Medical Nutrition Therapy – The Relationship of Dietary Fat and Carbohydrate Metabolism in Patients with Type 2 Diabetes

a report by

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The optimal composition of macronutrient intake for people with type 2 diabetes has been a subject of much debate. There are differing lines of thought as to the appropriate amount of carbohydrate, protein and fat that should be consumed to best regulate glucose control. This article will review literature on macronutrient intake in relation to glucose control in patients with type 2 diabetes, with a special emphasis on the impact of dietary fat.

Monounsaturated Fat

The American Dietetic Association recommends that 60–70% of total calories be derived from monounsaturated fat (MUFA) and carbohydrate for persons with type 2 diabetes.[1] However, the specific amount and type of carbohydrate and fat in the diet has been the subject of numerous studies. A comprehensive meta-analysis in people with diabetes concluded that, compared with high-carbohydrate diets, high-MUFA diets improve glycaemic profiles and have a favourable impact on lipoprotein metabolism.[2] Whether this is due to a direct impact on insulin secretion or from a reduction in the carbohydrate load has also been debated.

One study[3] found that diets with a high content of MUFA-rich foods provide a degree of metabolic control that is similar to or perhaps better than that obtained with a high-carbohydrate diet. The author postulates that a healthy diet does not necessarily have to be a low-fat one because a variety of MUFA-rich foods can be incorporated into the diet to increase palatability and therefore lead to better compliance.

One hypothesis for the potentially more favourable affect of MUFA on glycaemic profiles is the secretion of an intestinally derived incretin hormone called glucagon-like peptide 1 (GLP-1). The two major incretin hormones, GLP-1 and glucose-dependent insulinotropic polypeptide (GIP), are secreted in response to ingestion of nutrients.[4] The incretin effect (or glucose-dependent insulin secretion) from these hormones is attenuated in people with type 2 diabetes.[5] In humans, it has been shown that fat and protein intake may stimulate GLP-1, whereas fat and carbohydrate intake may stimulate GIP secretion. This suggests that incretin hormones may contribute to changes in glucose concentration after ingestion of certain nutrients.[6]

Studies have determined that monounsaturated long-chain fatty acids potentially stimulate GLP-1 *in vitro* in rats.[7] Another study further examined this hypothesis *in vivo*.[8] This study concludes that the benefits in terms of glycaemic control in MUFA-rich diets may be explained, at least in part, because these diets increase the secretion of GLP-1. However, since these studies were performed in rats, these results cannot necessarily be extrapolated to human populations.

Many studies do affirm that MUFA-rich diets may have beneficial affects on glycaemic control; however, most of these have been controlled metabolic studies in which subjects were not allowed to regulate their own energy intake. One study[9] found that when subjects were allowed to adjust their energy intake on the basis of satiety, a high-carbohydrate, high-fibre, low-fat diet resulted in greater weight loss than did a high-MUFA diet, and that this low-fat diet did not worsen glycaemic control in patients with type 2 diabetes.

The problem with the latter study, as well as the previously noted metabolic studies, is that many of these were short-term studies (two to six weeks in duration). Two long-term studies[1,10] (eight to 12 months in duration) found that both MUFA and low-fat diets can be beneficial for people with type 2 diabetes. These longer studies determined that both diets have comparable effects on anthropometric and metabolic parameters in adults with type 2 diabetes and that overweight or obese subjects had similar weight loss on both diets.

Polyunsaturated Fat

Many studies have shown that overall fat intake does increase the risk of cardiovascular disease; however, it is becoming more apparent that the type of fat is as important as the amount of fat in the diet. As noted above, there have been many studies on the topic of MUFA in relation to type 2 diabetes; however, fewer studies have been conducted on polyunsaturated fat (PUFA). Based on studies in Eskimo populations, there has been some discussion that populations with an increased intake of PUFA have a lower incidence of type 2 diabetes.

In normal subjects, acute ingestion of diets enriched with PUFA augmented insulin secretion significantly more than a diet comprising

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primarily saturated fatty acids.[11] In contrast, a similar study in patients with type 2 diabetes did not show any benefit of a diet enriched in PUFA.[12] The reason for the failure is unclear, but a possible explanation could be the attenuated incretin response observed in patients with type 2 diabetes.

The studies noted above were conducted in small control groups (~12 people) and there are few large-scale studies. In 2001, two large prospective studies were undertaken on fat intake and the incidence of type 2 diabetes in women. In one study, 84,204 women were studied over the course of 14 years.[13] This study found that total fat, saturated fat and MUFA intakes are not significantly associated with risk of type 2 diabetes, but that dietary transfatty acids increase and dietary PUFA reduces the risk of type 2 diabetes. The other study on PUFA was a prospective cohort study of 35,988 women over an 11-year period.[14] This study concluded that PUFA was inversely related to diabetes risk when substituted for saturated fats.

Saturated Fat

There have been many studies that have suggested that an overall high-fat diet may have adverse metabolic effects. These have mainly been associated with saturated fats and the increased risk of cardiovascular disease. Cardiovascular disease is a co-morbidity of diabetes, and studies have shown that the atherogenic alterations of cardiovascular disease and increased blood lipids are inter-related with insulin resistance and diabetes. One study[15] looked at the effect of different types of dietary fat using MUFA (olive oil) and saturated fat (butter). The researchers found that, in the short term, butter increased insulin response more than olive oil. However, butter intake also increased overall free fatty acid and triglyceride concentrations, which may lead to reduced insulin sensitivity and dyslipidaemia in the long term. The mechanism by which saturated fats increase insulin response is unclear; however, one theory discussed is the previously noted GIP-mediated response. An indirect effect via GIP-mediated glucose-dependent insulin secretion may be due to the fact that fat is a potent dietary stimulus of GIP.[16]

Although the above study noted an increase in insulin response to a particular saturated fat (butter), overall research concludes that, in terms of cardiovascular disease, saturated fat has been found to have an atherogenic effect. However, in terms of glucose control there are limited data to suggest that increased saturated fat has an adverse effect on insulin response in people with type 2 diabetes.

Transfat

There has been a lot of recent publicity on the role of transfats and increased risk of cardiovascular disease. There has been so much concern over the role of dietary transfats that the US Food and Drug Administration now requires that transfats be included on food labels. A recent review study[17] concludes that transfats from partially hydrogenated oils have considerable potential for harm because of evidence that transfats promote inflammation. The study references several studies that conclude that the presence of inflammation is an independent risk factor for atherosclerosis, sudden death from cardiac causes, diabetes and heart failure.

With regard to diabetes, there are few studies on the direct impact of transfats on insulin response or glucose control. A previously discussed large prospective study that followed 84,204 women found that subjects with high transfat intake and low PUFA intake were 66% more likely to develop type 2 diabetes over a 14-year duration than those with a low transfat and high PUFA intake. The study also found that for every 2% increase in calories from transfats, risk rose by 39%. The study authors acknowledge, however, that the positive associations with transfat intake were observed primarily in obese and less physically active women. The authors speculate that the effects of dietary transfats are not sufficient to cause diabetes, but that the presence of underlying insulin resistance may increase the probability of developing the disease.

Carbohydrate

The appropriate amount of carbohydrate intake in diabetes management has been an ongoing debate. Research has shown that the total daily amount of carbohydrate intake does affect blood glucose levels and that carbohydrates have the most immediate effect on blood glucose levels. In addition, excess carbohydrate intake leads to reduction in high-density lipoprotein (HDL)-cholesterol and higher triglyceride levels, which have been shown to have an atherogenic affect that leads to cardiovascular disease.

There is conflicting research on the impact of a high-fat, low-carbohydrate diet versus that of a low-fat, high-carbohydrate diet in regard to glucose control. Some studies indicate that it may be the type of carbohydrate that may have overall health implications. One study found that the glycaemic index of foods in a high-carbohydrate diet has differing affects on glucose control.[18] Subjects who consumed a high-carbohydrate diet with low-glycaemic-index foods had lower mean plasma glucose levels than subjects who consumed a high-carbohydrate diet consisting of foods with a high glycaemic index. In other words, subjects who ingested high-fibre, less refined carbohydrates had better mean plasma glucose levels than those who did not.

Protein

It has been widely thought that protein, when ingested with carbohydrate, slows the absorption of carbohydrates. There have been a number of studies that have concluded that in mixed meals the addition of protein to carbohydrate may reduce circulating glucose concentrations in people with type 2 diabetes. One study[19] concluded that protein, when given with carbohydrate, increased insulin secretion and reduced post-prandial glucose.

Another study[20] found differing results with regard to glucose concentration. In this study, fat and protein were added to breakfast meals containing 60g of carbohydrate. After the protein-enriched breakfast, post-prandial insulin responses were significantly increased. However, glucose concentrations were similar whether the subject consumed a regular, fat-enriched or protein-enriched meal.

Although there is debate as to whether dietary protein directly affects glucose absorption, there are a number of studies that have determined that a higher-protein diet does not affect glucose concentrations as readily as a higher-carboydrate diet. A study in 2003[21] concluded that a high-protein diet lowers blood glucose post-prandially in persons with type 2 diabetes and improves overall glucose control. A second study[22] confirmed these results and concluded that a low biologically available glucose diet may reduce circulating glucose concentrations in people with untreated type 2 diabetes.

The one result that many of these studies have in common is that, regardless of the meal type – a mixed carbohydrate–protein meal or a protein-only

meal – protein does appear to increase insulin secretion. This does not, however, seem to have a direct impact on lowering blood glucose concentrations. Many of the researchers conclude that lowered glucose concentrations in higher-protein diets may be due to a decrease in carbohydrate intake and not necessarily directly related to protein ingestion.

Another hypothesis is that exogenous protein may have an effect on the activity of incretin hormones. A study in mice[23] found that whey protein increased the levels of both intact GIP and intact GLP-1, resulting in increased insulin secretion. Whey protein inhibited the dipeptidyl-peptidase IV (DPP-IV) enzyme, which is the key enzyme in the rapid degradation of both GIP and GLP-1. Whether similar inhibition of the DPP-IV enzyme by whey protein would occur in humans in unknown, but deserves further study.

Discussion

Overall results show that in short-term studies MUFA diets may be beneficial to glyacemic control in people with type 2 diabetes. In controlled metabolic studies there is debate as to whether this is due to a direct impact on insulin secretion or to the reduction of the carbohydrate load. When subjects were allowed to regulate their own intake, those who consumed a high-fibre, high-carbohydrate diet had no detrimental impacts on glucose control and greater weight loss than those on a high-MUFA diet. Long-term studies have found that both MUFA-rich and low-fat diets may be beneficial to overall health in patients with type 2 diabetes.

There have been fewer studies conducted on the effects of PUFA diets on glycaemic control in humans and the results of short-term studies have been conflicting. However, long-term prospective studies have found that PUFA may reduce the risk of developing type 2 diabetes, especially when substituted for saturated fat.

There are studies that found that saturated fat intake may increase insulin secretion in the short term. However, there has been little evidence that this increase in insulin has a direct impact on glucose control. In addition, there is evidence that saturated fat does increase the risk of cardiovascular disease, which is a co-morbidity for diabetes and, therefore, may have overall detrimental health effects in the long term.

Little research has been conducted on the direct impact of transfats on glucose concentrations. However, there is evidence that people with a high transfat intake may be at greater risk of diabetes. This has been associated with the presence of inflammation and its role in cardiovascular disease, which is an independent risk factor for diabetes.

It has been shown that carbohydrate intake has a direct impact on glucose control. This is due to the fact that carbohydrate is the most readily converted macronutrient to glucose due to the process of glycolysis. Therefore, the amount of carbohydrate ingested can most certainly have a direct impact on glucose control. What seems to be as important, however, is the type of carbohydrate. Consumption of high-fibre, less refined carbohydrate is more beneficial for glycaemic control than foods with a high glycaemic index. There is evidence that dietary protein may increase insulin secretion and does not negatively influence blood glucose, although whether ingestion of protein with carbohydrate will slow the absorption of carbohydrate has been debated. Studies have shown that the ingestion of protein with carbohydrate lowers post-prandial glucose, but studies of whether this is due to a direct impact from dietary protein or a decrease in the carbohydrate load have been conflicting.

Based on a review of literature on macronutrients in relation to glycaemic control, it is apparent that more long-term studies are needed to accurately assess the optimal macronutrient distribution in people with type 2 diabetes. A factor that does appear to affect blood glucose control in type 2 diabetes is not only the distribution but also the type of individual macronutrients. Another major factor in blood glucose control is weight management in overweight or obese patients with type 2 diabetes.

These findings support the fact that a diet comprising unsaturated fats and higher-fibre carbohydrates may be the most beneficial diet for weight management and glycaemic control in people with type 2 diabetes. The challenge of medical nutrition therapy is to educate patients on the importance of substituting monounsaturated and polyunsaturated fats for saturated fat while also substituting high-fibre carbohydrates for low-fibre, more processed carbohydrates. The actual distribution of macronutrients may depend on the individual's medical history and what works best for an individual in terms of weight management and palatability. ■

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