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Biophysiological changes observed in members of the Italian expeditions to Antarctica

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Abstract

The objective of this study was to investigate whether food consumed by individuals working in Antarctica is adequate and sufficient, from the nutritional viewpoint, to sustain life in extreme environments. Malnutrition can be the cause of both health impairment and reduction in psychological and physiological efficiency. The study involved individuals from two subsequent expeditions in Antarctica, namely, 34 subjects (group A) from the Italian Mario Zucchelli Base (MZB) in October–November 2002 and 30 subjects (group B) from the Italian–French Concordia Station (CS) between November 2003 and January 2004. Each group of volunteers consisted of subjects with a controlled diet as well as of subjects with a free diet. Blood and hair samples were taken just before the expeditions (with the purpose of setting the baseline) and during the last week spent in Antarctica. Samples were then shipped to Italy to be analyzed, while the body composition and the hydration status were measured on the spot by Bio-Impedentiometric Assay (BIA). Anthropometrical measurements were carried out weekly. The data obtained were statistically assessed by using the Student *t*-test for correlated samples and showed, in all subjects, alterations of the hypothalamic–pituitary–thyroid axis, of blood parameters and of some components of the hair along with some variations of the psychological behaviour. The variations observed can probably be ascribed to environmental conditions and a combination of factors such as isolation, atmospheric conditions and prolonged presence of daylight.

Keywords: Hair analysis; Antarctica; Extreme environment; Nutrition; Diet; Essential elements

1. Introduction

The Agency for New Technologies, Energy and Environment (Ente Nazionale per le Nuove Tecnologie, l'Energia e l'Ambiente, ENEA) and the National Research Council (Consiglio Nazionale delle Ricerche, CNR) are two major partners of the National Programme for Research in Antarctica (Programma Nazionale di Ricerche in Antartide, PNRA). One of the projects included in the PNRA deals with nutrition under extreme environmental conditions.

Nutrition is a vital necessity and eating in an adequate way represents a key step in assuring a healthy psychological and physical state. A diet unbalanced as regards nutrients for an extended period of time can, in fact, compromise the health conditions and eventually results to a certain extent in pathological stress.

The importance of food, not only in terms of its nutritional value, but also as regards its preparation and the manner in which it is displayed and served, is recognized by most managers of

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remote environments [1]. Eating then plays a key role, probably also a compensatory function, as many usual sources of gratification are denied in extreme environments [2,3].

The determination of hematological parameters, body composition, hydration status, anthropometrical measurements and trace elements in human hair is potentially useful to assess the health status of an individual.

This study is based on data collected during the 2002–2003 summer expedition to the Italian Base of Terra Nova Bay, now Mario Zucchelli Base (MZB), and the 2003–2004 summer expedition to the Italian–French Dome Concorde Base (DCB).

The hematological parameters taken in account were as follows: total proteins, blood glucose, iron, triglycerides, total cholesterol, High-Density Lipoproteins (HDL), Low-Density Lipoproteins (LDL), transaminase, Free Tyroxine 3 (FT3), Free Tyroxine 4 (FT4), Tyroid Stimulating Hormone (TSH), insulin and, only for the samples coming from DCB, cortisol. The anthropometrical measurements included weight, height, upper arm, thighs, umbilical, waist and hip circumferences, bicipital, tricipital and subscapolar skin fold thickness and bioelectrical measurements using Bioelectrical Impedance Analysis (BIA) to determine the body composition, especially the hydration status. In turn, the elements detected in hair samples were Ca, Cu, Cr, Fe, Mg, Mn and Mo [4].

The choice of these parameters was suggested by the essential role they play in the human organism and by the necessity to estimate adverse effects caused by either their deficiency or excess.

2. Experimental

2.1. Diet schemes

The investigation was carried out by thoroughly instructing and involving the personnel at the MZB and DCB during the XVIII and XIX Italian expeditions in Antarctica. The study included 64 volunteers who previously gave their written consent to the monitoring programme. All subjects were interviewed to obtain information on their health status and lifestyle and thus be able to decide on their eligibility.

Participants were split into two groups, respectively named A and B. Group A consisted of 34 subjects from the MZB, *i.e.*, 31 males and 3 females, mean age 46.5 years (range, 31–62 years) with different jobs. Eleven of them belonged to the technical personnel, being, in particular, meteorologists, physicists, sea biologists and divers; 22 were base maintenance workers and alpine guides. The second group consisted of 30 subjects from the DCB, *i.e.*, 26 males and 4 females, mean age 40.0 years (range, 22–61 years). Thirteen of them belonged to the technical personnel, being, in particular, astronomers and divers, while the remaining 17 were base maintenance workers, airport runway maintenance workers, carpenters and mechanics. Each group was further subdivided into two subgroups, A1 and A2 for the MZB and B1 and B2 for the DCB. Groups A1 and B1 consisted of 19 and 6 subjects, respectively, with controlled diet, and groups A2 and B2 of 15 and 24 subjects, respectively, with free diet. Group A2 and group B2 were daily instructed about correct nutrition modes. Five kinds of diet were set up, each with an intake of nutrients adequate to the activity and daily requirements of the various subgroups. For all subjects with a controlled diet, food habits were recorded. The diet schemes were calculated by means of the Winfood software, version 1.5, by Medimatica S.r.l. (Italy). Winfood is a software used to evaluate, in real time, the actual food intake and to set up a personalized diet. This software contains also a database of the nutrients belonging to 313 different kinds of food. The proposed diets were calculated taking into account primarily sex and type and place of work of the people enrolled in the study. Differences in physical activity and environmental behaviour trigger different intakes of calories (from 1500 kcal, *i.e.*, 6279 kJ, to 3000 kcal, *i.e.*, 12,558 kJ). Diets were different in their energy contents, although all of them featured 10–15% proteins, 25–30% fat and 55–60% carbohydrates. Each volunteer was informed about the type of diet to be followed. The five diet schemes were checked daily according to the menu prepared by the cooks and displayed in the canteen.

2.2. Blood sampling

At the beginning and at the end of the study, blood samples were taken from the subjects of groups A and B, centrifuged, frozen, kept at −30 °C and subsequently shipped to the Nutrition Unit of the University of Siena (Italy). The parameters listed in the Introduction were tested in each blood sample. Cortisol was quantified only in one subject from the DCB.

All tests were performed in the General Laboratory of the main Hospital of Siena, where an External Quality Programme (Verifica Esterna di Qualità, VEQ) has been implemented. The majority of tests are performed by a completely automatic apparatus.

Anthropometrical quantities, including weight, height, upper arm, thigh and umbilical circumferences and thickness of bicipital, tricipital and subscapolar skin folds were measured for each subject in groups A and B.

The body weight was determined using an electronic balance type 861, with 200 kg of maximum load and with partition of 100 g, certified and homologated as class III.

Height was measured using a 200 cm class III Telefix telescopic stadiometer supplied by M Metrica (Italy).

Arm, thigh, umbilicus, waist and hip circumferences were measured using a flexible metric tape from KDS Measure.

Bicipital, tricipital and subscapolar skin folds were determined using Holtain® Tanner Whitehouse skinfold calliper. This instrument has been designed to give a constant pressure of 10 g/mm^2 over its entire operating range. Its scale is marked in divisions of 0–2 mm, but readings of 0–1 mm can be easily estimated. The method of use was as follows: 1) the thumb and forefinger of the left hand pick up a fold of skin and subcutaneous tissue and pinch it away from the underlying muscle; this fold is firmly maintained throughout the course of the measuring operation. The callipers are applied to the fold a little below the pinch point and the right hand is allowed to fully relax its grip on the trigger so that the jaws can exert their full pressure. Measurements up to 20 mm with this technique result in a stable reading, but above this value the measurement shows