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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The energy requirements in a cold environment are practically unchanged as compared to a temperate environment except for the 2% to 5% increase due to wearing heavy clothes and footgear, provided that the individual is adequately clothed. Based on observed V_{O2} increases, the daily energy requirements for men living and working in a hot environment are increased. This is related to the increased requirement of blood circulation in heat transport, increased action of the sweat glands, increased caloric loss due to sweat vaporization and to the

Block 20 - Abstract

increase in body temperature.

At high temperatures with increasing relative humidities (30% to 98%) although one observes increases in V_E, heart rates and body temperatures, the V_{O_2} during submaximal work appears to be unchanged. The reasons at this time are not clear. Preliminary data indicates that V_{O_2}, V_E and heart rates during standardized physical activities are significantly increased at 4300 meters. This indicates that the energy requirements at this elevation may be increased.

V sub O_2

V sub E

A 20

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NUTRITIONAL ADAPTATION TO THE ENVIRONMENT

Nutritional Studies Conducted

in Participation with

The International Biological Program

1967-1974

Coordinated by

O. L. Kline and C. Glen King

HUMAN ADAPTABILITY COORDINATING OFFICE

University Park, Pennsylvania

February 1976

Relationship of Diet to the Performance of the Combat Soldier

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Energy Requirement and Metabolism during Exposure to Extreme Environments

Energy metabolism is affected by many factors including age, sex, physical activity, body size and composition, environmental temperature, altitude. Recently in the United States the National Research Council's daily allowances were again revised and decreased for the "reference man" to 2800 cal/day. This was due primarily to the decreased physical activity of the modern-day American male that has resulted in a large percentage of the U.S. population being overweight. The modern American is a fairly sedentary individual since he does very little walking or any form of exercise. He rides everywhere in an automobile, lives in a heated environment in cold weather and in an air-conditioned environment in hot weather. The data on soldiers in Table 1 indicates the approximate number of hours/day being devoted to various physical activities. Although the soldier is considered to be fairly active, 84.1% of his day is spent in fairly sedentary activities. It appears that an increase in physical activity for Americans would result in a higher level of health since there is growing evidence that a sedentary-type existence may contribute to degenerative arterial disease as well as obesity and its many complications.

Summary

The energy requirements in a cold environment are practically unchanged as compared to a temperate environment except for the 2% to 5% increase due to wearing heavy clothes and footgear, provided that the individual is adequately clothed. Based on observed V_{O_2} increases, the daily energy requirements for men living and working in a hot environment are increased. This is related to the increased requirement of blood circulation in heat transport, increased action of the sweat glands, increased caloric loss due to sweat vaporization, and to the increase in body temperature.

At high temperatures with increasing relative humidities (30% to 98%) although one observes increases in V_E, heart rates and body temperatures, the V_{O_2} during submaximal work appears to be unchanged.

Table 1. Daily Energy Expenditure of U.S. Troops*

Time Spent in Daily Activities	% of 24-Hour Day
Sleeping	33.59
Sitting	34.03
Lying down excluding sleeping	16.47
Standing normally	4.36
Walking around areas normally	3.73
Morning and evening personal activities	3.15
Standing light activity	2.28
Physical fitness training and sports	1.97
Miscellaneous activities	0.42

*Daily expenditure after basic or advanced training.

From Brockett et al. (1957). USAMRNL Rept. 212, Denver, Colorado.

The reasons at this time are not clear. Preliminary data indicates that V_{O_2}, V_E and heart rates during standardized physical activities are significantly increased at 4300 meters. This indicates that the energy requirements at this elevation may be increased.

The Effects of Heavy Physical Training Upon Work Capacity and Protein Utilization

A consistent increased physical activity level, whether in military basic training, sports training, or exercising to increase physical fitness, results in increased muscle mass due to the increase in the amount of muscle protein in the muscle cells being exercised. This increase would require the increased biosynthesis of proteins, generally from dietary protein. Increased protein intake during sports training has been advocated for centuries; however, only a limited number of controlled scientific studies on the effects of protein intake levels upon training have appeared in the literature.

Two groups of men consumed two levels of protein (1.4 and 2.8 g/kg body weight) during a 40-day experimental period. Physical activity and the sweat rates were fairly high during the entire experimental phase.

Urinary nitrogen excretions remained fairly constant for both groups during the training and heavy physical activity periods. Nitrogen and potassium balances were positive exclusive or inclusive of the daily sweat losses showing nitrogen or protein retention. The essentially unchanged blood hemoglobin and serum protein levels showed that the control group was receiving an adequate protein intake to maintain nitrogen equilibrium, under conditions of fairly heavy physical activity.

In this study, although the men did increase body protein stores and muscle mass with the consumption of high protein diets, the additional body protein did not enhance physiological work performance. It is suggested that 100 g of protein are adequate for men performing fairly heavy work.

The data suggests that sweat losses of nutrients become relevant in determining requirements and will increase in importance as sweat rates are increased. The nutrient losses during profuse sweating constitute an error that could seriously invalidate the accuracy of metabolic balance studies.

Metabolic Imbalances and Body Hypohydration during Food Deprivation

In the initial study on six men who fasted completely for ten days, significant metabolic stresses developed which could eventually lead to serious abnormalities. These observations included great body hypohydration resulting in large body weight losses, large nitrogen and mineral losses, and a marked ketosis. These findings are not unusual since both the body fat and protein stores must be utilized as energy sources. The maintenance of normal blood carbohydrate levels require a known quantity of protein breakdown. As a result, it was suggested that low antiketogenic diets and adequate mineral supplementation could prevent the marked ketosis, minimize protein catabolism, maintain fluid balance, and decrease the electrolyte excretion.

Previous studies have shown that 400-500 calories of carbohydrate/day was very beneficial in reducing body water losses in relatively sedentary individuals. The 420 cal/day study, where the subjects were not obese and were moderately active (energy expenditure of approximately 3200 cal/day), indicated that the ingestion of 100 gm of sucrose/day prevented ketosis and resulted in some decrease of hypohydration; however, hypohydration was still considered a major problem. The addition of minerals to the carbohydrate intake further reduced body water loss after the first two days of caloric restriction. This loss during the first two days of restriction averaged only 550 gm of water/man which, in most instances, would not cause any serious decrement in performance. In the 500 cal/day study the negative nitrogen balances averaged 7.1 and 6.5 gm/day during restriction. Since no improvement in nitrogen balances were observed, this would indicate that this may be the best balance attainable under these conditions.

Some hypohydration occurred in Group 1 during the first few days of restriction, but Group 2 remained in water balance during the entire restriction period. Electrocardiograms and electroencephalograms were all normal in both groups during the entire study.

It appears that restricted diets containing less than 500 cal/day are inadequate for short-term performance. Although they spared water, the protein catabolism was still a major problem.

Increased Energy Requirements of Man after Abrupt Altitude Exposure

Increased physiological parameters during standardized work at 4300 meters indicated that the energy requirements were increased. Significant increases in oxygen uptakes, pulmonary ventilation and heart rates were observed during moderate and fairly heavy steady state work on the treadmill. Oxygen consumptions, in comparison to sea level values, were increased by 3% to 15% after 5 days, and 17%

to 35% after 9 days of exposure at 4300 meters. The larger increases occurred during the heavier work performances. These significant increases would suggest an increased calorie requirement during acute high altitude exposure of 4300 meters, and may be due to the increased metabolic cost of cardiac and respiratory work, or to decreased efficiency of work performance.

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