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ORIGINAL ARTICLE

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# Effect of yogic exercises on thyroid function in subjects resident at sea level upon exposure to high altitude

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**Abstract** Using radioactive iodine, the effect of 1 month's yogic exercises has been investigated on the thyroid function of subjects resident at sea level (SL) specially after their exposure to high altitude (HA). The results have been compared with a group of SL subjects who underwent physical training (PT) exercises for the same duration. Ten healthy male volunteers in the age range of 20–30 years were used as test subjects in this study with each serving as his own control. The subjects were randomly divided into two groups of 5 each. One group practised hatha yogic exercises, while the other group performed the regular PT exercises. The thyroidal accumulation and release of radioactive iodine have been measured in each of the subjects of both groups before and after 1 month of their respective exercises at SL. One month of yogic exercises at SL has been observed to cause a significant reduction in the trans-thyroidal availability of radioiodine. The thyroid radioactivity in this group of subjects was always below normal levels with the exception of two peaks of radioactive iodine uptake, when the levels of radioactivity in the thyroid were similar to the control values of pre-yogic exercises. The release of radiolabel at 24–48 h was significantly increased after yogic exercises. In contrast, the subjects performing PT exercises for the same duration at SL showed significant thyroid uptake of radioactive iodine at 24 h. Subsequently their $^{131}$I uptake continued to rise slowly until 72 h without any demonstrable thyroidal release of radiolabel. This indicated that increased thyroid activity was induced by conventional PT exercise. Exposure of SL residents to HA irrespective of their exercise regime altered the thyroidal handling of radioiodine. Thyroidal concentrations of freshly administered radioiodine at early and late sampling intervals were very high in both of the groups, especially the yogics, after their return to SL from HA. Possible mechanisms of the observed changes have been discussed.

**Key words** Thyroid function · Yogic exercises
High altitude

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## Introduction

The philosophical doctrine of yoga is based on moral precepts, ascetic and meditation techniques and a special type of physical training called hatha yoga, which includes the control of posture and respiration. Its development in India can be traced back to about 500 BC (Stanescu et al. 1981). Yogic exercises improve body functions through the manipulation of cardiovascular, respiratory, metabolic and other control mechanisms (Anand et al. 1961; Mayol 1966; Udupa and Singh 1972; Nayar et al. 1975; Stanescu et al. 1981; Ray et al. 1986). Yogic practices have been reported to induce a shift in the autonomic balance towards relative parasympathodominance, improved thermoregulatory efficiency and a relative hypometabolic state (Wallace and Benson 1972; Bhatnagar et al. 1978; Joseph et al. 1981; Selvamurthy et al. 1983). It appears that the type and duration of the period of yogic practice determine its specific effect on the system (Udupa and Singh 1972; Udupa et al. 1975a, b; Bhatnagar et al. 1978; Rao et al. 1980). Subjects practising certain types of yogic exercises develop improved tolerance to cold (Bhatnagar et al. 1978; Selvamurthy et al. 1988). A special sect of Tibetan g-tum-mo yogic practitioners can exhibit the capacity to raise the skin temperature of their fingers and toes by 8.3 °C upon cold exposure after yogic meditational practice for many years (Benson et al. 1982).

The thyroid plays an important role both in metabolism and thermoregulation, but so far no systematic attempt has been made to examine the effect of yogic exercises on thyroid function. The present communication reports the influence of yogic exercises and high altitude (HA) exposure on thyroid accumulation and its release of radioiodine $^{131}$I in subjects resident at sea level (SL). The thyroid response had been compared in these subjects and a group of subjects who underwent physical training (PT) exercises for the same duration.

## Materials and methods

*Subjects and experimental design.* Ten healthy euthyroid male volunteers who resided at sea level (belonging to the Indian Army) and were in the age range of 20–30 years participated in this study. None of the subjects were taking iodine-containing medication or other chemicals known to affect thyroid radioiodine uptake. They were free from any clinical disorders and had no previous exposure to HA. The subjects had a uniform pattern of routine daily activities and their nutritional status was comparable. They gave their informed consent to participate in the study and test procedures.

The subjects were randomly divided into two groups of 5 each. One group was assigned to routine PT exercises (PT group) daily during the morning; the second group (yoga group) underwent selected hatha yoga exercises daily in the morning under the supervision of a qualified yoga instructor. The PT schedule consisted of slow running for 4 km (30 min), body flexibility exercises (10 min), pull ups (5 min) and games (15 min). The yogic schedule included prayer (3 min), followed by hatha yoga asanas (50 min), pranayama or breathing exercises (5 min) and meditation (5 min) as described earlier (Selvamurthy et al. 1988; Fig. 1). After the completion of 1 month of yogic practice and PT exercises at sea level, the subjects were airlifted to an altitude of 3500 m in the Western Himalayas for a stay of 3 weeks. They later moved by road to an altitude of 4500 m and stayed there for 1 week before flying back to SL. The subjects continued to perform their respective exercise regimes during the sojourn at HA and until the end of the second week of their return from the period of exposure at high altitude.

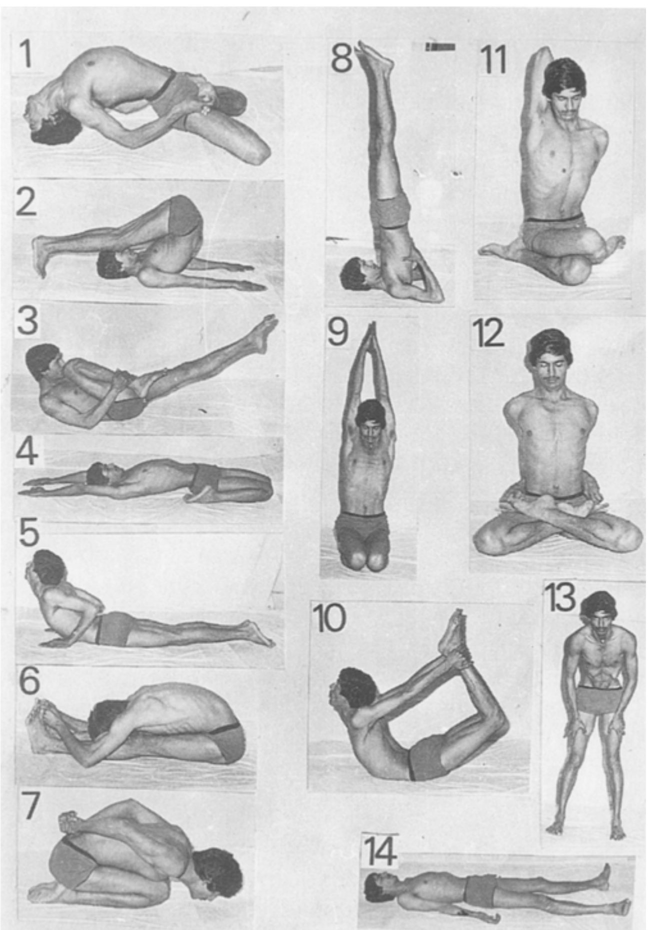


**Fig. 1** Postures adopted during the yogic schedule

*Schedule of radioactive tracer administration.* Tracer doses of $^{131}$I in the form of capsules were obtained from Bhabha Atomic Research Centre, Trombay, Bombay. $^{131}$I tracer (25–30 μCi) was administered orally to each subject in the postabsorptive state at each of the times mentioned below. Using a thyroid probe connected to a spectrometer (Electronic Corporation India Ltd.), the amount of radioactivity over each subject's thyroid and thigh was measured as a function of time after administration of the tracer. Counts of radioactivity were corrected for background and decay of the administered radioisotope. The first dose of radioactive tracer was administered to each subject before the commencement of either hatha yoga exercises or the regime of physical training exercises. A second dose of $^{131}$I tracer was administered after the completion of 1 month of yoga practice or PT exercises at SL. The third and final dose of tracer was administered 1 week after the subjects returned to SL from the stay at high altitude.

Before the administration of radioactive tracer for the second and third times, the counts were measured over the thyroid of every individual; no radioactivity from the earlier dose was found to be carried over in the thyroid. Control studies were carried out on the same subjects before they were subjected to the experimental conditions. The controls comprised studies of thyroidal radioiodine kinetics before the initiation of either yogic practice or the PT exercises. The results of the experiment have been computed and are expressed in the form of graphs.

## Results

Yoga practice for 1 month was found to cause a significant reduction in the concentration of radioiodine in the thyroid of subjects at SL (Fig. 2). The pattern of radioactive iodine uptake by the thyroid in this group of sub-

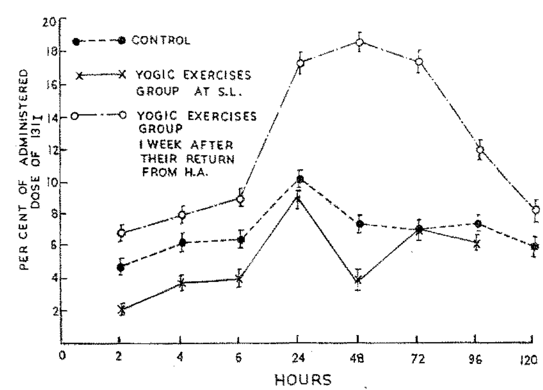


**Fig. 2** Thyroid uptake of iodine-131 and its release in subjects after yogic exercises and their exposure to high altitude (HA). Each individual received an oral dose of 25–30 μCi $^{131}$I in postabsorptive state and follow-up studies on thyroidal radioactivity were carried out at designated intervals. Results are expressed as mean ±SEM

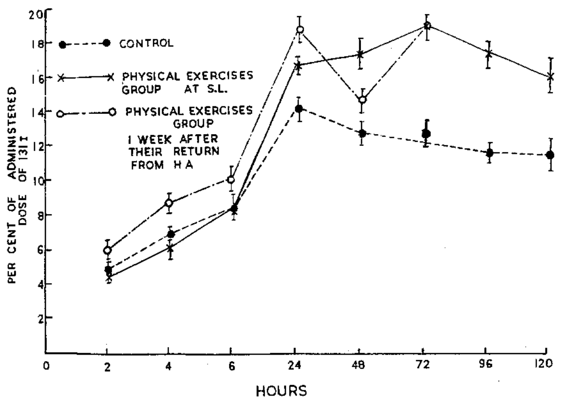


**Fig. 3** Thyroid uptake of iodine-131 and its release in subjects after physical exercises and their exposure to HA. Each individual received an oral dose of 25–30 μCi of $^{131}$I in post-absorptive state and follow-up studies on thyroidal radioactivity were carried out at designated intervals. Results are expressed as mean ±SEM

jects exhibited two peaks, one at 24 h and the other at 72 h, when the values reached those of the period of pre-yogic exercises at SL. About 50% of the $^{131}$I concentration of the first peak at 24 h was released between 24 and 48 h and the second peak of thyroid radioiodine uptake observed at 72 h was of a lower absolute value. In contrast, physical exercises caused an increase in the 24 h thyroidal uptake of $^{131}$I, and a subsequent slow rise in thyroidal radioactivity until 72 h was observed in this group of subjects at SL. About 15% of the peak concentration of $^{131}$I at 72 h of this group was slowly released over 120 h (Fig. 3).

Exposure to high altitude altered the thyroid concentration of $^{131}$I in subjects of the yogic and PT groups respectively. Even a week after their return to SL from HA, the thyroid radioactivity at early and late hours after the administration of a fresh dose of isotopic tracer was high in both groups of subjects compared to their pre-exposure control values at SL (Figs. 2 and 3). The changes were more marked in the yogic group of subjects compared to the PT group.

## Discussion

It is known to be difficult to assess the endocrine function indirectly by monitoring blood concentrations of hormones instead of studying the rate of their secretion, tissue utilization, or biodegradation within the body (Shephard 1985). There is no optimum in vitro test of thyroid function that can be used with equal reliability in all situations (Mitchell 1986). In the present investigation, an attempt has been made to evaluate the thyroid function by direct monitoring of radioiodine thyroidal accumulation and its release in the test subjects in vivo. The follow-up studies on thyroidal handling of radioiodine had to be carried out for a period of 5 days or more after the administration of a single dose of tracer.

Iodine-131 has been used as a tracer in the present series of subjects instead of $^{123}$I which has a very short shelf life. There were two distinct peaks of radioactive iodine uptake with below normal levels of thyroidal accumulation of iodine-131. The pattern of the release of radioactivity at 24 to 48 h in yogis at SL (Fig. 2) can be used as a model system to simulate endocrine changes. The results indicate that $^{131}$I uptake by the thyroid and release of hormones are probably adjusted in these subjects due to decreased peripheral demand of thyroid hormones with the low energy expenditure and hypometabolic state induced by yogic practice (Udupa and Singh 1972; Bhatnagar et al. 1978; Joseph et al. 1981; Selvamurthy et al. 1983). Increased thyroid activity, reflected by a higher thyroid concentration of radioactivity in the PT group of subjects (Fig. 3) at SL is in good agreement with the reported observation of exercise-induced accentuation of thyroid function (Shephard 1985). The reason for the significant increase at early and late sampling intervals of thyroid uptake of $^{131}$I in yogis at 1 week after their return to SL from HA (Fig. 2) is not clear. A similar increase in thyroidal radioactivity in subjects of the PT group 7 days after their return to SL from HA was also observed but was of lower magnitude (Fig. 3).

It is known that exposure of human subjects to hypobaric hypoxia either at natural elevation or at simulated high altitude induces an apparent increase in thyroid activity. This is characterised by: (1) increased thyroidal uptake of $^{131}$I (Moncloa et al. 1966; Rawal et al. 1993) and (2) hyperthyroxaemia (Surks 1966; Kotchen et al. 1973; Rastogi et al. 1977; Chakraborthy et al. 1987; Sawhney et al. 1991) without the manifestations of clinical hyperthyroidism. Perhaps in such situations body tissues become less sensitive to thyroid hormones at least for a temporary period, a suggestion requiring further study. The presence of high thyroidal radioactivity in subjects after completion of 1 week of their return to SL from HA was observed in the present series and previously on the 7th day of withdrawal of exposure to simulated altitude (Rawal et al. 1993). These results suggest that altered thyroidal handling of iodine by sufficient exposure to hypoxia requires more time for its reversal after cessation of hypoxic exposure. In contrast the increase in blood levels of thyroid hormones, induced by a similar treatment of human subjects, return to normal much earlier after the return of the subjects to normoxic conditions (Surks 1966; Kotchen et al. 1973; Rastogi et al. 1977; Chakraborthy et al. 1987; Sawhney and Malhotra 1991). The said publications indicate that the altered thyroid functions induced by exposure to HA is not mediated through pituitary. The observed pattern of thyroid uptake of $^{131}$I in yogis either at SL or after exposure to HA is completely new and needs a further study.

## Conclusion

Exposure to high altitude altered the thyroid concentration of $^{131}$I in subjects of the yogic and physical exercise groups respectively. Even a week after their return to SL from HA, the thyroid radioactivity at early and late time intervals after the administration of a fresh dose of isotopic tracer was high in both the groups of subjects compared to the pre-exposure control values at sea level. The changes were more marked in the yogic group of subjects compared to the physical exercise group.

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