[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 (rT3), concomitant with reductions in thyroxine (T4) and triiodothyronine (T3) levels and also in T3/T4 ratio. The increase in plasma levels of rT3 and the concomitant decrease in levels of T4 and T3 with no change in plasma osmolality, suggest inhibition of T4 secretion and 5'-monodeiodination, and conversion of T4 to rT3. The conversion of T4 to rT3, the inactive form of T3, represents a mechanism of autoreregulation 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 (T4) and triiodothyronine (T3) [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 T4, T3 and T3/T4 ratio were significantly reduced. It occurred to us that this was due to the possible inhibition of T4 secretion and 5 monodeiodination with the conversion of T4 to reverse T3 (3, 3', 5'-triiodothyronine or rT3), the inactive form of T3, 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 rT3 in plasma samples obtained from the same birds used in the previous experiment [3].

MATERIALS AND METHODS

Pigeons (Columbia 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
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 heparinized 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 ×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 samples obtained then are now used for the estimation of plasma rT3. 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 rT3 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 rT3 as opposed to decreases in T4, T3 levels, and T3/T4 ratio. The post-flight plasma rT3 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 plasma levels of rT3 with no significant change in plasma osmolality, observed in the present study is indicative of increased conversion of T4 to rT3. Similar increase in plasma rT3 as a possible regulatory mechanism to limit T3 activity by inhibiting T4 conversion to T3 has been observed in humans under increased physical exercise [4]. In flown homing pigeons the increase in rT3 and the concomitant reduction of plasma levels of T4, T3 and T3/T4 ratio (Table 1) indicate inhibition of peripheral deiodination of T4 in order to limit the continued production of T3. The peripheral conversion of T4 to T3 has been shown to be stimulated by GH in chickens [5].

| 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 (rT3) (pg/ml)          | 211.9±16.9 (10)  | 493.0±90.8 (7)** |
| Triiodothyronine (T3) (ng/ml)                    | 2.29±0.14 (10)   | 0.89±0.14 (8)*   |
| Thyroxine (T4) (ng/ml)                           | 19.07±1.54 (10)  | 12.54±2.36 (8)*  |
| T3/T4 ratio                                    | 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 T₄ release followed by an increase in rT₃ levels should be expected. If so, the production of rT₃ could not be concomitant but should follow the release of T₄ so that excess T₃ could be eliminated by conversion to rT₃. That this is so, has been indicated in experiments with tilapia [6] in which it was observed that rT₃ levels were the same as the low levels present in the control one hour after injection of T₄ despite the high concentrations of T₄ in the plasma. Since plasma T₄ and rT₃ increased following injection of T₄, it was suggested that conversion of T₄ into rT₃ 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 T₄ release in addition to releasing FFA from the fat depots. It is also possible that the inhibition of peripheral deiodination of T₄ to T₃ 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 T₄ secretion [7].

Rudas and Pethes [8] observed that rT₃ appears in the serum of chickens after warm exposure and suggested that cold exposure stimulates T₃ formation whereas heat exposure inactivates the T₄ secreted to produce rT₃. 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 T₄ to rT₃ instead of T₃ 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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REFERENCES