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James Lind Alliance research priorities: What role do carbohydrates, fats and proteins have in the management of type 2 diabetes, and are there risks and benefits associated with particular approaches?

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Author post-print (accepted) deposited by Coventry University's Repository

Original citation & hyperlink:

Pamela, D, Guess, N, McArdle, P & Mellor, D 2018, 'James Lind Alliance research priorities: What role do carbohydrates, fats and proteins have in the management of type 2 diabetes, and are there risks and benefits associated with particular approaches?' Diabetic Medicine, vol. (In-press), pp. (In-press).

ISSN 0742-3071
ESSN 1464-5491

Publisher: Wiley

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Article type : Invited Review

Title: Diabetic Medicine

Created by: Maria Davie

Email proofs to: pamela.dyson@ocdem.ox.ac.uk

Article no.: DME-2018-00427

Article type: Review Article

Short title/*Authors running head*: Carbohydrate, fat and protein in Type 2 diabetes management • *P. Dyson et al.*

Review Article

James Lind Alliance research priorities: what role do carbohydrates, fats and proteins have in the management of Type 2 diabetes, and are there risks and benefits associated with particular approaches?

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Abstract

Aims To assess the role played by carbohydrates, fat and proteins in the management of Type 2 diabetes.

Background Diabetes research tends to reflect the interests of academics or the pharmaceutical industry, rather than those of people living with Type 2 diabetes. The James Lind Alliance and Diabetes UK addressed this issue by defining the research priorities of people living with Type 2 diabetes. Three of the top 10 research priority questions focused on lifestyle.

Methods A narrative review was undertaken with a structured search strategy using three databases. Search terms included the three macronutrients and Type 2 diabetes. No restrictions were placed on macronutrient quantity or length of study follow-up. Outcomes included changes in HbA_{1c}, body weight, insulin sensitivity and cardiovascular risk.

Results There is no strong evidence that there is an optimal ratio of macronutrients for improving glycaemic control or reducing cardiovascular risk. Challenges included defining the independent effect of macronutrient manipulation and identifying the effects of macronutrients, independent of foods and dietary patterns. Extreme intakes of macronutrients may be associated with health risks.

Conclusions It is challenging to formulate food-based guidelines from studies based on macronutrient manipulation. Structured education should be offered to support individuals in discovering their optimal, individual dietary approach. Recommendations for dietary guidelines should be expressed in terms of foods and not macronutrients.

Introduction

Type 2 diabetes has been described as a global epidemic, affecting ~382 million people in 2017 (8.8% of the adult population), and is predicted to rise to 575 million people affected by 2045 [1]. In the UK in 2016, it was estimated that 3.8 million people were living with Type 2 diabetes, effectively doubling the prevalence over the past 20 years [2]. The prevention and management of Type 2 diabetes is complex and encompasses diet, physical activity, medication, weight control, management of diabetes-related complications, including cardiovascular risk reduction, and self-monitoring. There is a clear need for more research in diabetes [3], but often the priorities of people living with a disease are overlooked in favour of those of the pharmaceutical industry or academic researchers [4].

The James Lind Alliance was established to address the inequities in these priorities, and does this by bringing together people with a diagnosed specific condition, carers and health professionals in order to explore the uncertainties relating to that condition and to define research priorities [5]. This process has been conducted in people with Type 1 diabetes [6], and more recently in Type 2 diabetes [7]. The top 10 research priorities identified in Type 2 diabetes included a variety of topics, and lifestyle factors were mentioned specifically in three of the 10 research questions.

Successful diabetes management requires effective self-management, including dietary manipulation. Globally, diabetes associations have attempted to provide evidence-based dietary guidelines for the management of diabetes [8–10], including those recently published from Diabetes UK [11]. However, for many people with diabetes, there remains a degree of confusion about the most appropriate diet for optimizing glycaemic control, for weight management and for cardiovascular disease (CVD) risk reduction. The majority of authorities recommend a balanced or healthy diet for diabetes, yet the media is full of advice about low-carbohydrate, high-fat and high-protein diets. This confusion appeared to be reflected in the top 10 research priorities from the James Lind Alliance, and at number 10 was the question ‘What role do carbohydrates, fats and proteins have in the management of Type 2 diabetes, and are there risks and benefits associated with particular approaches?’ This review aims to explore and answer this question.

Methods

Conducting meta-analyses and systematic reviews of dietary intervention studies presents many challenges, including heterogeneity in terms of trial design, length of follow-up, type and intensity of intervention, comparator diet, duration of diabetes and use of medication. In addition, there are areas where many systematic reviews have already been published (low-carbohydrate diets) and some areas where there is little research in people with Type 2 diabetes (high-fat and high-protein diets). For these reasons, a formal systematic review with meta-analysis was not conducted for this article, and a narrative review using available evidence from published reviews and individual studies was undertaken.

Electronic databases including Medline, Embase and the Cochrane Central Register of Controlled Trials were searched from 1980 (when HbA_{1c} was routinely used to assess glycaemic control) to 31 May 2018 to identify suitable meta-analyses, systematic reviews and randomized controlled trials (RCTs). Key search terms included combinations and synonyms of Type 2 diabetes mellitus, diet*, carbohydrate, glyc*, index, fibre, protein, amino acids, fat*, saturat* and unsaturat*. There was no restriction on amount of macronutrient included in the dietary intervention and length of follow-up, and outcomes included changes in HbA_{1c}, body weight, insulin sensitivity and CVD risk.

Definitions of high, moderate and low intakes of macronutrients are not universally agreed, and, for the purposes of the present analysis, the definitions adopted are shown in Table 1 [12].

Results

Carbohydrate

Dietary carbohydrate in the management of Type 2 diabetes continues to be the subject of debate amongst both the popular media and within clinical and academic arenas. Nutrition guidelines for Type 2 diabetes in the UK have not made a specific recommendation for carbohydrate since 2011, but instead encourage an individualized approach to carbohydrate intake and focus on weight loss in the overweight [11]. It is estimated that the typical diet consumed in the UK contains ~47% of total energy intake from carbohydrate [13] and that people with Type 2 diabetes consume a similar amount, but still at a level that could be classified as ‘high carbohydrate’ [14].

Table 2 summarizes recent systematic reviews and meta-analyses of carbohydrate quantity in Type 2 diabetes. RCTs and systematic reviews are frequently associated with a common set of methodological concerns. These include the failure to measure the pre-study dietary intake of participants, the use of grams of carbohydrate vs percentage of total energy intake from carbohydrate and the definitions used to categorize high- or low-carbohydrate diets.

Glycaemic control

Carbohydrate quantity. Dietary carbohydrate is the only macronutrient which has a direct and immediate effect on postprandial blood glucose levels [15]. Yet, despite a large volume of published research on the subject, and including many systematic reviews and meta analyses, there is still no clear conclusion regarding the optimal quantity of carbohydrate for glycaemic control in Type 2 diabetes [16–24]. This lack of a definitive conclusion may have contributed to the confusion and lack of understanding reported in some people with Type 2 diabetes [25], and to the lack of a consistent approach in the advice given by registered dietitians [26].

High-carbohydrate diets (>45% total energy intake from carbohydrate or >225g carbohydrate per day) typically represent ‘healthy’ or ‘prudent’ eating patterns and are recommended for the general population. One challenge of using either %total energy intake or absolute amount of carbohydrate was demonstrated in the Look AHEAD trial, in which the dietary intervention provided 50.8% total energy intake from carbohydrate [27], although, as total energy intake was restricted to induce weight loss, the absolute amount of carbohydrate met the definition of a moderate carbohydrate diet.

Nine recent systematic reviews and meta-analyses of the effects of carbohydrate restriction on HbA_{1c} considered in the present review consistently reported a short-term improvement, maintained over 6–12 months, but which was not maintained over the longer term [16–24]. Of the seven meta-analyses, five reported statistically greater reductions in HbA_{1c} for restricted carbohydrate diets, but these were modest and typically in the order of 1–5 mmol/mol [16,19–24], with one reporting a reduction of 9 mmol/mol [23]. Two systematic reviews reported equivocal results, with larger numbers of included trials failing to demonstrate superiority of low-carbohydrate diets [17,18]. A variety of definitions for carbohydrate restriction/low-carbohydrate diets were used, and prescribed intakes ranged from 20 to 225 g per day (<10–45% total energy intake). This is important because moderate restriction (26–40% total energy intake) does not appear to reduce glycaemia significantly [22,24].

Evidence for clinical benefits of very-low-carbohydrate diets (<50 g per day) was lacking in the reviews. Studies that measured and reported end-of-study carbohydrate intake stated that the assigned dietary prescription was rarely adhered to in long-term trials. For example, in a meta-analysis of very-low-carbohydrate, ketogenic diets (<50 g/day) in people without diabetes, prescribed intake from carbohydrate was achieved in only one study out of 13 [28].

To reiterate, caution is required when interpreting biochemical and physiological efficacy from long-term randomized dietary trials where adherence is a concern [29].

It is challenging to separate the effects of carbohydrate restriction independently of weight loss because most of the trials included in the meta-analyses do not ensure study arms are isocaloric, and therefore differences in weight loss between diets may be contributing to effects on glycaemic control. One systematic review attempted to address this issue by comparing studies in which there were no differences in weight loss between groups, but the authors were still unable to conclude that a particular balance of macronutrients or one dietary pattern was superior to any other [18]. Only one of the meta-analyses of low-carbohydrate diets reported significant differences in weight between restricted- and higher-carbohydrate diets, and it appeared that any short-term improvements in glycaemic control were attributable solely to weight loss, with no significant differences between diets with equal weight loss [22].

These data suggest that carbohydrate restriction reduces HbA_{1c} more than control diets over the short term (6–12 months), but not the longer term, and reductions in medication are associated with carbohydrate restriction [18,22]; however, beyond the absolute amount of carbohydrate, or its percentage contribution to energy, are wider questions about dietary quality. Dietary patterns such as Mediterranean-style diets and vegetarian and vegan diets have led to improvements in glycaemic control, weight loss and reduced CVD risk, despite providing moderate to high intakes of carbohydrate [30,31]

Carbohydrate quality. Glycaemic index is a measure of the glycaemic response to a carbohydrate-containing food relative to a test food and has been the subject of significant research over many years. More recent systematic reviews and meta-analyses indicate decreasing significance of this dietary approach. Earlier meta-analyses concluded that low glycaemic index diets reduce HbA_{1c} by ~6 mmol/mol [32], although recent reviews report more modest reductions of 2–5 mmol/mol [33,34]. The most recent meta-analysis included papers over a shorter time period and therefore included fewer research studies in the analysis [34]. Methodological challenges are prevalent in this area as with other areas of carbohydrate research, including the potential for large variations in the glycaemic index values of a given food and the fact that most people consume moderate rather than high glycaemic index diets, which are commonly used as comparison diets in studies. Overall, the volume of research indicates a small but statistically significant benefit for low glycaemic index dietary patterns, although the overall clinical significance is open to question.

Studies of dietary fibre and its effects on glycaemic control in Type 2 diabetes typically use fibre supplementation in the form of guar gum, psyllium or food sources of cereal and wheat fibre in order to achieve the levels of fibre intake associated with significant effect. The most recent review of fibre comprised a review of 16 meta-analyses, five of which specifically addressed HbA_{1c} outcomes, and all but one reported a significant reduction [35]. Reported reductions in HbA_{1c} ranged from 2 to 6 mmol/mol (0.2–0.5%), and all trials used supplementation with either β-glucan (3–3.5 g/day) or soluble fibre (15–16 g/day). It is unclear whether evidence derived from supplementation translates to increased dietary fibre without the use of supplementation, but there is clearly a role for fibre in the diets of people with Type 2 diabetes, not least because the majority of people in the UK do not meet the recommended intakes of dietary fibre [36]. The positive effects on glycaemia of both low glycaemic index and high-fibre diets appear to occur independently of weight loss.

Sugars

Free sugars are defined as those added in the manufacture and preparation of food, and those added by the consumer, and include the sugars found in fruit juice, syrups and honey [37]. Traditionally table sugar (sucrose) has been restricted for people with Type 2 diabetes. Misunderstanding regarding the role of sugar in glycaemia may stem from previous characterization of carbohydrates into complex and simple sugars. In fact, the fructose component of the disaccharide sucrose gives this disaccharide a lower glycaemic index than some starches. Most studies show that isocaloric replacement of starch with fructose lowers glycaemia without any adverse cardiometabolic effects [38].

Cardiovascular disease risk

A major concern regarding low-carbohydrate diets has been a potential increase in CVD risk associated with increased fat intake. In general, trials of low-carbohydrate diets show a reduction in triglycerides, an increase in HDL cholesterol, and a reduction in blood pressure [21]. The effects on triglycerides and HDL cholesterol may occur independently of weight loss. It has been suggested that the LDL cholesterol-raising effects of foods high in saturated fat is not observed when carbohydrate is restricted, and that carbohydrate restriction *per se* improves the atherogenic risk profile specifically by reducing small, dense LDL particles [39].

However, in common with the positive effects seen on glycaemic control, dietary patterns such as Mediterranean-style diets and vegetarian diets, which provide moderate to high amounts of carbohydrate, are associated with reduced CVD risk [30,31].

Risks and benefits

Low-carbohydrate diets are effective for improvements in glycaemic control and for weight reduction in people with Type 2 diabetes, but there is no conclusive evidence of long-term benefit when compared with other dietary strategies, which is probably the result of lack of adherence in long-term trials Low-carbohydrate diets may be lower in fibre, however, which may increase the risk of gastrointestinal problems, including constipation [40]. The long-term effects of carbohydrate restriction on the gut microbiome are unknown, and may have implications for long-term colonic health. It is possible that a carbohydrate-restricted diet may be less diverse than a high-carbohydrate diet, but it should be emphasized that well-formulated low- and high-carbohydrate diets can both be varied.

Fat

Dietary fat has been long been a focus of interest because of the diet–heart hypothesis, linking intake of saturated fatty acids (SFAs) to CVD and its associated risk factors, most notably serum cholesterol [41]. This is particularly relevant to people with Type 2 diabetes as they are at greater risk of developing CVD; however, there are few studies in people with Type 2 diabetes investigating low-fat interventions and CVD outcomes, and recommendations are largely extrapolated from other groups at high risk of CVD.

Glycaemic control and insulin metabolism

The role of dietary fat in glycaemic control appears to be related to its action on insulin sensitivity and insulin resistance [42] and to insulin response, although it is much less pronounced than that seen after the consumption of carbohydrate

[43]. In general, data suggest that replacement of SFA with unsaturated fat can improve insulin sensitivity [42].

Fat and cardiovascular disease risk

The role of dietary fat in the management of Type 2 diabetes remains an area of controversy and debate. Although the majority of authorities continue to support substitution of SFAs by unsaturated fat [44], others have proposed that dietary fat has been incorrectly demonized and labelled as the primary dietary driver of CVD [45], and that the widespread consumption of low-fat, high-carbohydrate processed foods are causally associated with increased obesity and Type 2 diabetes [45,46]. This view is not consistently supported by the available literature [44].

Amount of fat

Dietary recommendations for total fat intake in the UK have not been reviewed since the 1990s and recommend that dietary fat should supply <30–35% of total energy intake [47]. A recent review by the European Food Safety Agency retained this upper limit, but added a lower recommendation for intake of at least 20% total energy intake from fat [48]. Diabetes UK do not recommend a specific amount of dietary fat for people with Type 2 diabetes because of contradictory evidence from published studies [49]. It is apparent that in many clinical studies, a low-fat diet (≤30% total energy intake) is effective in the treatment of Type 2 diabetes [49]. Nevertheless, in the Look AHEAD trial, this strategy failed to show a significant reduction in cardiovascular mortality, despite significant weight loss and improvements in both glycaemic control and CVD risk factors in the intervention group [50]. Conversely, the Prevention with Mediterranean Diet (PREDIMED) study (with nearly 50% of the cohort with Type 2 diabetes) reported a significant reduction in CVD mortality with a higher-fat diet (40% total energy intake), although the majority of fat was monounsaturated [30,51]. It is likely that the type, rather than the amount, of dietary fat is of greater importance for CVD risk reduction in people with Type 2 diabetes [52].

Type of fat

Restriction of SFAs has been the mainstay of past dietary recommendations and the UK Scientific Advisory Committee on Nutrition has recently published a draft document recommending that the dietary reference value for SFAs for the general population remain unchanged at no more than 10% total energy intake, and that SFAs should be substituted with unsaturated fats [44]. This recommendation is supported by Diabetes UK [11], although for people with Type 2 diabetes there is very little published evidence investigating the effects of different kinds of fat on CVD risk, with the notable exception of monounsaturated fatty acids. A meta-analysis of RCTs in people with Type 2 diabetes reported positive effects of Mediterranean-style diets, rich in monounsaturated fatty acids, on glycaemic control and CVD risk [30].

Despite contradictory opinion about the role of saturated fat and CVD risk [53], there is no evidence to recommend increasing SFA intake to improve glycaemic control or CVD risk for people with Type 2 diabetes [49]. A common feature of many studies is that the dietary intervention applied included the recommendation of <10% total energy intake derived from SFAs, independent of the total percentage energy derived from fat, so there is little available evidence of the independent effect of high-fat/high-SFA diets.

Risks and benefits

Low-fat diets. Beneficial outcomes of low-fat diets for people with Type 2 diabetes are reported in some RCTs [50], but not all [54], and, as a result, these diets are now recommended as only one of a number of dietary strategies suitable for those with Type 2 diabetes. Evidence suggests that the type of carbohydrate used to replace fat in low-fat diets also has a role, with increased risk of CVD associated with increased processed or refined carbohydrate and reduced risk associated with wholegrain and unprocessed carbohydrate [56]. For most people with Type 2 diabetes who are overweight or obese, weight loss is the primary aim and it is challenging to assess the effects of manipulation of dietary fat independently of weight loss. A recent review reported that weight losses of 10% in people with Type 2 diabetes reduce cardiovascular events by 21%, independent of the dietary strategy used to achieve weight loss [57].

High-fat diets. It has been suggested that high-fat diets (>40% total energy intake) help reduce appetite and aid weight loss, but these studies were carried out in the general populations and not specifically people with diabetes [58]. High-fat diets are usually associated with lower carbohydrate intake, and replacement of carbohydrate with fat lowers the postprandial insulin demand.

The major concern associated with high-fat, low-carbohydrate diets is that of increased CVD risk, and some deleterious effects have been reported. Higher intakes of SFAs do elevate plasma LDL cholesterol, but this is only a small part of CVD risk, and diets providing dietary fat as unsaturated fat do not appear to increase CVD risk [56].

Protein

There is no specific recommendation for protein in the management of Type 2 diabetes [8,11]. Compared with carbohydrate and fat, dietary protein has been less of a focus in the management of Type 2 diabetes [8,11], and relatively less well studied [16]. While carbohydrate is the macronutrient with the largest effect on postprandial glycaemia, protein may also play an important role in the long-term management of Type 2 diabetes because of the insulinogenic effect on the β cell [59]. In this section, we discuss the effect of protein on glycaemic control and cardiovascular risk factors [60] including intrahepatic triglyceride stores [61].

Glycaemia

Current guidelines in the UK suggest a protein intake of 0.75 g of protein per kg or 10–15% total energy intake [47]. In most studies, 20–30% total energy intake from protein is used in the high-protein arm [16,60]. Two meta-analyses were published in 2013, and compared the effects of high-protein diets with lower-protein diets on weight, glycaemic control and cardiovascular risk factors in adults with Type 2 diabetes [16,60]. The first meta-analysis included RCTs of >6 months in length and found that only two studies met their inclusion criteria [16]. Both these studies compared a high-protein diet (30% total energy intake from protein, 40% total energy intake from carbohydrate) with low-protein diets (15% total energy intake from protein, 55% total energy intake from carbohydrate) and reported significant reductions in HbA_{1c} (Table 3). The second meta-analysis included studies of >4 weeks' duration, specified a high-protein diet as >20% total energy intake, and stipulated a difference of >5% total energy intake from protein between the intervention and control arms [60]. This meta-analysis also found a significant pooled reduction in HbA_{1c}. Moderate to high heterogeneity was observed in both meta-analyses, and a sub-group analysis in the latter partly attributed the heterogeneity to differences in baseline HbA_{1c}. Weight loss appears to attenuate the effect of added protein on glycaemia, and it is likely that, as long as weight loss is achieved, the macronutrient composition of the diet is a minor regulatory factor [16, 60].

An additional factor which may contribute to the heterogeneity is the macronutrient composition of the rest of the diet. In one meta-analysis [60], the largest reductions in fasting plasma glucose and HbA_{1c} were in the two studies which severely restricted carbohydrates (<20% total energy intake) [62,63]. Given complementary findings from low-carbohydrate studies (that low-carbohydrate studies with high protein tend to result in lower glycaemia than low-carbohydrate diets with low protein), it is possible that a low-carbohydrate, moderate-protein diet may be a physiologically optimum dietary protocol for managing glycaemia. This hypothesis should be formally tested in a well-designed trial. Since the publication of the two meta-analyses, more randomized trials have reported [64–69]. In general, their results are consistent with those of the meta-analyses: a higher proportion of protein in the diet appears to have little effect on glycaemia independent of weight loss.

The finding from meta-analyses that high-protein diets may lower HbA_{1c} but not fasting glucose [60] may reflect the acute insulinogenic effect of dietary protein [59]. The pancreas releases insulin in response to both glucose and amino acids, although sensitivity to both is lost as Type 2 diabetes progresses [70]. Acute studies show a dose–response effect of dietary protein on glycaemia [71], and short-term trials combining protein with moderate and severe carbohydrate restriction reported prandial increases in insulin concentrations associated with decreasing blood glucose levels [65,72, 73]. Importantly, these trials provided all study foods in order to increase adherence.

Cardiovascular risk factors

A 2013 meta-analysis that included people with Type 2 diabetes showed that replacement of carbohydrate with protein significantly lowered blood pressure, with pooled reductions of ~2 mmHg and ~1 mmHg observed for systolic and diastolic blood pressure, respectively [74]. Importantly, this is observed for both animal and vegetable sources of protein [75]. This meta-analysis included studies with a range of dietary protocols including protein supplementation, but the effect of dietary protein vs protein from supplements does not seem to alter the findings [74,75]. The replacement macronutrient is probably important, and the hypotensive effect of protein may only be observed when it replaces carbohydrate [16,74,75]. In contrast, the quantity of dietary protein does not seem to affect the lipid profile [16,60].

Source of dietary protein

The dietary source of protein may not be an important determinant of its antiglycaemic or antihypertensive effects [60,74,75]. Both dairy proteins, such as whey and casein, and high-protein foods, such as chicken and meat, have all been used in studies reporting increased postprandial insulin and reduced blood glucose concentrations [16,60]. The effect is probably driven by a reduction in carbohydrate, and by the addition of amino acids individually and in combination. Similarly, studies comparing animal and vegetable protein show no difference in terms of their antihypertensive effects [74,75]. In contrast, the source of protein is an important consideration for managing lipidaemia [16], and in this regard general dietary recommendations are appropriate: limiting excessive red meat intake, oily fish twice per week, and a variety of vegetable protein sources, which are also high in fibre such as pulses, nuts and seeds.

Risks and benefits

Intrahepatic triglycerides are closely linked to Type 2 diabetes, insulin resistance and cardiovascular risk. The available studies are few in number and of varying quality, but the data are intriguing and suggest that elevated dietary protein attenuates the increased intrahepatic triglyceride levels observed after hypercaloric feeding with fructose [76] or fat [77], and that 4 weeks' supplementation with 60 g/day of whey protein reduced intrahepatic triglyceride levels in obese women without any concomitant reduction, independently of body weight changes [78]. A 6-month prospective clinical audit of patients with Type 2 diabetes and non-alcoholic fatty liver disease showed a reduction in intrahepatic triglycerides with a high animal or vegetable protein diet (30% total energy intake from protein, 40% total energy intake from carbohydrates) [79]. Other studies have supported these findings but are confounded by marked carbohydrate restriction [79,80]. Historically, health concerns regarding increasing the protein content of the diet have included accelerated decline in renal function [81] and osteoporosis [82] caused by excessive calcium loss. These concerns have not been substantiated in trials in individuals with Type 2 diabetes without renal disease [81,82].

Dicusssion

The James Lind Alliance has shown that people with Type 2 diabetes and health professionals alike want to know details of the optimum diet for diabetes, especially how much carbohydrate, fat and protein they should eat. This is a question without a definitive answer for reasons which include the strategies used to formulate evidenced-based advice, the fact that it is challenging to determine the effect of a dietary intervention independent of weight loss, the fact that manipulating the amount of one macronutrient will have an effect on the remaining two macronutrients and the fact that there is individual variation in people's response to different foods and nutrients.

Formulating evidence-based dietary guidelines is a complex, challenging process, and has become increasingly demanding as general interest has increased alongside a rapidly expanding science base. One of the most challenging aspects is distilling the available evidence into concepts that are readily understood and which can be applied in practice by people with diabetes. There is now general agreement that food-based rather than nutrient-based guidelines help translate science into recommendations that most people understand [83]. The main challenge remains the fact that much of the dietary evidence for people with Type 2 diabetes is derived from studies that manipulate macronutrients rather than food. For example, despite data supporting the substitution of saturated fat with unsaturated fat in reducing CVD risk [52,53], focusing narrowly on the fat content may not include accurate consideration of the nutritional influence of the foods containing the fat and the individual's dietary pattern. Studies have demonstrated the efficacy of the Mediterranean-style dietary pattern for CVD prevention where the focus was on incorporating olive oil, nuts and seeds, reducing butter and replacing red meat with fish and white meat [51]. This food-based approach was successful in meeting nutritional targets for reducing SFAs by emphasizing a dietary pattern rather than specific nutrients. Different dietary patterns, including Mediterranean-style diets and the DASH (Dietary Approaches to Stop Hypertension) intervention, are associated with improved outcomes in people with Type 2 diabetes and, although these diets are both plant-based and include similar foods, they have very different amounts of macronutrients [30,83], suggesting that specific foods and dietary patterns may have more influence than macronutrients. Research that focuses on individual nutrients is limited by definition, as it cannot take into account the complexity of interdependence between foods and their effects on diabetes outcomes [85].

In the UK, >90% of people with Type 2 diabetes are overweight or obese and would benefit from weight loss [86], and Diabetes UK recommends this as the primary strategy for improving glycaemic control and reducing cardiovascular risk [11]. There is no evidence of superiority of one weight-loss strategy over another and, for this reason, it is recommended that people with Type 2 diabetes adopt a dietary approach that suits their lifestyle, that they are able to sustain over the long term and that has a positive impact on their quality of life. The contradictory results of some studies and media interest combine to cause confusion. This is best illustrated by the recent reports of the effects of low-carbohydrate diets. Low-carbohydrate diets are suggested to be the answer to the Type 2 diabetes epidemic, based on the observation that carbohydrate foods have the most pronounced effect on postprandial blood glucose levels. However, despite the contradictory results of individual RCTs, and, although these diets are effective for weight loss and improvements in glycaemic control, most meta-analyses have reported that there is either no advantage for glycaemic control when comparing low-carbohydrate diets with other strategies over the long term, or that the reductions in HbA_{1c} may be of statistical, but not clinical, significance. The same applies to studies comparing low-fat and high-protein diets, and it appears that if weight loss is achieved, then the macronutrient content of the diet is of minor importance [87]. For this reason, Diabetes UK recommends a variety of strategies for weight loss, including low-carbohydrate, energy restriction, low-fat healthy eating and Mediterranean-style diets and the key is to individualize advice.

In conclusion, to date, there is no evidence of an optimal amount of dietary macronutrients for people with Type 2 diabetes, and most guidelines and recommendations emphasize the need for individualization and taking into account culture, food availability and personal preference. People with Type 2 diabetes should be offered structured education, including nutritional advice, and should be supported in their choice of diet for weight loss, if appropriate, and for improving glycaemic control and reducing cardiovascular risk. Food-based guidelines are recommended, and dietary advice should be expressed in these terms rather than as macronutrients.

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Table 1 Definition of high or low macronutrient intake as defined in the research literature or as consensus definitions

Macronutrient	**g/day**	**% total energy intake**
Carbohydrate		
Very-low carbohydrate	20–50	6–10
Low carbohydrate	<130	<26
Moderate carbohydrate	130–225	26–45
High carbohydrate	>225	>45
Fat		
Mean UK fat intake	67–89	30–40
Low fat	67	≤30
Recommended lower limit	44	20
Protein		
High intake (90th–97th centile in Europe)	85–135	17–27
High protein	125	25
Proposed upper limit	175	35

Adapted from: Mellor *et al.* [12].

Table 2. Summary of results of meta-analyses of restricted carbohydrate dietary interventions in people with Type 2 diabetes

Lead author	**Year**	**Length of follow-up months**	**Number of studies**	**Number of participants (n)**	**Reported outcomes for restricted carbohydrate vs comparator diet**	
					HbA_{1c} WMD (95% CI), %	**Weight WMD (95% CI), kg**
Ajala *et al.* [16]	2013	6–24	8	810	–0.12 (–0.24, 0.00) $P = 0.04$, $I^2 = 75\%$	–0.69 (–1.77, 0.39) $P = 0.21$
Fan *et al.* [19]	2016	3–48	10	1080	–0.33 (–0.51, –0.151) $P < 0.01$, $I^2 = 88.4\%$	–2.35 (–3.65, –1.06) $P < 0.001$
Huntriss *et al.* [20]	2017	12	7	1866	–0.28 (–0.53, –0.02) $P = 0.03$, $I^2 = 54\%$	0.28 (–1.37, 1.92) $P = 0.74$, $I^2 = 75\%$
Meng *et al.* [21]	2017	3–24	9	743	-0.44 (-0.61, –0.26) $P < 0.001$, $I^2 = 19.6\%$	–0.94kg (–1.92, 0.05) $P = 0.06$, I^2 35.5%
Sainsbury *et al.* [22]	2018	12	11	1779	–0.09 (–0.21, 0.03) $P = 0.12$, $I^2 = 16\%$	–0.43kg (–0.93, 0.07) NS
Schwingshackl *et al.* [23]	2018	3–24	27	2799	–0.82 (–1.11, –0.52) Significance and heterogeneity not reported	Not reported

Snorgaard *et al.* [24]	2017	12	7	1376	0.04 (–0.04, 0.13) $P = 0.29$, $I^2 = 0\%$	0.2 (–0.97, 1.36) NS

NS, nonsignificant; WMD, weighted mean difference.

Table 3 Summary of recent meta-analyses of quantity of dietary protein in people with Type 2 diabetes

Lead author	**Year**	**Length of follow-up, months**	**Number of studies**	**Number of participants**	**Reported outcomes for higher- vs lower-protein diets**	
					HbA_{1c} WMD (95% CI), %	**Weight WMD (95% CI), kg**
Ajala *et al.* [16]	2013	12	2	174	–0.28 (–0.38, –0.18) $P < 0.0001$, $I^2 = 60\%$	0.44 (–0.96, 1.84) $P = 0.54$
Dong *et al.* [60]	2013	1–24	9	418	–0.52(–0.9, –0.14) $P = 0.02$, $I^2 = 57.2$	-2.08 (–3.25, –0.9) $P = 0.84$, $I^2 = 0\%$

I^2, measure of heterogeneity (% of total variation due to heterogeneity rather than chance); WMD, weighted mean difference.