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ABSTRACT

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Energy metabolism is markedly increased in humans during intense physical exercise, but opinions have differed about the extent to which the nutritional needs resulting from training and competition on an elite level can be adequately met by ordinary food.

The principal objectives of these investigations were to develop a calorimeter suitable for use in metabolic experiments on humans engaged in physical exercise and to study different aspects of energy turnover (ET) and substrate metabolism in relation to nutritional needs in endurance athletes.

A newly constructed water-cooled suit calorimeter is described and evaluated. It was shown to be a flexible and reliable tool for determination of daily ET in humans engaged in physical exercise. Since the suit is an effective heat exchanger, it could also be used in studying the effect of moderately increased cooling on ET, and ET was found to increase in proportion to the increased rate of heat removal during light-intensity work.

The addition of a layer of highly absorptive material in the calorimeter suit for collection of total body sweat was shown to offer a reliable method for determining dermal losses of nutrients. A specific pattern of amino acids in sweat collected under various conditions in 28 subjects different from that in plasma and urine was found. Amino acid concentrations were higher in sweat from men and untrained subjects than from women and trained athletes. The loss of amino acids in sweat was still of limited nutritional significance, however.

Using the doubly labelled water technique, ET was shown to be balanced by energy intake ($r=0.98$, mean difference 0.1 $MJ \cdot d^{-1}$, $p<0.001$) during a 7-day period of endurance training in 8 elite endurance athletes also at high ET (18 $MJ \cdot d^{-1}$ in female and 30 $MJ \cdot d^{-1}$ in male elite cross-country skiers). To evaluate the relevance of using BMR factors for estimations of ET in elite athletes, BMR in such athletes was studied. It was found that at least 39 hours after their last bout of exercise, elite athletes had a 16% higher BMR than expected from theoretical calculations according to WHO/FAO/UNU (1985) and 13% higher than that in a group of sedentary controls matched for FFM.

Since endurance athletes often consume large amounts of carbohydrate drinks with a high glycaemic index (GI) the effects of high and low GI were studied in a group of 8 endurance-trained subjects, exercising twice daily. It was found that diets with a high GI led to greater increases in b-glu and s-ins but had no general effect on extracellular fat substrate availability (s-FFAs) after each meal compared to an isocaloric diet with a low GI. No persistent effect on substrate utilisation but signs of a better ability to maintain glucose homeostasis and a tendency to a higher endurance capacity were found during exercise to exhaustion after a diet with a high GI.

The practical conclusions to be drawn from these studies are that during exercise even moderately increased cooling might influence ET, that calculations of ET based on BMR might lead to an underestimation, and that energy intake may balance ET within a 7-day period even at high ET levels. There is little evidence that the glycaemic index is of major importance for substrate utilisation during endurance performance, and sweat losses of amino acids are probably negligible even during intense, prolonged endurance exercise.

Key words: Amino acids, BMR, calorimetry, carbohydrates, energy turnover, energy balance, glycaemic index, sport nutrition, sweat losses, thermally induced thermogenesis.

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