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EFFECT OF TRIIODOTHYRONINE, THYROTROPIN-RELEASING-HORMONE AND PROPYLTHIOURACIL ON THE THERMOGENIC CAPACITIES OF DJUNGARIAN HAMSTERS LIVING IN NATURAL PHOTOPERIOD

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Abstract—Treatment with triiodothyronine (T_3) or thyrotropin-releasing-hormone (TRH) did not affect cold resistance of capacity for nonshivering thermogenesis (NST) in seasonally acclimatized Djungarian hamsters. Suppression of thyroid function with Propylthiouracil (PTU) lessened cold resistance but did not affect NST as measured by injection of noradrenalin. Basal metabolic rate (BMR) was increased by T_3 in summer-acclimatized hamsters, whereas PTU or TRH did not affect BMR in summer or winter.

Key Word Index—Thyroid function; BMR; NST; cold resistance; hormones; seasonal acclimation; *Phodopus*.

INTRODUCTION

To survive in the cold small mammals are dependent on nonshivering thermogenesis (NST). The development of NST can be stimulated by various environmental cues such as temperature (Jansky *et al.*, 1967) and photoperiod (Heldmaier *et al.*, 1981). Many studies focus on the role of the thyroid gland in development of NST during cold acclimatisation. In laboratory rats the plasma titers of thyroid hormones and the thyroid gland secretion increase during the initial period of cold exposure (Krulich *et al.*, 1976; Heroux, 1963; Hudson, 1980). LeBlanc and Villemaire (1970) found higher NST-capacity and improved cold resistance in thyroxine-treated rats. These results suggest an important role of thyroid hormones in thermogenic acclimation. However, wild Norway rats living outside in winter acclimate to the lowered temperature without any sign of an increased thyroid activity (Heroux, 1963) and in voles and muskrats the thyroid seems to be less active in winter as compared to summer (Aleksiuk and Frohlinger, 1970; Rigaudiere, 1969). These different patterns found in wild mammals indicate that the endocrine mechanisms of seasonal cold adaptation may be different from those observed during acclimation to chronic cold in the laboratory (Heroux, 1970; for review see also Wunder, 1979). In Djungarian hamsters the seasonal control of thermogenesis by seasonal changes in photoperiod and/or ambient temperature has been described recently (Heldmaier *et al.*, 1981). However, the endocrine mechanisms involved in control of thermogenesis during acclimation are still unknown. We therefore investigated the potential role of triiodothyronine (T_3), thyrotropin-releasing-hormone (TRH) and Propylthiouracil (PTU) in seasonal thermogenic adaptation in the Djungarian hamster.

MATERIALS AND METHODS

Adult Djungarian hamsters *Phodopus sungorus sungorus*, were kept singly in plastic cages with wood shavings as nesting material. Ambient temperature was 23 ± 1.5°C and the light regime was similar to natural photoperiodic conditions (for details see Heldmaier and Steinlechner, 1981). The hamsters received commercial hamster breeding chow (ALTROMIN GmbH; iodine content 1.1 mg/kg) and water *ad libitum*. Groups of 6–8 hamsters were injected sc. daily with 0.4 mg/kg TRH (BACHEM) or every second day with 1 μg/kg T_3 (SIGMA) for two weeks. Both hormones were dissolved in 0.9% saline. To suppress thyroid function, hamsters were fed with pellets containing 0.15% PTU (SIGMA) in summer and 0.2% in winter.

To separate the direct effects of TRH from those mediated via the thyroid, a group of hamsters was fed with PTU and treated with TRH as described above. Experiments were performed in August on summer-acclimatized hamsters and in early December on winter-acclimatized hamsters.

Metabolic measurements were performed in an open system as described by Heldmaier and Steinlechner (1981). Basal metabolic rate (BMR), maximum cold-induced metabolic rate (HPmax), cold limit and noradrenaline-induced oxygen consumption (NA-response) were measured using the procedure described elsewhere (Heldmaier *et al.*, 1982). Noradrenalin was used at a dosage of 0.8 mg/kg, which stimulates maximum NST in Djungarian hamsters. As shown by Böckler *et al.* (1982), this NA-stimulated NST occurs also during cold exposure. If HPmax and cold limit could not be determined experimentally, it could be estimated by using the

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Table 1. Body weights (g) of the hamsters used in our experiments. Means ±SEM are given for 6–8 hamsters

	Control	TRH	PTU + TRH	PTH	T_3
Summer	37.9 ± 1.92	36.0 ± 1.46	33.5 ± 1.47	34.6 ± 1.53	34.6 ± 1.43
Winter	28.5 ± 1.62	26.7 ± 1.22	26.8 ± 1.8	27.9 ± 1.37	27.8 ± 2.22

relationship between HPmax and NA-response given by Steinlechner and Heldmaier (1980).

For statistical evaluation all means were compared by analysis of variance. Means ±SEM are given.

RESULTS

Body weights of hamsters used in our experiments (Table 1) were lower in winter as compared to summer ($P < 0.001$), which is in accordance with the seasonal body weight changes in this species. No treatment at any season caused changes in body weight.

BMR in summer-acclimatized hamsters was increased by T_3 from 1.4 ± 0.09 to 2.0 ± 0.10 ml $O_2/g \cdot h$ ($P < 0.001$). In winter acclimatized hamsters BMR was found to be higher as compared to summer (1.43 ± 0.09 vs 1.73 ± 0.09 ml $O_2/g \cdot h$; $P < 0.002$) and T_3-treated hamsters had the same BMR as controls. PTU or TRH did not affect BMR at any season (Figs 1 and 2).

NST-capacity (NA-response minus BMR) was also higher in winter-acclimatized hamsters (5.2 ± 0.4 ml $O_2/g \cdot h$ vs 8.6 ± 0.6 ml $O_2/g \cdot h$, $P < 0.001$) but was not affected by any treatment. HPmax showed a similar increase during seasonal acclimation ($P < 0.001$). However, it was significantly reduced in both groups of PTU-fed hamsters (PTU vs controls $P < 0.01$; TRH + PTU vs TRH $P < 0.005$). This effect was more pronounced in winter-acclimatized hamsters when HPmax was reduced from 15 ml $O_2/g \cdot h$ in controls down to levels of about 10.5 ml $O_2 g \cdot h$ in PTU-fed hamsters.

The changes in cold limit parallel those described for HPmax. Seasonal acclimation improved the cold limit of controls from −33.2 ± 1.0°C in summer to −49.3 ± 1.3°C in winter ($P < 0.001$). PTU-feeding lessened the cold resistance of winter-acclimatized hamsters to levels of about −31 ± 2.8°C ($P < 0.001$). Like HPmax, cold limit was not affected by TRH alone or by T_3.

DISCUSSION

Earlier studies have shown that treatment with thyroid hormones improves both cold resistance and the calorigenic response to noradrenalin in rats (LeBlanc and Villemaire, 1970) and in golden spiny mice (Borut *et al.*, 1979). During the first period of cold acclimation, rats show an increase in thyroid activity (Krulich *et al.*, 1976); the same is true for guinea pigs and sheep (Bento and Gonzalo-Sanz, 1980; Freinkel and Lewis, 1956). In contrast, inhibition of thyroid function leads to a reduction in both cold tolerance and NST-capacity (LeBlanc, 1975; Fregly *et al.*, 1979). In contrast to these results, we could not detect any influence of T_3, TRH or PTU on NST in Djungarian hamsters. During fall even PTU-fed hamsters develop a NST-capacity similar to hamsters with a normal thyroid function (Seidel and Heldmaier, 1982). This suggests, that even the seasonal increase of NST during fall may not require an enhanced thyroid secretion. This mechanism may not be unique to the Djungarian hamster, since wild Norway rats living outdoors in winter acclimate to

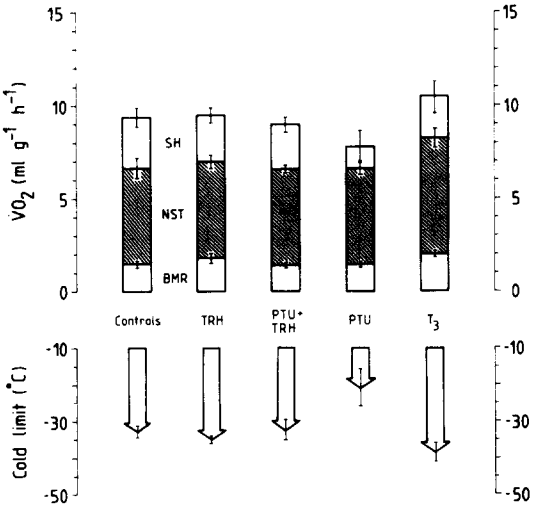

Fig. 1. Thermogenic capacities of summer-acclimatized Djungarian hamsters. Means ±SEM are given. BMR: basal metabolic rate. NST: nonshivering thermogenesis. SH: shivering thermogenesis. Hamsters were injected every second day with T_3 or daily with TRH for 2 weeks and PTU was fed for at least 4 weeks before metabolic measurements were performed.

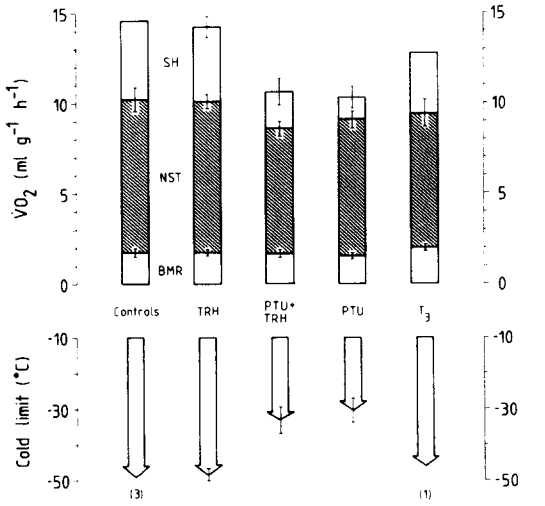

Fig. 2. Thermogenic capacities of winter-acclimatized Djungarian hamsters. Number of hamsters in which HPmax and cold limit was estimated are given in parenthesis. For further explanation see Fig. 1 and text.

cold without any sign of an increased thyroid activity (Heroux, 1963). Whereas NST remained unaffected by PTU, cold tolerance was considerably impaired in hypothyroid hamsters. A similar reduction has been reported for laboratory rats (Fregly *et al.*, 1979). However, we have shown previously, that in contrast to other laboratory mammals in *Phodopus* the activity of NST by endogenous noradrenaline is reduced by PTU instead of thermogenic capacity itself (Seidel and Heldmaier, 1982).

The increase of BMR by T_3 was not observed in winter-acclimatized hamsters and in summer T_3 elevated BMR to levels found in untreated hamsters in winter. This coincidence may suggest that seasonal changes of thyroid function could be responsible for the seasonal changes of BMR in Djungarian hamsters. Such a hypothesis is supported by findings of Hudson and Deavers (1976) and Lynch *et al.* (1978), who found different effects of thyroidectomy on BMR in ground squirrels and white-footed mice depending on season or photoperiod. However, the failure of PTU-treatment to reduce BMR in *Phodopus* in summer or winter argues against this concept. Contrary results have also been reported by Hudson (1980) in chipmunks. This shows that the role of thyroid function in the regulation of seasonal changes of BMR is not clear yet, but it appears unlikely that thyroid hormones are a major endocrine pathway for seasonal thermogenic acclimation.

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