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High or Low Carbohydrate Diets in the Prevention and Treatment of Obesity?

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It is widely accepted that our genetic background influences how efficiently we adapt to positive or negative energy balance. The classical overfeeding study of identical twins from Quebec clearly demonstrated that the amount of weight gained by different individuals can vary up to three-fold when overfed an equal number of calories.[1] However in spite of all of the advances in the understanding of the genetic basis of weight regulation, genes cannot explain the explosive increase in the prevalence of obesity over the last three decades. Therefore obesity is generally accepted as resulting from an imbalance between food intake and daily physical activity. Obesity is now the largest nutrition-related problem in the developed world.

Lifestyle changes and food intake

Health guidelines have been focused on 3 particular lifestyle factors:

1. Increase levels of daily physical activity
2. Reduce intake of fats
3. Reduce intake of sugars, particularly added sugars.

The urgency to take public action to increase physical activity levels is widely accepted, but there is much debate about changing one dietary macronutrient above another. In the 1970s, some nutritionists considered sugars, particularly added sucrose, as perhaps the most important dietary factor leading to weight gain. However, during the 1980's the message that fat in the diet is responsible for excess energy intake and weight gain became stronger.

As a consequence of recommendations to reduce fat intake, and particularly saturated fat, the market for low-fat food expanded rapidly in the 1990s. Actual intakes of fat (expressed as % energy) measured in dietary surveys has decreased significantly over recent decades. A number of meta-analyses in which the relationship between ad-libitum low-fat diets and body weight was investigated have shown that higher dietary fat intake is directly associated with obesity. However, the scientific evidence for the relationship between dietary fat intake and the prevalence of obesity has been challenged in recent years[2].

Another important argument concerns the so-called fat paradox. With the increasing popularity of lower-fat products, food intake statistics have shown a decrease in dietary fat intake, but a rise in the prevalence of obesity. However intake statistics must be considered with great caution as we know that systematic under-reporting of energy and fat occurs probably in the whole population, but most certainly in the obese (who are no longer a minor segment of the population in most countries).[3] Despite all efforts to validate food intake data, the message to reduce fat intake has an impact on food recording. This massive systematic under-reporting is reinforced by the recent WHO/FAO report on Diet, Nutrition and the Prevention of Chronic Diseases, which showed that production figures for edible fat and available food energy has risen steadily over recent decades. (See Table 1)

Table 1
Edible fat and energy production from national food balance sheets.
Source WHO/FAO[4]

Availability	1965	1998	% increase
Fat (g/day)			
USA	117	143	+ 23 %
Europe	117	149	+ 27 %
Energy (kcal/day)			
USA	2947	3380	+ 15 %

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The fat content of food has a direct relationship with energy density, which relates to the incidence of overweight.

Although food wastage has increased substantially, it is unlikely to explain the increase in production completely. In fact, the decrease in fat intake observed in the national food surveys can be accounted for a great deal by the under-reporting phenomenon.[3]

Should we recommend low fat or low carbohydrate diets?

Body weight changes are mostly related to differences in energy intake and so the relation between type of macronutrient and body weight when subjects have unlimited access to food is important.

Meta-analysis of the relationship between ad-libitum, low-fat diets and body weight control have shown that reduction of dietary fat intake is directly associated with weight loss.[5]

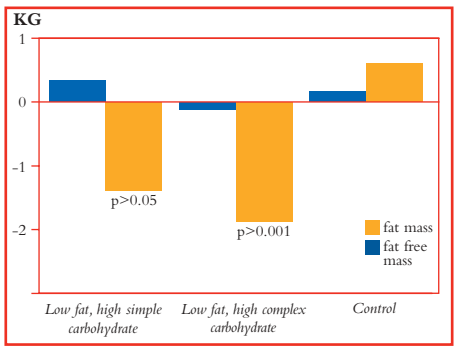
In general, a reduction of 10% energy coming from fat leads to a weight loss of about 2-3 kg. Obese subjects will lose more weight. These findings underline the importance of the public health measure to reduce fat intake. A decrease in body weight of 2–3 kg by means of a general reduction in fat intake of around 10% energy in the general population could reduce the prevalence of obesity from 25% to 15%.

Human dietary intervention trials looking at the combined effects of low fat intake and the type of carbohydrate on body weight are very limited.

The only large-scale, long-term, randomised control trial on the role of carbohydrate/fat ratio in the diet, as well as the simple versus complex carbohydrate issue, is the European CARMEN multi-center trial, which involved 398 moderately overweight subjects in 5 different countries.[6] This study investigated the effect on energy intake, body weight, and blood lipids over 6 months of unrestricted intake of low-fat diets (reduction of 10% energy), rich in either simple or complex carbohydrates. The results showed that both of the 'low-fat, high-carbohydrate' diets reduced body weight significantly: by 1.6 kg (for high simple carbohydrates) and 2.4 kg (for high complex carbohydrates) compared with a control normal-fat, normal-carbohydrate diet. (Fig 1)

Figure 1

Changes (kg) in fat free mass and fat mass on a 'low fat, high simple carbohydrate' diet, 'low fat, high complex carbohydrate' or 'normal fat, carbohydrate' diet (Control). (Adapted from ref 6).



The energy density of both high carbohydrate diets was significantly reduced (–0.10 (high simple) and –0.18 (high complex) kcal/g, respectively), although a large number of the low-fat alternatives containing higher levels of carbohydrates, particularly sucrose, were used in this trial.

Recently, the debate about high or low carbohydrate diets has received new attention from both the media and the scientific world as to the effects of the Atkins diet (high fat and protein/low carbohydrate). Studies published in the last two years[7 8 9 10] comparing the Atkins diet (low carbohydrate) versus a low fat – high carbohydrate diet showed an advantage in weight loss during the first months of dieting for the high fat & protein – low carb diets, but no difference in weight loss after one year. The consensus was: that the low carbohydrate – high fat/protein diets are effective for short-term weight loss, but not at one year; that they are not associated with deleterious changes in glucose metabolism, insulin sensitivity or cardiovascular risk factors; but that more studies are needed to evaluate long-term efficacy and safety.

In May this year the first results from the European multi-centre NUGENOB trial were presented at the European Congress on Obesity meeting in Prague.[11] 747 obese subjects in eight European centres were put on a very controlled, energy restricted (-600 kcal/day), low fat-high carb (25%/57% energy respectively) or a high fat-low carb (40%/43% energy respectively) diet for 10 weeks. Both groups lost an identical amount of weight. (6.6 vs 6.9 kg).

What can we learn from these studies? First of all that a calorie is still a calorie. One can argue that on a metabolic level the high fat, and more importantly high protein, diets are less energy efficient. However these differences are hardly detectable in free living subjects where the differences in energy intake are normally much greater. Secondly, the high fat-low carb diets are also higher in protein. Protein has more satiating power than carbohydrate, and certainly more than fat per calorie. This combination with the lower energy efficiency makes protein a very attractive candidate to replace, to a certain extent, fat in the diet to maintain a better body weight. Intervention studies with an increase in protein content of the diet do show a positive effect on body weight loss[12] as well as body weight regain.[13]

This debate also shows us that there are few other areas where the frontiers of science are so confused by such a multitude of conflicting opinions. Nevertheless, a better understanding of what is going on is directly needed since the epidemic of obesity is growing at rate that urgently needs valid intervention strategies at a population level.

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Effects of a Low-Fat, High-Carbohydrate Diet on Weight Loss

The efficacy of ad libitum low-fat diets in reducing weight and body fat in overweight adults remains controversial. This study examined whether, compared to a control diet, a freely consumed high-carbohydrate, low-fat diet resulted in spontaneous weight loss among overweight subjects. Additionally the impact of exercise added to the high-carbohydrate regimen was assessed.

Thirty-six overweight, sedentary, men and women aged 55-85 years took part in the study for 14-weeks. Participants were randomly allocated to the control, a high-carbohydrate diet or to a high-carbohydrate diet in combination with exercise. Foods were supplied to provide 150% of predicted energy needs.

The groups following the 'high-carbohydrate' and 'high-carbohydrate + exercise' diets lost significant amounts of body weight (-3.2kg and -4.8kg) and body fat (-2.2% and -3.5%), compared to the control group, with the greatest reductions in the 'high-carbohydrate + exercise' group.

Unrestricted consumption of a high-carbohydrate diet for 14 weeks, with no attempt at energy restriction, resulted in significant decreases in weight and body fat. The addition of exercise showed a trend towards greater loss of both body weight and body fat.

This study challenges the suggestion that high-carbohydrate diets encourage body fat storage. It supports the contrary view that body fat balance is maintained mainly by total fat intake and not by total energy intake. In addition to this, exercise is known to result in increased fat breakdown.

Low-carbohydrate diets have recently become popular for individuals attempting to lose weight. It has been hypothesised that because dietary carbohydrate stimulates insulin production this could lead to additional fat storage. This study does not support this hypothesis. The results of this study show that free consumption of a high carbohydrate diet, either with or without exercise, was highly acceptable to individuals and resulted in successful reduction to both weight and body fat. This approach appears to be an effective method of weight loss for the older, sedentary population.

Nutrient	Diet type	
	Control	High Carbohydrate
Protein	14%	19%
Fat	41%	18%
Carbohydrate	45%	63%
Fibre	7g/1000kcal	26g/1000kcal

Reference: *Effects of an Ad Libitum Low-fat, High-Carbohydrate diet on body weight, body composition, and fat distribution in older men and women. Hays NP et al (2004) Archives Internal Medicine 164:210-217*

Comment: *We know from population studies that individuals who eat a high-carbohydrate diet tend to eat less fat, more fibre, and have a lower body weight than individuals eating a high fat diet. This is also confirmed by the CARMEN study (see page 2). The current study has added new evidence that simply increasing the carbohydrate content of the diet results in successful weight loss, even when energy intake is not controlled. A high-carbohydrate, low-fat diet offers a successful route to weight control. Regular physical activity will improve the results even more.*

Health Implications of Low-Carbohydrate diets

While the concept of low carbohydrate diets has been with us for many years, they appear to have had a recent resurgence, fueled in part by media attention. However, scientific evidence relating to the short- and long-term health effects of reducing carbohydrate intake is scarce. The evidence that does exist suggests that low-carbohydrate diets offer no significant advantage over traditional, energy-restricted, nutritionally balanced diets in terms of weight loss or weight maintenance. While the health impact of restricting carbohydrate for short periods is likely to be low, of more concern are the potential health effects of pursuing a low-carbohydrate style of eating for longer periods of months or even years.

There are many variations of a low-carbohydrate diet. For this review a low-carbohydrate diet was considered to contain less than 100g of carbohydrate per day, with typically 50-60% of energy coming from fat, 20-30% from protein and less than 30% from carbohydrate. By comparison a standard diet was assumed to contain approximately 50% of energy from carbohydrate.

The theory behind low-carbohydrate diets is that eating less carbohydrate lowers background insulin levels and promotes the breakdown of body fat for energy. However, numerous studies demonstrate that weight loss on low carbohydrate diets is entirely due to lower energy intakes rather than a metabolic effect of a lower carbohydrate intake per se. Often overlooked is the fact that protein rich foods also raise insulin levels, which argues against the insulin theory as a mechanism. In addition, the hypothesis that protein and fat are more effective at reducing hunger has not yet been proven in real diets. Many factors (such as mood, ambience, activity etc.) influence appetite, hunger and food intake, with macronutrient intake being just one element of these.

When the body is starved of carbohydrate it begins to burn fat for energy. One side effect of this is the production of ketones, which can also provide an alternative source of energy for body tissues. Ketones, however, can result in headache, bad breath and fatigue. Studies exploring the long-term safety of diets generating large amounts of ketones diets are few. Side effects also include dehydration, gastrointestinal symptoms, low blood sugar levels, vitamin deficiencies, cognitive impairment, and osteoporosis, all of which pose potential health risks to individuals. In addition, the combination of ketosis and dehydration is likely to have a negative impact on the activity level of the overweight, unfit person.

All energy restricted diets result in a loss of body fat and protein, and neither a high- or low-carbohydrate approach offers particular advantages in terms of preservation of lean tissue like muscles. However, low-carbohydrate diets are more likely to be nutritionally inadequate as they limit food choice, typically restricting fruit, vegetables, whole grain cereals and dairy foods such as milk and yoghurt, and particularly intakes of fibre, antioxidants, thiamin, folate, vitamins A, E, B6, calcium, magnesium, iron and potassium.

Weight loss per-se often results in a reduction in total and LDL cholesterol, and triglycerides. However, reductions in lipid levels are typically greater from diets low in saturated fats (low-carbohydrate diets typically are high in saturated fats).

Of potential concern is the impact of a low-carbohydrate diet and ketosis on the muscle function of the heart. Animal studies have shown a loss of heart contractile function of up to 50% when ketones are the main energy source, an effect which is reversed when glucose is supplied. The safety of low-carbohydrate diets in relation to cardiac arrhythmias needs to be established. Foods rich in carbohydrates often also have higher fibre levels that help to reduce feelings of hunger.

Any diet that restricts energy intake, irrespective of dietary composition, normally results in weight loss. Where a decrease in body fat is the desired end point, low-carbohydrate diets offer no significant advantages to the dieter over nutritionally balanced, low calorie diets. Although further research is needed, current available evidence suggests the reverse may be true, in that the metabolic consequences of a low-carbohydrate diet may put the individual at risk of a number of adverse health consequences.

Review reference: *Low-carbohydrate diets: what are the potential short- and long-term health implications? Bilsborough SA & Crowe TC (2003) Asia Pac J Clin Nutr 12:396-404.*

Comment: *Weight loss comes down to one simple fact – if you eat less energy than you burn you will lose body fat, no matter what combination of carbohydrate, proteins and fats that you choose to consume. Many are unaware of the potential adverse health consequences of particular diets and are therefore not making fully informed choices The potential costs for long term health of low carbohydrate dieting are still uncertain. A safer, and equally effective route is to follow an energy restricted, high-carbohydrate, high fibre, low fat diet combined with regular activity.*

Fibre-Rich Carbohydrates Combat Syndrome X

This paper reviews the role of fibre rich carbohydrates in Syndrome X, also called Insulin Resistance Syndrome. This syndrome is a specific cluster of metabolic abnormalities, including abdominal obesity, insulin resistance, raised blood pressure and raised blood lipids. This condition which affects many people, significantly increases the risk of coronary heart disease and stroke.

Syndrome X – clinical symptoms

- Abdominal obesity
  - waist >102cm in men
  - waist > 88cm in women
- Raised blood glucose levels & insulin resistance
- Raised cholesterol & triglycerides
- Hypertension

Major health organisations have historically recommended high-carbohydrate, low-fat diets to reduce chronic disease. However, it has recently been suggested that a high intake of carbohydrate, and especially refined carbohydrate, may adversely affect one or more of the symptoms of Syndrome X, for example increasing triglyceride levels.

Research results are however inconsistent, and no clear consensus has been made. This is due to differences in methods used and the dietary parameters studied.

This review draws several conclusions from the evidence available. Weight loss, and specifically the reduction of body fat, may be the most effective strategy for improving the abnormalities associated with Syndrome X. Freely eaten high-carbohydrate, low-fat diets generally result in weight loss, and would thus be preferable to a diet high in mono-unsaturated or poly-unsaturated fats for insulin resistant individuals. Fibre rich diets may be less energy dense and may promote satiety, thus aiding weight loss further.

In addition, fibre rich foods also contain other beneficial components e.g. essential fatty acids and antioxidants. Epidemiological studies suggest that these components may exert an effect independently of fibre intake alone in reducing risk of coronary heart disease.

Fibre intakes among the general population remain low, therefore promotion of a healthy diet, remains a primary focus of consumer education.

While further research is needed, an ideal diet for people with Syndrome X appears to be one that is high in fruit and vegetables, wholegrain cereals, and low fat dairy foods, contains fish, chicken and small amounts of red meat, and is low in fat, saturated fat, and added salt.

Review reference: *The effect of fiber-rich carbohydrates on features of Syndrome X. Davy BM et al (2003) J Am Diet Assoc 103:86-96.*

Comment: *Syndrome X is increasingly recognised by health professionals as a problem to be taken seriously. This review provides a scientific basis for the treatment and prevention of Syndrome X using a healthy eating, high-carbohydrate, high fibre approach to controlling both weight and biochemical parameters.*

Sugar Intake and Risk of Type-2 Diabetes in Women

The role of sugar in the development, and treatment of Type-2 diabetes has been an area of interest for many years. This prospective study of 39,345 middle-aged American women, examined whether the amount or type of sugar eaten is associated with an increased risk of developing Type-2 diabetes.

Dietary habits were assessed at baseline and throughout the 6 years of follow up. During follow up 918 cases of Type-2 diabetes developed, and no definitive influence of sugar intake on the risk of developing Type-2 diabetes was found. Glycemic Index and intake of starch were not associated with an increased risk of Type-2 diabetes.

In summary a high intake of sugars did not lead to higher prevalence of Type-2 diabetes. However the results of this study should not be interpreted as an endorsement for unlimited sugar intake. Rather it should be emphasised that moderate sugar intake can be incorporated into a well-balanced diet.

Reference: *A prospective study of sugar intake and risk of type 2 diabetes in women. Janket S et al (2003) Diabetes Care 26:1008-1015.*

Comment: *Typically high-carbohydrate diets contain a mixture of both simple and complex carbohydrates. It is therefore logical to examine not only the amount of carbohydrate eaten, but also the type of sugar consumed. This large prospective study shows that eating sugar per-se does not appear to cause Type-2 diabetes and that sugars can be consumed in moderation as part of a healthy balanced diet.*

Carbohydrate and Fibre Recommendations for Diabetics

This meta-analysis reviewed international nutrition recommendations, with a special focus on carbohydrate and fibre, in order to form recommendations for individuals with diabetes, and for those at high-risk of developing diabetes.

Most international organisations recommend that diabetics achieve and maintain a desirable body weight, with a BMI of 25 or less. Most also recommend a carbohydrate intake of at least 50-60% energy, with an emphasis on whole grains, fruits, vegetables, beans and pulses. Many recommend some form of restriction of sugar intake and an increase in fibre intake. At present there is no clear consensus on use of glycemic index. Total fat is usually restricted to below 30% energy, with an emphasis on restricting saturated fats. These core recommendations, made by diabetes associations in the UK, USA, Australia, Canada, across Europe, Japan, India and South Africa, formed the basis for the review of evidence.

In a review of 24 clinical studies, the fibre content of the diet appeared to play a key role in control of blood glucose, cholesterol and triglycerides levels. A summary of the diets and their impact on clinical outcomes is provided in table 1. The low fibre vs. high fibre comparisons shown indicate that increasing the fibre content in the diet of a diabetic individual is likely to improve glycemic control and lower risk for coronary heart disease.

Table 1: ***Comparisons of different diets on clinical outcomes.***

Diet A		Diet B		Outcomes
Moderate carbohydrate (30-59% energy), high fibre (≥20g/1000kcal)	vs	Moderate carbohydrate (30-59% energy), lower fibre (≤10g per 1000kcal)	→	Higher fibre content resulted in significantly lower blood glucose, cholesterol and triglyceride levels
High carbohydrate (≥60% energy), high fibre (≥20g per 1000kcal)	vs	Moderate carbohydrate (30-59% energy), lower fibre (≤10g per 1000kcal)	→	High CHO and fibre gave significantly lower fasting, post-prandial and fasting glucose, haemoglobin A1c, total and LDL cholesterol, HDL cholesterol* and triglycerides.
Low Glycemic Index diet	vs	Higher glycemic Index Diet	→	Low GI diets are associated with lower fasting glucose and lower glycated protein values.

** The small increase in risk for heart disease likely to arise from a lowered HDL cholesterol was reported to be more than compensated for a larger reduction in risk arising from reduced LDL cholesterol and triglycerides level.*

Based on the results of this analysis, diabetics are recommended to achieve and maintain a desirable body weight, by reducing energy intake and increasing physical activity levels. Based on a compilation of results, the recommended diet should contain at least 55% energy from carbohydrate, 12-16% energy from protein, 30% or less energy from fat, 12-15% energy from mono-unsaturated fats and 25-50g/day of dietary fibre. Information on glycemic index should be included in the teaching of diabetics.

Translation of these recommendations into practical guidelines equates to the daily choice of whole grain breads, breakfast cereals and pasta, brown rice, beans and pulses, peas, fruits and vegetables.

Reference: *Carbohydrate and Fibre recommendations for individuals with diabetes: A quantitative assessment and meta-analysis of the evidence. Anderson JW et al (2004) J Am Coll Nutr 23:5-17*

Comment: *Comparison of the recommendations made by Diabetes organisations across the globe produces some remarkable similarities. The healthy diet for the diabetic, or those at risk of diabetes is now clearly established as the same as that recommended to the entire population for good health – a diet that is based upon fibre-rich cereal products, with beans and pulses, nuts, lean meats, low fat dairy foods and fish included on a regular basis.*

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