Diabetes:

Nutritional Management

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Knowledge does not necessarily lead to behavioural change

History and Epidemiology

The use of low carbohydrate diets in the management of diabetes persisted after the discovery of insulin until well into the 1970s. Before this, recognition of different types of diabetes had scarcely altered this approach. Now, attempts were made to incorporate knowledge about improved glucose tolerance on high carbohydrate diets into overall nutrition management. The problem, with both insulin deficiency and insulin resistance, was that on any particular occasion a greater oral glucose load led to a greater glycaemic response. These 2 considerations were accommodated by encouraging that the consumption of the recommended larger quantity of daily carbohydrate be spread throughout the day.

At the same time, the emergence of dietary guidelines for the reduction of the major chronic diseases of industrialised societies also encouraged a relatively greater intake of plant food and a reduction in saturated animal fat in the community at large. This approach seemed not particularly different from that of the emerging nutritional management approach to diabetes. For those with insulin-dependent diabetes (IDD), it seemed that a preferred food pattern could be determined on general nutritional grounds and insulin tailored around that pattern. This became more possible with the use of twice-daily medium- and short-acting insulins and, later, the use of insulin pens. Short-acting insulin delivered from a cartridge pen just prior to a meal allowed more flexibility of meal times as well. For those with non-insulin-dependent diabetes (NIDD), however, the need to decrease insulin resistance by nutritional means and to avoid glucose overload at a particular time remained important. Where it was possible to reduce body fatness in obese NIDD individuals, this remained the best option.

Given this background, and the present intensity of research in the area, we are poised for new levels of both sophistication and simplification in the nutritional management of diabetes. New data suggest the following possibilities:

- Not only the *degree* of body fatness [1], but also its *distribution*, appear to determine the expression of NIDD [2].
- Nutritional factors may affect the development or expression of diabetes *independent* of body fatness. Doubts have been raised about the merits of a low carbohydrate intake in the avoidance of diabetes [1].

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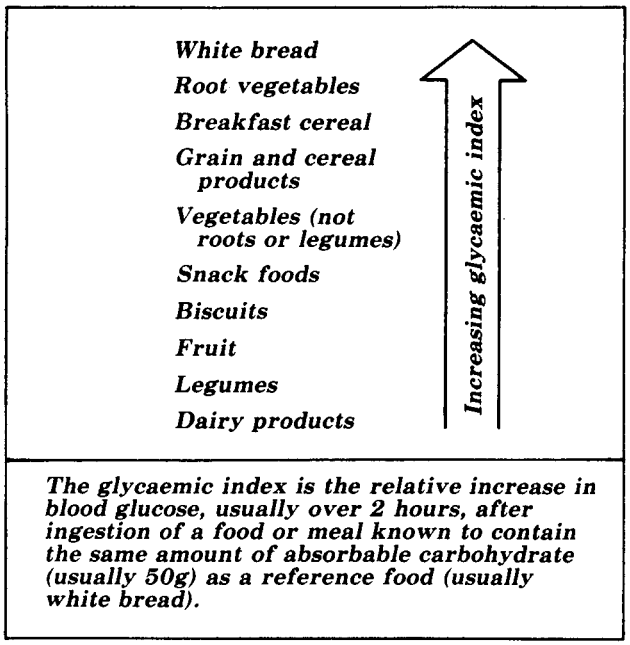

The glycaemic index is the relative increase in blood glucose, usually over 2 hours, after ingestion of a food or meal known to contain the same amount of absorbable carbohydrate (usually 50g) as a reference food (usually white bread).

- The *total food pattern* may be the crucial element [3], and there may be more than one food pattern conducive to low risk.
- *Malnutrition* (as well as overnutrition) may allow the expression of diabetes. *Alcohol abuse* and *proneness to iron storage disease* may also contribute to the development of diabetes.
- Despite the increasing incidence of IDDM, a nutritional contribution to its development is not clear.

More than Food?

Inappropriate food intake is often regarded as the basis of unacceptable blood glucose control when other factors may be responsible or more important, e.g. changes in physical activity [4]. Emotional stress, although difficult to measure and sometimes clinically obscure, may, via the autonomic nervous sytem and release of hormones counter-regulatory to insulin, contribute to hyperglycaemia [5].

Moreover, good social networks may ameliorate the potentially adverse effects of stress on regimen adherence [6]. Too complex a dietary regimen may be counter-productive to patient survival in NIDD [7].

Food and the Pathogenesis of Diabetes

The ways in which food intake may contribute to the development of diabetes, on present understanding, can be summarised as follows:

1. Positive energy balance
2. Macronutrient disproportion, i.e. saturated fat intake too high and carbohydrate and dietary fibre intake too low. However, these dietary characteristics may, in part, be markers for other important food factors. Moreover, there are no adequate prospective data available on the development of diabetes mellitus in relation to such food intake patterns
3. Alcohol abuse probably accounts for a few per cent of the population with diabetes in developed countries
4. Micronutrient deficiencies, e.g. zinc and chromium may contribute to the development of diabetes
5. Food toxins, notably cyanide from cassava, may lead to development of diabetes. Streptozotocin, a β-cell toxin produced by soil micro-organisms, may also be a prototype for other such factors in food. Some cases of diabetes have been related to the consumption of cured meat at a vulnerable stage of pregnancy amongst the mothers of those with diabetes [8]. There has been much debate about the validity of these observations.

Management of Blood Glucose

Food Factors

The food factors which may be of value in the management of blood glucose are:

- physical properties (viscosity and structure)
- components: nutrients and non-nutrients.

The previous notion that a distinction between simple sugars and starches accounted for different effects of food carbohydrate on blood glucose is inadequate. Glucose-containing molecules, whether mono-, di-, penta-, or polysaccharide, have the same effect on blood glucose [9]. Factors other than the carbohydrate content of food alone help

determine blood glucose and insulin responses, and some isolated dietary fibre types alter glucose tolerance on the basis of viscosity.

It seems that one of the most important properties of food which creates a different glycaemic outcome is its physical structure. Grains of various kinds have been shown to have different effects on blood glucose, although the same does not apply to legumes. The differences may relate to the cracking or grinding of grain as opposed to the blending of legumes. Cooking may further modify starch granules, thereby increasing the glycaemic response.

There is no question that dietary fibre isolates, such as cereal brans (wheat), oat bran, and gums, can favourably alter blood glucose. Arguably, this is more food pharmacology than physiology since dietary fibre, as found in food, may not contribute in a chemical sense to the glycaemic response in healthy subjects or diabetic patients [10].

It has been known for many years that the macronutrients fat and protein can affect the glycaemic response to food. It is also very likely that a number of other non-nutrient compounds in food are biologically active in respect of the glycaemic response, e.g. enzyme inhibitors, lectins and polyphenols.

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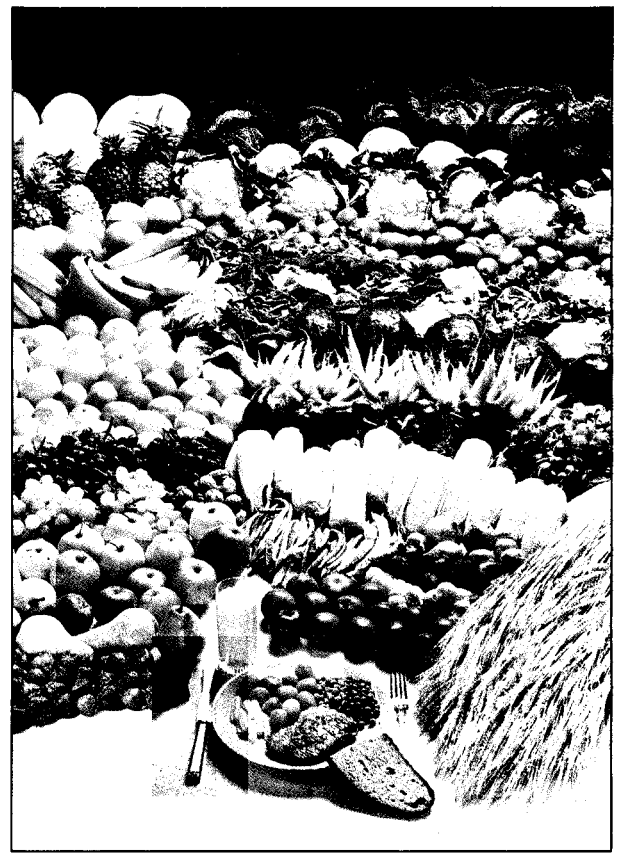
The sum total of both the physical factors and the chemical properties of food is responsible for the diversity of glycaemic responses possible despite the same amount of carbohydrate. The general hierarchy of glycaemic indices, usually with reference to white bread as 100%, is shown in the box. With such a vast range of glycaemic indices from 4 or 5 to 100% (or even a little more for pure glucose or maltose), dietary counselling for diabetic patients cannot afford to restrict itself to the consideration of carbohydrate only [11].

Another important consideration is that although there is considerable inter-individual variation in glycaemic index, it appears that the intra-individual variation in glycaemic index in those with



diabetes is small (personal communication). What this means is that individual counsel in respect of food response is desirable.

Meal Patterns

When the overall use of foods of either low or high glycaemic index is compared in terms of their impact on blood glucose across the day, the prevailing blood glucose is lower with lower glycaemic index foods [11]. Improvement in blood glucose control also appears to be maintained when there is preference for low glycaemic index foods.

It has been assumed that distribution of carbohydrate-containing food *across the day* would be preferable to having more at once for diabetic patients, especially those with type II, who are sensitive to endogenous insulin. This proposition has not been formally tested, however. We recently demonstrated that a main evening meal gives a better overall glycaemic control than does

an even distribution of energy and carbohydrate between 3 main meals and between 3 snacks, at least for those with NIDD [12].

Acute versus Chronic Effects

The continued use of foods with high carbohydrate and dietary fibre contents induces a progressive decrease in fasting blood glucose which reaches a nadir after about 2 weeks. The response above this changed baseline glucose may not be different after 2 weeks. It is most important to distinguish between the acute and longer term effects of foods on overall blood glucose control.

Fat Type and Glycaemic Management

There has been much interest in the role of fish consumption as a protection against ischaemic heart disease. However, when fish oil (18 g/day) was fed for 1 month to men with NIDD, deterioration in fasting glucose and glucose response to a mixed meal was demonstrated [13]. Despite these findings, recent studies show that healthy and diabetic fish-eaters have better arterial wall characteristics than do their non- or low-fish-eating counterparts [14]. Ultimately, it must be more important to know healthy outcomes rather than blood glucose responses. An adverse effect on the latter may prove less important to the patient overall if other effects of fish oil mediate favourable biological responses sufficiently to offset adverse glycaemic effects.

In a study of the effects of dietary olive oil instead of unrefined carbohydrate, a high monounsaturated fat diet led to lower mean plasma glucose levels and reduced insulin requirements, lower levels of plasma triglycerides and VLDL cholesterol, and higher levels of HDL cholesterol [15]. Thus, from the point of view of glycaemic and lipid control, it would seem reasonable for diabetic patients to include olive oil as partial substitution for unrefined carbohydrate. No information is provided in the study as to the sources of dietary fibre.

Moreover fat, in its own right, is more prone to lead to increase in body fatness – such an outcome may, in the long run, offset the advantage

of olive oil seen in the study. Perhaps what is emerging is that the Mediterranean diet, as one of several food cultures, may be conducive to improvement in overall diabetic control. Whether or not it will be possible to extrapolate from one monounsaturated fat such as olive oil to another such as peanut oil or avocado is not clear. The mechanism for the effects of olive oil is uncertain and could be attributable to components of olive oil other than monounsaturated fat.

Food Intake and Body Fatness

Not only total body fat, but its distribution abdominally, increases the risk for diabetes [2] and total mortality [16]. Control of the distribution of fatness is thus likely to be of value in the management of diabetes. There is increasing evidence that, long term, regular physical activity is the preferred way of dealing with body fatness.

Sweeteners and Sucrose

One of the most advocated dietary changes for diabetes has been the avoidance of sucrose. Recent acute [1] and long term studies [18] in NIDD and IDD patients have demonstrated that amounts of sucrose of the order of 30 to 40 g/day have no detectable effect on blood glucose or lipid control. It would therefore seem that diabetic patients can use small quantities of sucrose to sweeten their foods at mealtime or in hot beverages. Diabetic patients should not be encouraged to use sucrose *ad libitum*, but these findings may enable them to adhere to the more important aspects of nutritional management, especially in those food cultures where the use of sucrose is so widespread.

Alcohol

Adverse effects of alcohol relevant to those with diabetes include pancreatic damage and hepatic cirrhosis. Alcohol has a high energy value of its own and may contribute to obesity, as well as the potential to cause hypoglycaemia and to interact with oral hypoglycaemic agents. On the other hand, alcohol may have favourable effects through the facilitation of social activity and increases in HDL cholesterol concentration. In those who have not been alcohol abusers in the past, it would seem

reasonable to take modest amounts of alcohol – 1 to 2 standard drinks per day, preferably with food.

Food and Health Outcomes

Glycaemic and lipoprotein control in diabetes provides fairly ready feedback to patient and clinician about the ways in which food may be important. However, long term morbidity and mortality outcomes are the most important considerations. It is possible that food intake may affect cardiovascular, renal, pharmacological and neurological complications in ways other than those currently regarded as important for blood glucose and lipoproteins. For example, the connection between fatty acid composition and the development of retinopathy is being explored; and protein restriction may delay decline in renal function. It has been suggested that protein intake make up not more than 15% of energy intake. It will probably be necessary to consider food intake in its entirety when predicting these outcomes from a nutritional point of view.

Because of the need to have more outcome data, short of major population studies, there has been considerable recent interest in the non-invasive monitoring of macrovascular disease in those with diabetes. For healthy subjects, the classical risk factors such as total cholesterol and HDL cholesterol are predictive of arterial wall characteristics such as compliance. In NIDD patients, glycaemic status is the most important predictor of arterial compliance [19]. Arterial compliance probably reflects atherosclerosis as well as arterial changes such as glycation of arterial proteins. Plasma free fatty acid concentrations may be almost as important as glucose in the predicition of arterial compliance, but problems of methodological accuracy may not allow measurement of free fatty acids to achieve the same predictive power as glucose.

Alternative Indices

The glycaemic index has proven to be a valuable approach to describing the short term effects of particular foods on blood glucose. Evidence is beginning to show that composite diets made up of food of low glycaemic index may be useful for long term prediction of blood glucose and lipoprotein control. It has yet to be seen, although it is expected, that such an approach would favourably influence morbidity and mortality rates.

Other nutritional considerations, such as essential nutrient adequacy, may require alternative food indices. One of the most frequently advocated dietary guidelines in industrialised countries is that of consuming a wide variety of foods, a recommendation thought to confer protection against chronic disease. In one study, variations in the degree of variety in the diet accounted for about 16% of the variance in arterial wall characteristics [20]. Food variety also significantly predicted fasting blood glucose and the area under a glucose tolerance curve in the same NIDD patients.

Food Education

The emerging understanding of how food intake may favourably influence metabolic control and health outcomes in diabetic patients now needs to be translated into action – through education. It is well known that knowledge does not necessarily lead to behavioural change.

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In an effort to understand facilitators and inhibitors of nutritional change in those with diabetes, a recent study has looked at factors associated with adherence and non-adherence to high unrefined carbohydrate, low fat diets in diabetic patients attending a Melbourne teaching hospital clinic [21]. Those who adhered had a greater orientation towards health and health habits; a lesser need for motivation; a belief that diet was worth while, and a feeling that learning about diabetes had been accomplished. Adherents were more

likely to recognise that they had achieved the use of target foods and they did not find food likes and dislikes a barrier to change.

Individual Applications

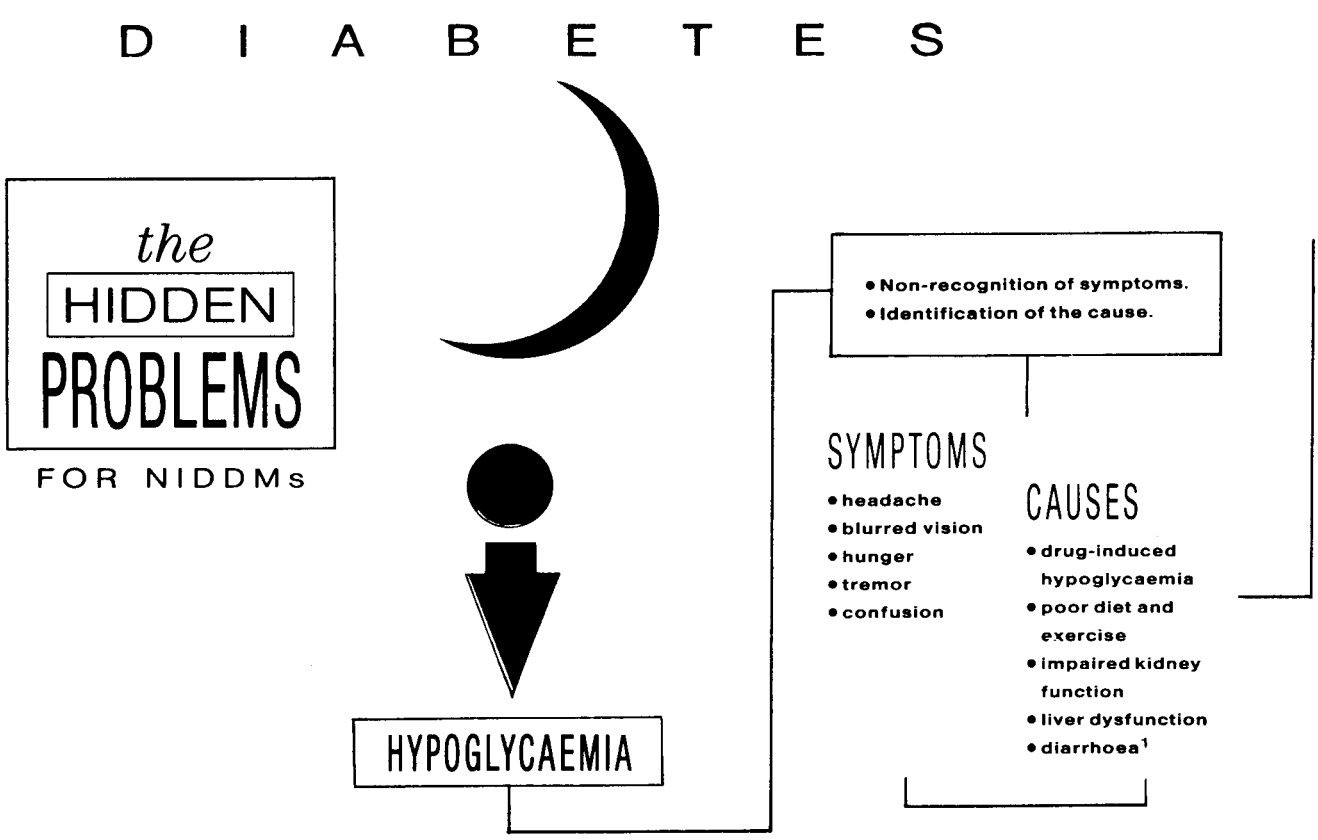
Concepts and principles of relevance in food education for diabetic patients which might be advanced include:

1. Respect for the patient's food culture
2. Consideration of family, occupational and other personal needs
3. An aim for overall health
4. The positioning of food intake amongst other lifestyle variables, e.g. exercise, smoking and stress management
5. The need to judge potential for change in glycaemic control through food in that particular individual (this may require an individual 'experiment')
6. A distinction between short and longer term effects of food on metabolic control
7. Allowance for the use of insulin. For IDD patients, it should be possible to tailor insulin dosage around preferred food choice and meal pattern. For NIDD patients, food will need to be used to increase insulin sensitivity as much as possible
8. Encouragement of self-monitoring of food intake and its relationship to outcomes. These outcomes will be not only the metabolic outcomes of glycaemic and lipoprotein control, but also those of body composition and fat distribution (rather than weight alone), wellness and fitness, and, where possible, indices of macrovascular disease.

The *steps* towards the realisation of the ultimate aims of low morbidity and optimal life expectancy could be:

1. Enunciation of the principles of food management of diabetes
2. Documentation of current food intake and beliefs
3. Definition of the possibilities for favourable food change
4. Evaluation of response(s)
5. Fine-tuning of food intake at successive consultations.

Nutritional management of diabetes is now more respectful of the individual and of ethnicity; it has more to do with food and real life – it is more rational and scientifically based; and it has the prospects of being even more so.



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