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"OBESITY: DO CARBOHYDRATES MAKE YOU FAT?"

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ABSTRACT

In the past an increase in body weight, essentially due to the accumulation of fat, has been considered, rather simply, to be the result of energy intake exceeding energy expenditure. This implies that the energy derived from the different macronutrients is treated the same within the body. However, more recently it has been demonstrated that energy balance should rather be considered to be the sum of the individual macronutrient balances and that fat balance is far more difficult to attain than that of either protein or carbohydrate.

It has been known for many years that provided protein intake is adequate, an increase or decrease in protein intake is rapidly followed by a subsequent increase or decrease in nitrogen excretion so that nitrogen balance is maintained. Carbohydrates, on the other hand, have always been implicated in obesity due in part to the pleasant taste of simple sugars and their use in confectionery products, which it should be remembered often contain high proportions of fat. A further possibility, supported by many animal studies, is that carbohydrates consumed in excess are converted to fat. Studies in human volunteers will be presented to support the hypothesis that very little carbohydrate is converted to fat, even when large quantities of carbohydrate are consumed and that under normal dietary conditions the body achieves carbohydrate balance. Further evidence will illustrate that fat balance is weakly controlled and that dietary fat is more dangerous for body weight control than either carbohydrate or protein.

Key Words : Carbohydrates, Gulf countries, obesity, protein

INTRODUCTION

In Western Industrialised Nations it has been recognised for many years that obesity is an important factor associated with high mortality and morbidity. Although, in the United States 25% of the population is considered to be overweight and 10% severely overweight (USDHHS, 1988), the prevalence of obesity is much greater in certain sub- groups of the population, of the order of 36% in American Blacks (both sexes) and 46% in Black females (NCHS, 1991) increasing to 60-80% in the Pima Indian population (Knowler et al. 1991).

Few large population, studies have been carried out in Saudi Arabia and the Gulf States, however, it is feared that over the last 20

years increased prosperity, associated with the oil boom, and subsequent changes in life-style and food habits have resulted in an increase in the incidence of obesity similar to that observed in the United States. Studies in Saudi Arabia and Kuwait, suggest that the incidence of obesity is as high as that observed in American Blacks (Amine 1980, Amine and Al-Awadi 1990) and, in a smaller study, similar to that of the Pima Indians (Al-Rehaimi and Bjorntorp 1992).

The increase in incidence of obesity in the Arab Gulf would appear to be due not only to an increase in per capita energy intake, rising from ~2000 kcal/day in 1975 to almost 3000 kcal/day in 1988 (Al-Shoshan 1992) but also to a decrease in energy expenditure, associated with a more sedentary life style (Musaiger 1987).

These observations agree very well with the energy balance equation which predicts that if energy intake is greater than energy expenditure an individual will gain weight. However, the energy balance equation assumes that the energy provided by the macronutrients, protein, carbohydrate and fat, are treated the same within the body and yet weight gain is essentially due to an increase in body fat mass. In reality energy balance depends upon the balance of the individual nutrients (Figure 1) and it is of interest to consider the metabolic fate(s) of the individual nutrients to obtain a better understanding of the contribution of the diet to the development of obesity.

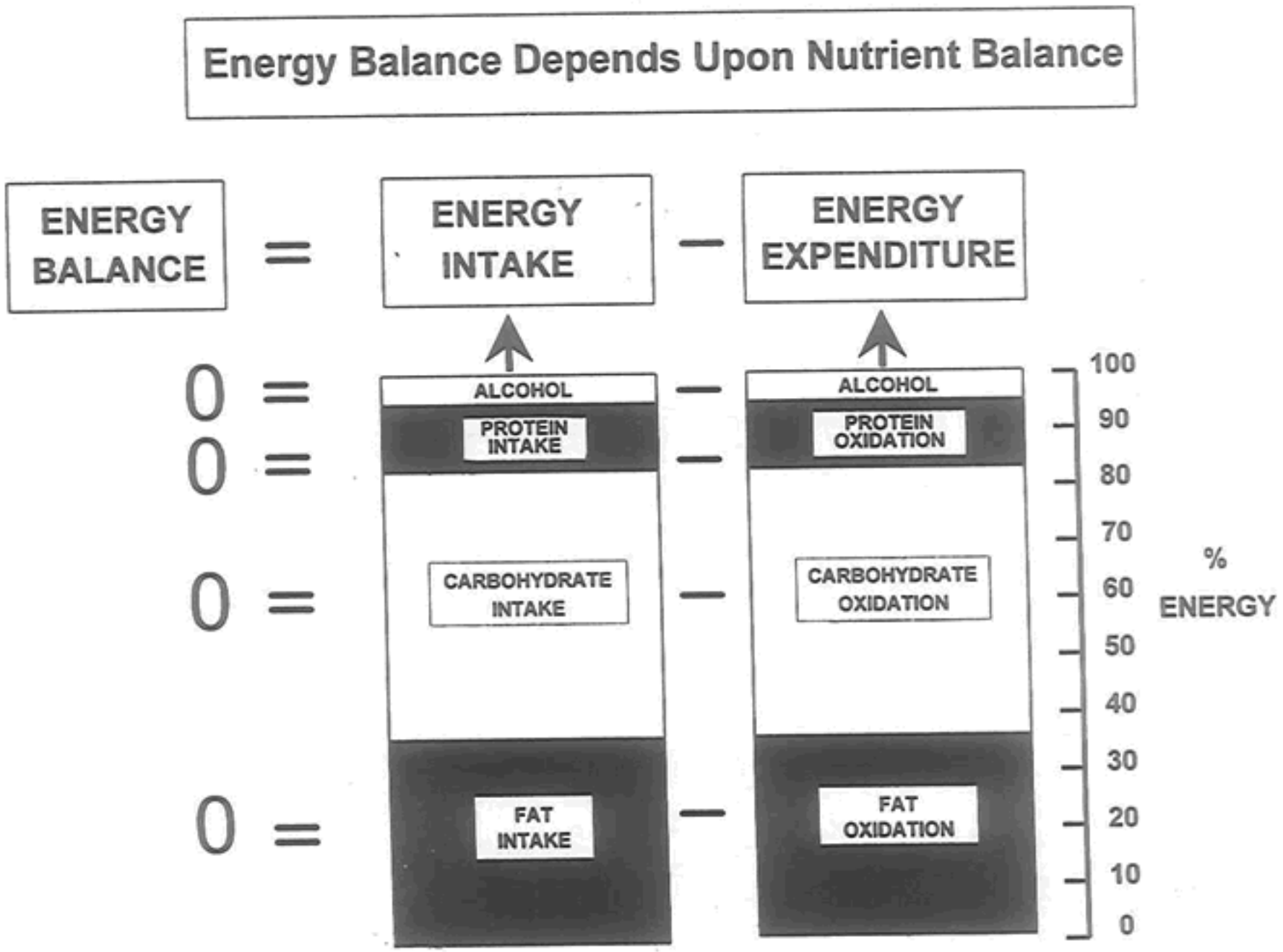
Protein

Proteins which contribute only 10-15% of total energy intake have a number of metabolic options; - protein storage, conversion to glucose and oxidation. Under normal conditions protein storage or a positive protein balance occurs during growth and adolescence. In adults it is quite difficult to increase muscle mass by increasing protein intake alone. However, protein supplementation in combination with intense weight training, such as body builders and weight lifters, or the influence of anabolic sterioids will cause an increase in lean body mass.

Protein conversion to glucose occurs when the liver glycogen stores and carbohydrate intake are insufficient to provide glucose for the brain. This occurs towards the end of an overninght fast and in the initial stages of starvation before ketone bodies become the energy source for the brain.

The fact that protein oxidation closely follows protein intake was demonstrated by Oddoye and Margen (1979). Using a cross-over design in which their subjects were fed either 12 or 36 g nitrogen per day, for a period of seven weeks, they observed that nitrogen excretion

Figure 1


Energy Balance Depends Upon Nutrient Balance
ENERGY BALANCE
=
ENERGY INTAKE
–
ENERGY EXPENDITURE
0 =
ALCOHOL
PROTEIN INTAKE
0 =
0 =
CARBOHYDRATE INTAKE
0 =
FAT INTAKE
–
ALCOHOL
PROTEIN OXIDATION
CARBOHYDRATE OXIDATION
FAT OXIDATION
100
90
80
70
60
50
40
30
20
10
0
%
ENERGY

very closely matched nitrogen intake. When the subjects changed from the 12 g to 36 g nitrogen diet or from the 36 g to the 12 g nitrogen diet nitrogen excretion rose and fell respectively until nitrogen balance was attained. Although they did observe a slightly positive nitrogen balance on the 36 g nitrogen diet, it is rare that such large quantities of protein are habitually consumed. When protein intake is adequate protein balance has been shown to be achieved on a day-to-day basis (Abbott et al 1988).

Carbohydrate

Carbohydrates provide the major proportion of energy in the diet, contributing 45 to 50% in European countries and the United States and even more (~60%) in the Gulf States (Al-Shoshan 1992). Carbohydrates can be stored as glycogen, converted to and stored as fat or they can be oxidised. Although carbohydrates provide 45 to 60% of our daily energy, the body can only store very small amounts of energy as glycogen; 500-1500 g (Acheson et al. 1988), in comparison with the limitless adipose tissue fat stores.

It is commonly believed that dietary carbohydrates are converted to, and stored as fat. Much of the evidence for this is provided by experimental data obtained from animals such as rodents, who consume high carbohydrate diets but require a means of storing energy in the most compact form possible i.e. fat, to enable them to survive periods of food deprivation e.g. winter and hibernation. In man there is some, but little, evidence that *de novo* lipid synthesis occurs. Patients receiving energy in excess of their requirements, in the form of hypertonic solutions of amino acids and glucose, have been observed to have non-protein respiratory quotients (NPRQ) higher than 1.0, indicating the formation of fatty acids from carbohydrates (Elwyn et al. 1979). In healthy individuals considerable amounts of fat synthesis (150g/day) have only been observed during the very unnatural conditions of carbohydrate overfeeding (Acheson et al. 1988). When uncommonly large carbohydrate meals providing 500g or 2000 kcal are ingested, carbohydrate oxidation increases but rarely does the NPRQ exceed 1.0, and over a 24 hour period fat oxidation far exceeds any fat synthesis which might have occurred (Acheson et al. 1982, Acheson et al. 1984). Under normal circumstances when a mixed meal is consumed carbohydrates will be absorbed and disposed of by increased oxidation and/or storage in the glycogen stores which, although small, are sufficiently large to avoid the necessity for *de novo* lipogenesis.

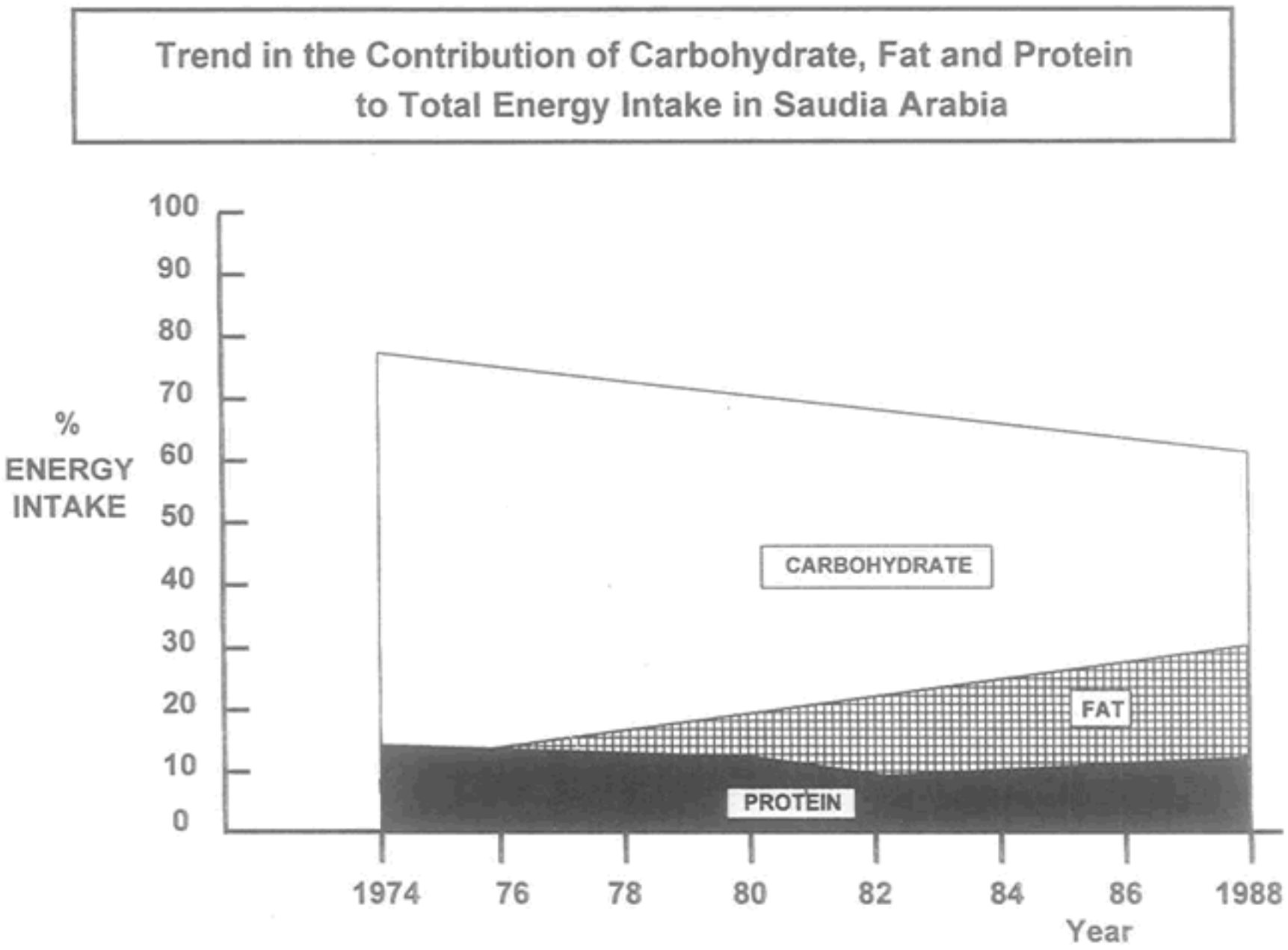
Fat

Fat provides approximately 40% of our dietary energy and once it is absorbed it can only be disposed of by either oxidation or storage. Thus if fat storage is to be avoided, dietary fat must be oxidised. When a mixed meal is ingested, carbohydrate absorption, followed by the increase in blood glucose concentrations, stimulates insulin secretion. This in turn increases glucose uptake by the tissues and glucose oxidation. Unfortunately only a very small increase in insulin concentration is necessary to inhibit lipolysis and fat oxidation. The consequence of this is that although dietary carbohydrate stimulates its own oxidation it will also effectively inhibit the oxidation of any fat contained in the meal. Even when the fat content of a meal is increased significantly, nutrient oxidation is not directed towards greater fat oxidation (Flatt et al. 1985, Schutz et al. 1989).

The implications of this nutrient balance concept (Flatt 1988) are that in the short-term protein and carbohydrate balances are achieved, whereas that of fat balance is not. In consequence, dietary fat is far more dangerous for the maintenance of body weight than either carbohydrate or protein. To a certain degree these metabolic explanations for the development of obesity are supported by the changes in dietary composition which have occurred in the Gulf States over the past 20 years (Figure 2). The contribution of protein to the energy composition of the diet has changed very little, whereas that of carbohydrates has decreased and that of fat has increased (Al-Shoshan 1992). The increase in consumption of fast foods, oil and fat consumption and rapidly absorbed sugars (Musaiger 1990) combined with a more sedementary life style do nothing to prevent the development of obesity in this region.

From the above discussion the answer to the problem is obvious and not very surprising : the amount of fat in the diet should be reduced. A reduction in the fat content of the diet to 30% of total energy, with a maximum of 10% from saturated fats, has already been advocated in the United States and Europe. However, it is more easy to advocate a reduction in fat consumption than to ensure that the population follows this advice. This requires a concerted effort to make people aware of the dangers of obesity and provide them with sound nutrition education and practical advice. The food industry should also be aware of this problem and can contribute by investigating ways of providing interesting and appetising foods, low in fat and high in complex carbohydrates.

Figure 2


Trend in the Contribution of Carbohydrate, Fat and Protein to Total Energy Intake in Saudia Arabia
% ENERGY INTAKE
100
90
80
70
60
50
40
30
20
10
0
CARBOHYDRATE
FAT
PROTEIN
1974
76
78
80
82
84
86
1988
Year

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