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September 1984, with each subject serving as his own control. The protocol was approved by our Institutional Review Board, and all participants provided signed informed consent. The men were similar with respect to age [24.5 ± 0.9 (SE) yr] and body weight (81.3 ± 2.7 kg).

Acute Cold Air Exposure

Three standardized 60-min SCATs (0 ± 2°C) were performed with each subject seated in an environmental chamber (wind speed ~4.5 m/s) (2, 11, 21). One SCAT was carried out in California (control) initially and then repeated after 24 and 44 wk AR. SCATs were performed between 0800 and 1100 h local time in an identical fashion for each testing period. Subjects, wearing a cotton T-shirt, shorts, socks, and shoes, had a Teflon catheter inserted into the brachial vein for free-flowing blood sampling. Pre-SCAT blood samples were obtained in the postabsorptive state 20 min after catheter placement while the subject was seated in a warmed laboratory (22°C) before entering the climatic chamber. Post-SCAT blood samples were obtained from the same catheter after 60 min of cold air exposure. Subjects were quiet during the cold air exposure and were not allowed to smoke, eat, or move excessively. The sublingual oral temperature (T_{or}) was recorded with a digital display analog input circuit thermocouple (IVAC, San Diego, CA) after local oral thermal equilibrium. All subjects were asked to breathe through the nares with mouth closed while the T_{or} was recorded. Changes in respiratory rate were not clearly evident. The subjects were not allowed to eat or drink for 20 min before temperature measurements, thus minimizing variables that might affect T_{or}. Auscultatory blood pressure and pulse from the brachial artery were measured by the same investigator pre-SCAT and after 15, 30, 45, and 60 min of each cold air exposure. Mean arterial pressure (MAP) was calculated as [diastolic pressure + (pulse pressure/3)]. Serum from blood coagulated at room temperature was frozen at −30°C, and all samples were transported to Bethesda, MD, for processing and then analyzed together at the completion of the 1-yr study.

Extended Antarctic Residence

The men were studied in August 1983 while in Port Hueneme, CA (latitude 34° 07′ N, longitude 119° 07′ W), before departing for Antarctica, in April 1984 after 24 wk, and in September after 44 wk in McMurdo Sound, Antarctica (77° 51′ S, 166° 37′ E). The 24- and 44-wk time points are similar to previous reports (24, 25). The mean monthly ambient temperatures for California in August (22.7°C) and McMurdo Sound, Antarctica, in April (−23.6°C) and September (−29.2°C) were similar to those of past reports (24, 25, 27). An internationally utilized US Navy diet as previously described (24, 25) was consumed, with calories distributed as ~40% carbohydrate, 35% protein, and 25% fat. Energy intake increases with AR at this base from ~2,000–2,500 to 3,000–3,500 kcal/day (24, 25, 27). Each subject wore standard military polar clothing while in McMurdo Sound; the face and hands are commonly exposed during outdoor activity. Subjects were exposed to outdoor temperatures for an average of 4.3 ± 0.7 h/day. Indoor fluorescent lighting was used during the austral winter months. Indoor temperatures ranged from 19 to 27°C. All subjects maintained routine sleep cycles of 8 h/day. Blood samples and physiological measurements were taken just before each SCAT as described.

Blood Analysis

Serum TT_4 and TT_3 were measured by RIA (Nichols Institute, San Juan Capistrano, CA). The percent free fraction of T_4 and T_3 (%FT_4 and %FT_3) were measured by equilibrium dialysis (Nichols Institute) by use of a modified method of Sterling and Brenner (32). After dialysis, contaminating free iodine was removed by antibody precipitation. The percent dialyzable fraction of total hormone is referred to as the percent free fraction (normal %FT_4 ~0.03% and %FT_3 ~0.3%) (19). The free hormone concentrations were calculated as the product of the total hormone concentration and the percent free fraction of the hormone. We tested the effect of freezer storage on this assay of thyroid hormone binding. The sera of 10 subjects different from those in the present study were analyzed for %FT_3 before and after 21 mo of storage at −30°C. We did not find an increase in the %FT_3 with this duration of storage. Serum TSH was measured by a sensitive and specific enzyme-linked immunosorbent assay technique (34). Serum cortisol and prolactin responses in the SCAT were measured as standard markers of cold exposure (11, 13). Serum cortisol levels were measured using a commercially available RIA kit (Clinical Assays, Cambridge, MA). SI unit conversion for cortisol is nmol = 2.759 × μg. Serum prolactin was measured by a commercially available RIA kit (Organon Teknika, Irving, TX) with an assay detection limit of 4 μg/l. We analyzed TT_4, TT_3, %FT_4, and %FT_3 with a well-known model of thyroid hormone binding to predict whether the observed changes were primarily due to increases in receptor number or affinity (28). The serum total protein of six subjects was measured pre-SCAT by spectrophotometry to test for hemoconcentration (bicinchoninic acid protein assay, Pierce, Rockford, IL).

Data Analysis

Statistical analysis was performed by using a randomized block design ($n = 15$) with one- and two-way (date and time = treatments) analysis of variance (ANOVA), general linear model (GLM), and Dunnet's test for differences between the one-way ANOVA means (SAS, SAS Institute, Cary, NC, and STAT PAK version 4.1, Northwest Analytical, Portland, OR). The data are expressed as means ± SE. Significance was determined as $P < 0.05$.

RESULTS

Acute Cold Air Exposure (SCAT)

Thyroid hormones. The SCAT did not induce any differences in serum TT_4, FT_4, TT_3, FT_3, and TSH (Table 1) or in serum %FT_4 or %FT_3 (Tables 2 and 3). Serum TT_3 increased, although not significantly, during the control SCAT and did not change with the SCATs in Antarctica (Table 1).

The opinions and assertions expressed herein are those of the authors and are not to be construed as official or reflecting the views the Department of the Navy, Department of the Army, Department of Defense, or the National Science Foundation.

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