Dietary strategies for weight management—the importance of carbohydrates

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Abstract The prevalence of obesity is increasing rapidly in all age groups globally and is one of the fastest growing epidemics, now affecting 4 to 8% of children and 10 to 20% of adults. Obesity is followed by serious co-morbidities such as type 2 diabetes, cardiovascular disease, certain cancers, and reduced life expectancy, and these complications may account for five to ten percent of all health costs. There is robust evidence to support the view that a diet which is low in carbohydrates and high in fat is energy dense and, together with physical inactivity, is an independent risk factor for weight gain and obesity. Furthermore, interactions between dietary fat and physical fitness determine fat balance, so that the obesity promoting effect of a high fat diet is enhanced in susceptible subjects, particularly in sedentary individuals with a genetic predisposition to obesity. Skipping breakfast may further increase the risk of obesity. A diet with a higher fat content seems to be better tolerated without weight gain by physically active individuals than by sedentary people. Ad libitum consumption of diets low in fat (20–30% of energy) and high in protein (15–20%) and carbohydrates, contributes to the prevention of weight gain in normal weight subjects. It also causes a spontaneous weight loss of 3 to 4 kg in overweight subjects, and has beneficial effects on risk factors for diabetes and cardiovascular disease. The source of carbohydrate is less important than the fat content. The main effect of the low fat, high carbohydrate diet composition on energy balance is exerted through enhanced satiety, increased faecal energy loss and slightly increased energy expenditure. The addition of daily physical activity to the diet doubles the weight loss in overweight subjects. Implementation of dietary change and increased physical activity may reduce the mean body weight of the population and decrease the prevalence of obesity and diabetes substantially. In conclusion, important interactions exist between genetic make-up, dietary fat and carbohydrate, meal pattern and physical fitness. Increasing daily physical activity and reducing dietary fat content may be more effective in combination than separately in preventing weight gain and obesity. Energy balance seems only to be achieved with less energy-dense diets and fat intakes of 20 to 25% of energy in sedentary subjects, but 25 to 30% in highly physically active subjects. (Aust J Nutr Diet 2001;58 Suppl 1:S9–S12)

Introduction

To assess any possible causal link between dietary fat and body weight, it is important that all types of studies are included and assessed in a systematic, critical way using an evidence-based methodology (Figure 1). Failure to do this has led to premature statements, which have been disseminated to the already confused public (1,2). One such statement is the suggestion that saturated fat should be replaced by mono-unsaturated fat rather than by carbohydrate. This advice poses the risk that current fat consumption, which already exceeds recommended levels, may be further increased (3). However, all lines of evidence linking dietary fat with obesity should be taken into consideration.

Observational studies assessing the association between diet composition and body weight

Numerous cross-sectional studies clearly have demonstrated positive associations between body fatness and the proportion of total energy intake contributed by fat, and inverse associations between carbohydrate intake and body fatness (4–6). For several methodological reasons it is more complicated to demonstrate associations between change in dietary fat content and subsequent weight change, particularly in the health conscious population. It seems to be easier to demonstrate associations between dietary fat intake and subsequent weight changes in less health conscious populations such as in China (7) than in the European Union and the United States (8).

The shortcomings of observational studies are reviewed elsewhere (5), but are due partly to limitations in the validity of the information about dietary intakes given by the subjects under examination (4). This is a major problem particularly in overweight and obese subjects who under-report their energy intake by 30 to 40% (5). Fat

Figure 1. The evidence-based assessment of the causal relationship between dietary fat and obesity

(a) Note that the sizes of the weights of the different kinds of studies denote the weight in the final conclusion. Observational studies are given the lowest weights because they rely on dietary information given by the subjects under investigation, and the energy and fat intakes are subject to severe (30 to 40%) under-reporting by overweight and obese subjects.

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may be over-represented in this under-reporting. Diet contributes to the maintenance of the obese condition (6).

Mechanistic studies providing physiological insight into the differences in macronutrient effects on energy balance

High fat diets promote passive over-consumption

Subjects exposed to high fat foods for several weeks tend to over-consume energy. This effect depends largely on the high energy density of the high fat foods and the overeating effect has been referred to as ‘passive over-consumption’ (9). It should be noted that the stimulatory effect of fatty foods on energy intake is due not only to their high energy density but also to the probable facilitatory action of fat in the mouth. It has been known for many years that offering subjects high fat or high carbohydrate foods which have been manipulated to be equally energy dense eliminates the high fat overeating phenomenon in normal, non-genetically predisposed individuals. A large body of short-term studies on appetite and energy intake unequivocally show that fat is less satiating than carbohydrate and protein when compared joule for joule, and that high fat foods are more likely to induce passive over-consumption and weight gain than low fat foods with higher contents of carbohydrate and protein (10).

High fat diets reduce energy output

Diet-induced thermogenesis following high fat diets is much lower than following high protein and high carbohydrate diets (11). This is due partly to the lower cost of processing and storage of fat from the diet into the adipose tissue stores. For fat, the value is about 1% of the energy content of the ingested fat, while the value for carbohydrate is 8 to 15%, and for protein 30%. It may be difficult to pick up the effect on 24-hour energy expenditure due to the large daily variability in physical activity, but it has been demonstrated in carefully controlled studies (12). During overfeeding, the effects are amplified and much easier to detect, particularly during sleep, where the confounding effect of physical activity is low (Figure 2). In addition to the greater thermogenic effect of carbohydrate and proteins than of fat, fat is also more effectively absorbed from the gastrointestinal tract than carbohydrate. Lammert et al. (13) found during overfeeding that the low fat, high carbohydrate diet produced a substantially larger faecal energy loss than the high fat diet.

Intervention studies

As briefly reviewed above, there is substantial physiological, mechanistic support to expect that switching from a normal high fat diet to an ad libitum low fat diet would cause a spontaneous weight loss providing there is similar palatability of the diets being compared. Randomised controlled ad libitum low fat, high carbohydrate intervention studies actually show great variability, and if a single negative study is picked out it may give a biased, unbalanced view. This has contributed to doubt about the effectiveness of a low fat diet in the prevention and treatment of overweight and obesity. In a systematic review and meta-analysis based on 28 intervention trials it was found that a reduction of 10% in the proportion of energy from fat was associated with a reduction in weight of 16 g per day. This corresponds to a weight loss of 2.9 kg over six months (6).

We have conducted a more restrictive meta-analysis (5), where studies only with no other interventions than the ad libitum low fat diet and a proper control were included. These analyses included a total of 1728 individuals—1074 women and 654 men. Thirteen studies were randomised controlled trials, 12 used a parallel design, and one used a cross-over design. The control groups were either advised to maintain their regular diet or to consume a diet with a fat content similar to the background population. The low fat interventions as compared with the control groups produced a weight loss of 2.40 kg more (95% CI, 1.93–2.87; P < 0.0001) in the fixed effects analysis and 2.52 kg more (95% CI, 1.51–3.53; P < 0.0001) in the random effects analysis. In a simple correlation analysis the major determinant of the weight loss difference was pre-treatment body weight (r = 0.52, P < 0.05) (Figure 3). After adjustment for pre-treatment body weight, there was a dose-response relationship between the reduction in percentage of energy from dietary fat and weight loss (r = 0.66, P < 0.005) (Figure 3). With no change in the percentage of energy from dietary fat, no weight change occurred (intercept with 0: P = 0.14). The slope of the relation indicated that for every 1% reduction in energy from dietary fat, a weight loss of 0.37 kg (95% CI, 0.15–0.60 kg) was achieved. Weight loss was not associated with duration of the intervention.

Another meta-analysis was based on 37 dietary intervention studies, and found weight loss in the intervention groups to be 2.79 kg larger than in the control groups, and there was a highly significant relationship between reduction in dietary fat and weight loss (14). For every 1% decrease in energy from fat there was a 0.28 kg decrease in body weight. These three meta-analyses thus consistently show that a reduction in dietary fat without restriction of total energy intake causes weight loss in a dose-dependent fashion and may produce a modest, but clinically relevant, weight loss in overweight subjects. The importance of carbohydrate source has been reviewed recently (5). Recent data also are available on the effect on

Figure 2. The fate of surplus energy provided during 21 days of overfeeding on a very low fat, high carbohydrate diet in normal weight subjects. Adapted from Lammert et al. (13)
weight loss of replacing some carbohydrate with protein. Two reduced fat diets (30% of total energy), a high carbohydrate diet (protein 12% of total energy) and a high protein diet (protein 25% of total energy), were compared in 65 obese patients (15). Weight loss after six months was 5.1 kg in the high carbohydrate and 8.9 kg in the high protein groups, and more subjects lost more than 10 kg in the high protein group (35%) than in the high carbohydrate group (9%). The protein-rich diet had no adverse effect on blood lipids, renal function or bone mineral density. More freedom to choose between protein-rich and complex carbohydrate-rich foods may encourage obese subjects to choose more lean meat and low fat dairy products and hence improve adherence to low fat diets in the long term.

Importance of carbohydrate source for obesity and risk factors

The relative contributions of carbohydrate sources in the diet may have potential implications for body weight regulation and obesity. The intakes of alcohol and protein have remained relatively constant in most European Union countries over the last 50 years and together these nutrients represent less than 20% of the total energy intake. The main dietary change has been the increase in fat intake at the expense of carbohydrates. The inverse relationship between dietary fat and carbohydrate has been demonstrated in numerous cross-sectional studies in countries with very different socioeconomic status. It is particularly the simple sugars, and not the complex carbohydrates, which tend to counterbalance the fat energy of the diet. This phenomenon has been dubbed ‘fat-sugar see-saw’. Cross-sectional observational studies have shown quite consistently a negative association between body weight and the proportion of dietary carbohydrate, and in particular with simple sugars.

One of the largest data sets is derived from the Scottish part of the Monica survey (16) and clearly shows an inverse relationship between sugar intake and obesity. When divided into quintiles according to the fat:sugar ratio, there was a two- to three-fold higher prevalence of obesity in the highest versus the lowest quintile. One of the shortcomings of cross-sectional surveys is the possibility that the dietary pattern may represent a post-hoc event, whereby obese individuals have adopted a particular diet composition consequent to their obesity. For example, if obese subjects in an effort to reduce their energy intake have replaced sugars with artificial sweeteners their sugar intake will be low. Experimental studies and short-term intervention studies do not produce a firm conclusion as some studies suggest that low fat, high sugar diets may increase energy intake above that of a similar low fat diet with a high complex carbohydrate content.

The only available long-term study is the European multi-centre trial, CARMEN (17). In this study 398 overweight and obese adults with a body mass index (BMI) between 26 and 35 were randomised to a dietary intervention of either a low fat, high simple carbohydrate diet, or a low fat, high complex carbohydrate diet, or to a continuation of the control diet. The diets were supplied by a validated laboratory shop system. A diet low in fat and with an increased level of complex carbohydrates lowered body fat mass 2.4 kg more than the control diet. To a lesser extent it also reduced fat mass compared to the control diet (1.9 kg). Though the difference in weight loss between complex and simple carbohydrate groups was not statistically significant, it is possible that the low fat, simple carbohydrate diet is slightly less effective in inducing weight loss. It should be noted that there was no difference in energy density between the two low fat diets in the study. Given the important role of energy density in passive over-consumption, the introduction of low fat foods such as cakes and biscuits in which fat is substituted by simple sugars but energy density is unchanged, may impair the expected decrease in energy intake and hence play a role in maintaining an excessive body weight in some subjects.

Figure 3. The unweighted association between study means of difference in weight loss, adjusted for pre-treatment body weight, and change in percentage of dietary energy from fat. The weight loss and the change in percentage of dietary fat are calculated as the difference between mean changes in intervention and control groups (5)(a)

Do low fat, high carbohydrate diets cause adverse cardiovascular effects?

It is often argued that a reduction in fat intake and increase in carbohydrate intake produce a rise in plasma triglycerides and a fall in plasma HDL-cholesterol, which would be expected to increase the risk of coronary heart disease. Moreover, it is argued that mono-unsaturated fatty acid (MUFA) has a more beneficial effect on risk factors of coronary heart disease than carbohydrate. This is true in studies where carbohydrate has been compared with MUFA under strictly iso-energetic conditions and no weight loss was allowed to occur on the low fat, complex carbohydrate diet (18). But in the studies allowing ad libitum intake the changes in blood lipids are dominated by the slight weight loss induced by the low fat diet. This was illustrated in a study on hyperlipidaemic patients where the dietary fat content was first changed from 35 to 15% of energy under iso-energetic conditions so that body weight was kept constant (19). Consumption of the low fat diet under weight maintenance conditions had significant lowering effects on plasma total cholesterol (TC), low density lipoprotein (LDL) cholesterol, and high density lipoprotein (HDL) cholesterol levels (–12.5%, –17.1%, and –22.8%). This diet significantly increased plasma triglyceride levels (+47.3%) and the TC:HDL-cholesterol ratio (+14.6%). By contrast, consumption of the low fat ad libitum diet was accompanied by significant weight loss (–3.63 kg), by a mean decrease in LDL-cholesterol (–24.3%), and by mean triglyceride levels and TC:HDLC-cholesterol ratio that were not significantly different from values obtained at baseline. This has been confirmed in a systematic review and meta-analysis evaluating the effects of the American national cholesterol education program’s dietary interventions on major cardiovascular disease risk factors (14).

However, the carbohydrate source and the glycaemic index may have importance for the effect on risk factors. Both observational and short-term intervention studies show that a low glycaemic index diet exerts more beneficial effects than a high glycaemic index diet on LDL- and HDL-cholesterol, insulin resistance, and plasminogen activator inhibitor-1 activity (20,21). However, the only available long-term study, the six month CARMEN study, failed to show any adverse effect on blood lipids of a low fat, high simple carbohydrate diet (17). Consequently, the high carbohydrate content of low fat diets should stem mainly from the complex carbohydrates of different vegetables, fruits and whole grains, which are more satiating for fewer calories than fatty foods and are good sources of vitamins, minerals, trace elements and fibre. However, to comply with a low fat diet it may be required to allow for a slightly increased intake in extrinsic sugars. This diet composition also has been shown to reduce mortality in high risk patients (22).

References