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[COMMUNICATION]

Flight Behaviour and Thyroid Hormone Regulation in Homing Pigeons

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ABSTRACT—Homing pigeons which were not given flight training for 3 months prior to the experiment, were flown the same distance of 48 km from the usual release site as reported in our earlier studies using pigeons which were in regular training. In these pigeons the flight lasted 90–160 min instead of the usual 60–80 min taken by pigeons which had regular training. This flight produced a more than two-fold increase in plasma levels of reverse triiodothyronine (rT_3), concomitant with reductions in thyroxine (T_4) and triiodothyronine (T_3) levels and also in T_3/T_4 ratio. The increase in plasma levels of rT_3 and the concomitant decrease in levels of T_4 and T_3 with no change in plasma osmolality, suggest inhibition of T_4 secretion and 5′-monodeiodination, and conversion of T_4 to rT_3. The conversion of T_4 to rT_3, the inactive form of T_3, represents a mechanism of autoregulation of thyroid hormone function during strenuous and extended flight.

INTRODUCTION

Our recent studies with homing pigeons before and after natural homing flight, have shown significant post-flight (a distance of 48 km from the usual release site covered in 60–80 min) increases in plasma levels of glucose, free fatty acids (FFA), lactate, adrenaline, noradrenaline and growth hormone (GH), but not in the levels of corticosterone and the thyroid hormones, thyroxine (T_4) and triiodothyronine (T_3) [1, 2]. The increase in plasma adrenaline and noradrenaline was indicative of increased sympathetic activity and it was suggested that the flight-induced increase in plasma adrenaline could have stimulated the release of glucagon which in turn would have brought about the increase in plasma glucose. The increase in plasma FFA was attributed to the increase in at least one adipokinetic hormone, GH, and the lack of any increase in plasma corticosterone to the stress-free nature of the flight.

In a subsequent study [3], the homing pigeons used, unlike those in the previous studies, did not receive the regular flight-training for a period of 3 months prior to the experiment, and so they took 90–160 min to fly the same distance. Significant increases in the levels of plasma glucagon (glucagonlike immunoreactivity) and presumably of glucagon-stimulated FFA, were observed. In marked contrast to the observations in the previous study [2], plasma levels of T_4, T_3 and T_3/T_4 ratio were significantly reduced. It occurred to us that this was due to the possible inhibition of T_4 secretion and 5′monodeiodination with the conversion of T_4 to reverse T_3 (3, 3′, 5′-triiodothyronine or rT_3), the inactive form of T_3, as a mechanism for the regulation of thyroid hormone metabolism during a more strenuous and extended flight. In the present study, we have ventured to test this postulation by measuring levels of rT_3 in plasma samples obtained from the same birds used in the previous experiment [3].

MATERIALS AND METHODS

Pigeons (*Columba livia*) used in our studies were from a colony of homing pigeons which were raised and maintained out-doors in lofts under natural photoperiod and temperature. They were

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fed a daily ration of corn, wheat and barley. All studies [1–3] were conducted in the forenoon of a typical sunny mid-autumn day (6°C). The release site and distance flown (48 km) were the same in all studies. The control birds were given the usual 40 min car ride in order to simulate the 40 min car ride received by the experimental birds while being taken to the release site. Pigeons of both sexes weighing 350–400 g were used and blood samples (5 ml) were drawn from the brachial vein of each bird into heparizined syringes within 1–3 min of their arrival after the car ride (control birds) or flight (experimental birds). Blood samples were kept on ice and transported to the laboratory within 15 min and centrifuged (3000 $\times g$ for 10 min at 4°C). The separated plasma was stored at −20°C in separate vials in duplicate. The present investigation is an extension of our previous study [3] and parts of plasma sampels obtained then are now used for the estimation of plasma rT_3. In contrast to the previous studies [1, 2], these pigeons [3] had not received the regular flight training for a 3-month period between end of the racing season and time of the experiment.

The levels of rT_3 were measured in freshly thawed frozen plasma samples using a radioimmunoassay kit (code 10834) manufactured by BIODATA S.p.A., Italy. Osmolality was measured using a vapor pressure osmometer (Wescor, Utah).

Analysis of variance (ANOVA) was initially employed to test for sex differences and flight effect. Since sex did not prove to be a significant variable from the ANOVA results obtained, values from both sexes were subsequently pooled and subjected to unpaired Student's *t*-test.

RESULTS

These pigeons, unlike the pigeons which received flight training prior to the experiment, took 90–160 min to fly "home" instead of the 60–80 min taken by the trained pigeons. Flight induced significant increases in plasma levels of rT_3 as opposed to decreases in T_4, T_3 levels, and T_3/T_4 ratio. The post-flight plasma rT_3 amounted to more than a two-fold increase over control values. Flight caused no significant change in plasma osmolality (Table 1).

DISCUSSION

The marked increase in plamsa levels of rT_3 with no significant change in plasma osmolality, observed in the present study is indicative of increased conversion of T_4 to rT_3. Similar increase in plasma rT_3 as a possible regulatory mechanism to limit T_3 activity by inhibiting T_4 conversion to T_3 has been observed in humans under increased physical exercise [4]. In flown homing pigeons the increase in rT_3 and the concomitant reduction of plasma levels of T_4, T_3 and T_3/T_4 ratio (Table 1) indicate inhibition of peripheral deiodination of T_4 in order to limit the continued production of T_3. The peripheral conversion of T_4 to T_3 has been shown to be stimulated by GH in chickens [5]. In

Table 1. Plasma osmolality and levels of thyroid hormones in resting and flown homing pigeons

	Control pigeons	Flown pigeons
Osmolality (mmol/kg)	303.5± 1.1 (10)	306.1± 3.8 (7)
Reverse triiodothyronine (rT_3) (pg/ml)	211.9±16.9 (10)	493.0±90.8 (7)**
Triiodothyronine (T_3)[1] (ng/ml)	2.29±0.14 (10)	0.89±0.14 (8)*
Thyroxine (T_4)[1] (ng/ml)	19.07±1.54 (10)	12.54±2.36 (8)*
T_3/T_4 ratio[1]	0.12±0.10 (10)	0.08±0.01 (8)**

Values are mean±SEM. Figures in parentheses denote number of birds.
* $P<0.05$; ** $P<0.01$
[1] Data from previous study (George *et al.*, 1989)

an earlier study using trained homing pigeons, post-flight circulating levels of GH were found to be significantly increased [2]. In more strenuous and extended flight such as was involved in the present investigation, an initial stimulation of T_4 release followed by an increase in rT_3 levels should be expected. If so, the production of rT_3 could not be concomitant but should follow the release of T_4 so that excess T_4 could be eliminated by convertion to rT_3. That this is so, has been indicated in experiments with tilapia [6] in which it was observed that rT_3 levels were the same as the low levels present in the control one hour after injection of T_4 despite the high concentrations of T_4 in the plasma. Since plasma T_4 and rT_3 increased following injection of T_4, it was suggested that conversion of T_4 into rT_3 is independent of pituitary control. In light of these observations, it may be stated that the post-flight increase in plasma levels of GH observed in homing pigeons [2] could stimulate T_4 release in addition to releasing FFA from the fat depots. It is also possible that the inhibition of peripheral deiodination of T_4 to T_3 could have been brought about by the increased plasma levels of glucagon since it has been shown in the domestic fowl that glucagon inhibits 5′monodeiodination and may also cause initial reduction of T_4 secretion [7].

Rudas and Pethes [8] observed that rT_3 appears in the serum of chickens after warm exposure and suggested that cold exposure stimulates T_3 formation whereas heat exposure inactivates the T_4 secreted to produce rT_3. During flight there is significant increase in body temperature of pigeons [9]. As flight becomes more strenuous and extended as observed in the present study, thermoregulation becomes crucial. Conversion of T_4 to rT_3 instead of T_3 would be a useful mechanism of thermoregulation and conservation of thyroid metabolism.

Since familiarity with the release site has been shown to reduce "release site bias", a behaviour characterized by deviation in the direction and better orientation of homeward flight [10–13], the longer time (90–160 min) taken by these pigeons could be attributed to the lack of the flight training prior to the experiment.

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