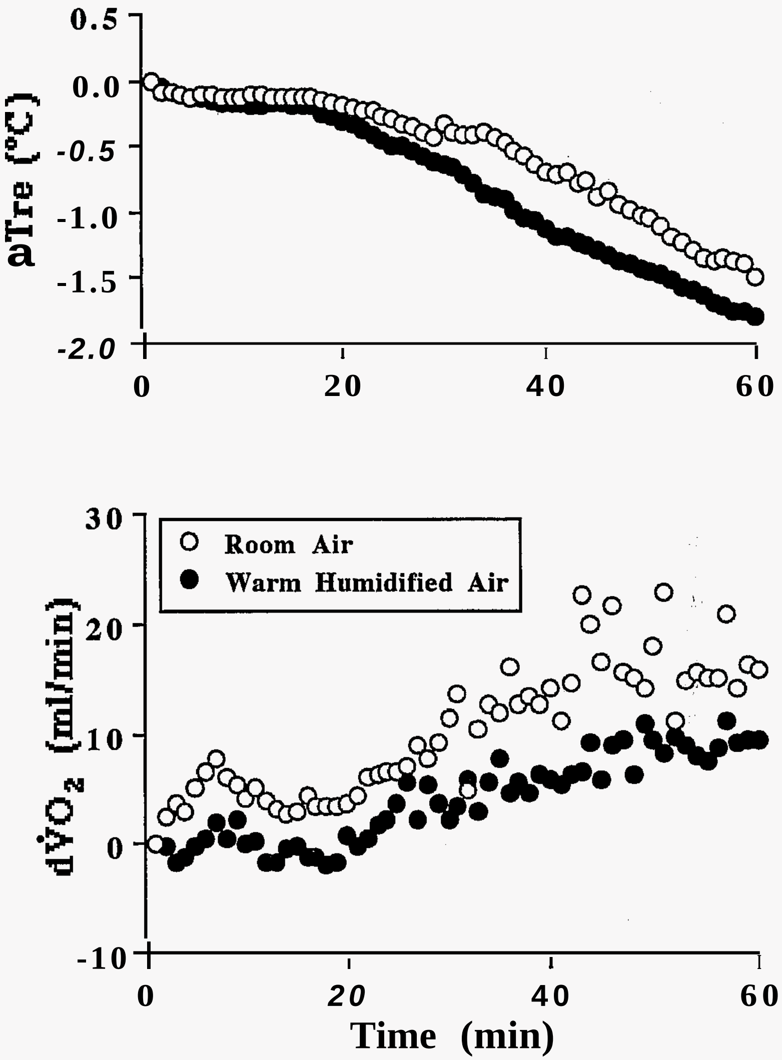

Fig. 1: The Tre (upper graph) and VO_2 (lower graph) response of one subject to immersion in 10°C water while inspiring either room air (open circles) or warm humidified air (closed circles) relative to pre-immersion values (dTre and dVO_2).

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