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The Effect of Endurance Exercise on Energy and Protein Balance

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A thesis submitted in fulfilment of the requirements for the degree of Doctor of Philosophy, The
University of Auckland, 2009

Abstract

Background

The energy cost of endurance exercise is significant and the ability to consume enough food to maintain energy balance is critical for success. In addition maintenance of body protein stores is also critical and there is a well known relationship between energy and protein balance. The establishment of any relationship between energy and protein balance and markers of overtraining in endurance athletes is also beneficial for endurance performance.

Purpose and Aims

The purpose of this thesis was to investigate the effects of endurance exercise on energy balance and protein balance. The aims were to establish accurate values for EI, EE and protein balance in two endurance sports, Road Cycling and Ironman. The rationale was to determine whether endurance athletes are able to maintain energy and protein balance over periods of increased EE and whether parameters of energy and protein balance related to markers of overtraining

Methods

Two research projects were conducted, the first at the Tour of Southland cycle event (5 high performance male cyclists) and the second at an Ironman training camp (7 male Ironman athletes). In both studies EE was determined by the DLW technique and EI by supervised weighed diet records. Protein balance was determined by an 18-hour primed continuous infusion of ^{13}C -leucine at the Tour of Southland and via the traditional 24-hour nitrogen balance technique at the Ironman camp. Both techniques were performed prior to and immediately after the given event. Nude body weight, blood overtraining parameters, urine samples and a mood questionnaire were collected in the mornings for analysis of daily parameters.

Results

The Tour of Southland: Subjects maintained energy balance with a mean EI of 27.3 ± 3.8 MJ/day and a mean EE of 27.4 ± 2.0 MJ/day. There was no significant change in protein breakdown or parameters of overtraining. Ironman Training Camp: Athletes maintained energy balance with a mean EI of 20.27 ± 2.91 MJ/day and a mean EE of 20.5 ± 3.4 MJ/day and nitrogen balance was positive. There were indications of a relationship between energy and protein balance and markers of overtraining in both studies.

Conclusions

Endurance athletes are able to maintain energy balance when EE is high. When nutrients are sufficient to meet energy demands, protein stores are maintained.

Dedication

In memory of my grandparents

EDWARD RATIMA ROLLESTON

17 March 1912 – 23 August 1987

WILENA PARETIAKI ROLLESTON

18 June 1924 – 29 August 1993

ELIZABETH MARY HILDRETH

19 September 1920 – 28 October 2001

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List of Abbreviations

| | | | |
|-----------------|----------------------------------|----------------------|---------------------------------|
| % Δ PV | percent change in plasma volume | IRMS | isotope ratio mass spectrometry |
| α KIC | α -ketoisocaproate | kcal | kilocalorie |
| AA | amino acid | kJ | kilojoule |
| AGF | Atwater general factor | LBM | lean body mass |
| APE | atom percent excess | MJ | megajoule |
| AV balance | arteriovenous balance | MS | mass spectrometer |
| BCAA | branched chain amino acid | POMS | profile of mood state |
| BD | body density | R _a | rate of appearance |
| BF% | body fat percentage | R _d | rate of disappearance |
| CO ₂ | carbon dioxide | RMR | resting metabolic rate |
| DLW | doubly labelled water | RQ | respiratory quotient |
| DXA | dual energy x-ray absorptiometry | TBW | total body water |
| EE | energy expenditure | TDEE | total daily energy expenditure |
| EI | energy intake | TEF | thermic effect of food |
| FFM | fat free mass | ToS | Tour of Southland |
| FQ | food quotient | TUN | total urinary nitrogen |
| FSR | fractional synthesis rate | UUN | urine urea nitrogen |
| GC | gas chromatography | VO ₂ max | maximal oxygen consumption |
| Hct | haematocrit | VO ₂ peak | peak oxygen consumption |
| Hgb | haemoglobin | WBPT | whole body protein turnover |