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Metabolic Response to Chronic Energy Deficiency

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In this paper, we briefly consider the metabolic processes involved in so-called "adaptation" to chronic energy deficiency (CED). It is useful to consider total daily energy expenditure as being composed of three distinct components: 1) basal metabolic rate, 2) thermogenesis which is the increase in oxygen consumption over the basal state caused by factors such as cold exposure or diet, and 3) the extent and energy cost of physical activity.

Basal Metabolic Rates

Basal metabolic rate (BMR) constitutes the major part of total daily energy expenditure. There are two major determinants of BMR: the mass of metabolically active tissue and the "metabolic efficiency" of these tissues. Reduction in BMR is a constant finding in experimentally induced semistarvation[10] Two separate mechanisms (not mutually exclusive) have been implicated in the decrease in BMR seen during energy restriction: (a) a decrease *per se* in the activity of the metabolically active tissue mass of the body and (b) a decrease in BMR consequent to the loss of metabolically active tissues associated with the body weight loss. The Minnesota semistarvation studies indicated that a decrease in the mass of metabolically active tissue was the main factor responsible for the reduction in BMR; according to this study, the bulk of the reduction in BMR(about 65 percent) was attributable to the shrinkage of the metabolising mass of cells and only the rest (35 percent) to an actual decrease in cellular metabolic rate. Grande and others,[6] however, applying similar methods of computation to data from a subsequent series of human semistarvation experiments found that the actual decrease in metabolic activity of cells contributed between 65 to 73 percent of the reduction in BMR. The differences observed in the two series of semistarvation studies were obviously due to the differences in the duration of energy restriction viz the long term restriction of energy (24 weeks) in the Minnesota study as compared to the short period of energy restriction (three weeks) in the study by Grande. From a comparative analysis of both experimental semistarvation studies it seems reasonable to conclude that the reduction in BMR during energy restriction occurs in two different phases. In the initial phase (i.e. two to three weeks) there is a marked decrease in the BMR which exceeds any change attributable to reduction in body weight or that due to measurable changes in body composition. With continued restriction of energy, however, the reduced cellular metabolic rate attains a constant level and further decrease in the BMR is accounted for solely by the loss of active tissue. Thus, the longer the duration of semistarvation, the more important becomes the contribution of decreased lean body mass (LBM) to the decrease in BMR. This reduction in LBM is apparently a passive process and a consequence of body tissues being used as metabolic fuel during energy restriction. Thus the major part of the adaptive response to chronic energy deficit is achieved largely through an actual loss of body tissues.

Victims of severe malnutrition in the Warsaw ghettos had a markedly low BMR; similar observations were also made in other groups of chronically malnourished individuals during World War II. A substantial decrease in BMR has also been reported in severely undernourished individuals during naturally occurring severe food restriction as seen during famine and among the destitute poor[3,20]. Ashworth reported in 1968[1] that Jamaicans on energy intakes of 60 to 70 percent of FAO-WHO requirements had a 12 percent reduction in BMR when compared with standard values. Subsequently, we observed low BMRs even when expressed per unit body weight or per unit LBM in chronically undernourished labourers on low energy intakes[15]; a finding also noted by Srikantia[18]. A recent study done in South India was unable to confirm the presence of lowering of BMRs expressed per unit LBM[13]. However, the studies are not comparable and the mean energy intakes of subjects examined by the latter study was over 10 MJ per day. BMRs are doubtless lower in the chronically undernourished subjects but much of the reduction in BMR in CED can be accounted for by reduction in body mass. It has been far more difficult to establish definitely a decrease in the metabolic activity of the LBM indica-