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Development of food groupings to guide dietary advice in people with diabetes

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Abstract

Foods commonly consumed by 16 adults with diabetes were grouped according to macrinutrient value and type of fat to form 13 categories of which 10 would form the focus of dietary advice. Dietary modeling demonstrated that the food group pattern provided adequate nutrition and low variation in dietary targets. Idealised proportions of fat types were achieved only when daily servings of foods such as oils, nuts, oily fish and soy were included. The food groupings proved appropriate for dietary advice for diabetes.

Keywords

diabetes, dietary advice, food groups, type of fat

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The development of food groupings to guide dietary advice for people with diabetes

Food advice for diabetes

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The development of food groupings to guide dietary advice for people with diabetes

Objective: To describe the development and characteristics of a food categorisation system and its application to guide advice for diabetes treatment.

Research Design and Methods: Foods reported as commonly consumed by 16 adults with diabetes were grouped according to macronutrient content and the type of fat to form a set of reference food groups for dietary advice purposes. Means for energy and macronutrients from individual food groups were then used to construct an overall pattern of intake targeting 8,000kJ and relative amounts of carbohydrate, protein and different types of fat (SFA<10%E and PUFA~10%E). Variation in energy and macronutrients contributed by all foods partitioned into each food group was assessed by the coefficient of variation (CV) of data on the whole diet.

Results: To differentiate between sources of fat, 13 food groups emerged and 10 were deemed acceptable according to nutritional guidelines for diabetes treatment. The food group pattern was judged adequate for the achievement of dietary recommendations with low potential variation in total energy (5%) and macronutrient proportions (protein 6%, fat 6%, carbohydrate 3%), but higher variation for different types of fat (SFA 22%, MUFA 11%, PUFA 12%). Targeted proportions for these fat types were achieved only when daily servings of PUFA-rich, oils, nuts and oily fish or soy were included in an ideal intake pattern.

Conclusions: In theory, a dietary pattern constructed from food group sources of macronutrients and individual fat types results in low potential variation from recommended nutrient targets and, therefore, is appropriate to guide advice for the treatment of diabetes.

Keywords: diabetes, food groups, dietary advice, types of fat

Diet is often quoted as the cornerstone of treatment for diabetes, and there is considerable evidence that advice targeting specific dietary change offers substantial benefit [1-5]. Current guidelines for the treatment of diabetes and related complications provide nutrient intake recommendations, the most specific of which target the proportions of different types of fat in the diet. [6]. Where dietary advice necessarily refers to foods, the system of advice generation, however, needs to assure that nutrient targets can be met.

A number of food guidance systems are available with varying purposes. For example, to support glycaemic control, the carbohydrate counting system [7] focuses on the distribution of carbohydrate and the Glycaemic Index (GI) [8] focuses on the type of carbohydrate throughout meals. General food guidance systems, such as the Australian Guide to Healthy Eating (AGHE) [9] and the Food Guide Pyramid [10], outline the number of servings from core food groups required to meet nutritional requirements for the general population. Exchange lists published by the American Dietetic Association (ADA) [11] take a total diet approach, where 'all foods can fit into a healthful eating style' [12], and provide some information on the type of fat contained in foods [13]. While certain food groups are generally recognised for contributing a particular type of fat, for example meat and dairy for providing saturated fat, none of the current guidance systems provide adequate reference to food sources high in monounsaturated or polyunsaturated fats. Hence, general low-fat advice strategies based on these systems do not necessarily address specific relative amounts of different types of dietary fat [14]. While it is acknowledged that individualising advice is fundamental to the treatment of diabetes, a structured food-based advice strategy to guide the achievement of appropriate targets for each type of fat is also required and must satisfy both recommended and practical evaluations in order to determine whether the resultant intake pattern does indeed achieve the nutrients targeted.

The aim of this paper, therefore, is to describe the development and characteristics of a food categorisation system resulting in a set of food groups inclusive of the type of fat (vegetables, cereals, fruits, milk/soymilk, meat, oily fish/soy, and MUFA and PUFA fat) and its application to guide advice to meet energy and nutrient targets with minimal potential variation for the treatment of diabetes.

Methods

The process for the systematic development and evaluation of a specific food group intake pattern to guide advice for the achievement of overall energy and nutrient targets is summarised in Fig. 1, and outlined in detail below:

[INSERT FIG 1]

1. Development of food groups as sources of macronutrients and fat types

1.1 Identification of foods to include in the food groups

Foods to be included in a set of food groups for the achievement of specific nutrient targets were identified from foods commonly consumed by 16 women with gestational diabetes mellitus (GDM) from Wollongong, Australia. Characteristics of the study sample have been previously described [15]. Individual foods reported in a diet history [16] by each woman were analysed for energy and macronutrient content using the nutrient analysis software program FoodWorks (Version 2.1, 2000, Xyris software, Brisbane, Australia) incorporating nutrient tables for use in Australia (AUSNUT, Canberra, 2000). Mixed dishes and prepared foods were analysed using individual ingredients where possible. Using pooled data, the percentage contribution of common food groupings, such as cereal, meat, and cheese, to total macronutrient consumption for carbohydrate, protein and fat was determined. The groupings were then rank ordered under these macronutrient headings to determine major food sources of each (Table 1). Food groupings contributing to <75% of total intake for each macronutrient variable were then taken as representative of foods commonly consumed by the study sample.

[INSERT TABLE 1]

1.2 Categorisation of the included foods based on macronutrient composition

Individual foods belonging to the food groupings determined in 1.1 were then categorised by the relative proportions of all macronutrients contained in a single serving. Thus, with reference to existing standards [9,10], mean energy (kJ) and macronutrient content (grams)

per serving were derived. Each macronutrient was considered in turn, commencing with the main macronutrient (carbohydrate, protein or fat). A fourth category accommodated foods which did not have the levels of macronutrients identified in the other three lists, mainly vegetables, but never-the-less needed to be included in terms of total energy and micronutrient intakes. Sub-categories were developed based on secondary macronutrient compositions. For example, in the case of fat content, the need to identify the type of fat required SFA-rich versus PUFA-rich sub-categories in the milk and meat groups, but not MUFA-rich as this type of fat largely coincided with SFA content. Fast foods, such as ham/cheese burgers and fried chicken, had similar fat profiles to that of SFA-rich high-fat meat and cheese and, therefore, were included in that group. Similarly, fat-rich foods (oils, spreads and nuts) were categorised as PUFA-rich or MUFA-rich, according to the main type of fat they contained. This process would also have necessitated a SFA-rich sub-category within the fat-rich group except that the study sample was already limiting fat-rich food sources of this type of fat, for example butter.

To minimise variation between individual foods within each food group, the following steps were followed:

i) A reference food was identified within each main macronutrient category. For example, bread was taken as the staple food for carbohydrate.

ii) Portion sizes for individual foods in each list were modified to produce a gram amount for the main macronutrient close to that of a standard serving of the staple food. Thus, portion sizes for foods listed under carbohydrate were modified to more closely match the 15 grams of carbohydrate taken for one slice of bread.

iii) Sub-categories were based on secondary macronutrients and also on other nutritive components such as the presence of starch and sugar.

Thus, a set of reference food groups representing the mean macronutrient content of common foods was determined (Fig 2).

[INSERT FIG 2]

1.3 Estimation of food group variation

For each food group, the mean nutrient content, range and coefficient of variation (CV=SD/mean x 100) was determined for all foods in that group. Acceptable variation was set at a CV $\leq$ 15% for the main macronutrients, otherwise acceptability of the variation was assessed by comparison with an existing food guidance system. Thus, the SD and range results were compared to those reported in the 1995 ADA Exchange Lists for Meal Planning, the only other set of exchange lists to provide specific data on within-list variations from mean nutrient estimates [17].

1.4 Comparison with core food groups

In order to establish whether general nutritional adequacy and diabetes principles might be achieved from an intake pattern based on the reference food groups, they were compared with core food guide classifications outlined by AGHE and food guide pyramid [9,10] and current practices aimed at controlling glycaemia. Additionally, food groups that did not meet nutrient density criteria consistent with ADA guidelines, that is, foods with high (saturated) fat or sugar (sucrose) content, were identified as 'foods to limit' and excluded from the final set of food groups for which intake levels were set.

2. Determination of a recommended food group intake pattern

2.1 Construction of a food group intake pattern to meet nutrient targets

Mean amounts for the energy and macronutrient content from each of the food groups were rounded-off to the nearest whole number, with the following exceptions: the protein content of one serving of milk was rounded down to 10g instead of up to 11g due to a greater number of individual food items containing nearer that amount; the fat content of medium-fat meat

was rounded down to 5g rather than up to 6g in order to be consistent with the sum of available data from individual fat types; finally, the small carbohydrate content of soybeans and nuts was ignored to enable a better representation of more common foods listed in these groups, such as fish, and oils and spreads, respectively. In this way, a simplified nutrient composition table in a 'ready reckoner' format was produced.

A total diet pattern was constructed from a defined number of servings from selected reference food groups using corresponding ready reckoner estimates to produce specific targets for total energy and macronutrient intakes. Based on the average requirement for moderately active, weight stable adults, the target for energy was around 8,000 kJ/day [18,19]. Core food recommendations were adhered to by aligning the number of servings from the reference food groups with minimum daily requirements from core food guide classifications [9,10]. Nutrition principles for diabetes management [6] were also considered in order to enable advice on portion control, carbohydrate-counting, and identification of the type of carbohydrate (wholegrain, high fibre, low GI). Macronutrient goals corresponded to low fat intakes and current diabetes recommendations [6]: approximately 30% energy as total fat (<10% saturated (SFA) and ~10% total polyunsaturated (PUFA) fat) and around 20% protein, leaving 50% energy as carbohydrate. Atwater Factors were used to convert percentage of energy to grams of macronutrients [20]. Steps in the determination of the recommended food group pattern are outlined below:

(i) Foods from the carbohydrate group were included in the diet first, where 50% of energy translated to around 250g carbohydrate, or 15 exchanges of foods delivering 15g carbohydrate per exchange [allowing for some carbohydrate from vegetables]. Ready reckoner estimates for the protein and fat content of these foods were also calculated at this stage.

(ii) Protein targets were next addressed by referring to the recommended amount from cooked meat or meat equivalent [9,10], with an average amount from all sources achieving, 5oz [150g]. Protein means were added to those obtained from carbohydrate-rich foods, established in (i).

(iii) Targets for different types of fat were lastly addressed, mainly through the inclusion of foods that deliver PUFA, since SFA from carbohydrate and protein foods was already found to be adequate from the inclusion of lean and low fat groups in steps (i) and (ii).

Total kJ and grams of macronutrients from the overall intake pattern were calculated and compared to targets.

2.2 Matching dietary advice to the recommended food group intake pattern

Using this framework, dietary advice would refer to a specific number of servings per day from each of the reference food groups defining the recommended food pattern in 2.1. The advice would be appropriate for people with diabetes, allowing individualised food choices and the type and distribution of carbohydrate-rich foods and meals throughout the day.

2.3 Nutritional adequacy of the food group intake pattern

Overall nutritional adequacy was assessed qualitatively by comparing the number of servings from across the food group intake pattern with the number of servings required to meet core food recommendations for adults [9,10]. In addition, a random selection of food items in the recommended pattern and the amounts specified was compared with 75% of the recommended intakes for protein and vitamins A, C, E and folate, and minerals iron, calcium, magnesium, zinc and fibre [18,19].

Selection of a ‘random’ food item was achieved when an individual, blinded to the food database, chose a number between zero and the number of foods contained in the corresponding food list, inclusively. When the foods from that list were arranged in reverse

order, the food corresponding to the number chosen became the representative food. This process was repeated independently for each serving within each food group.

2.4 Comparison with unrounded estimates of dietary intake

The effect of using rounded estimates for calculations of total dietary intakes was assessed. Based on the food group intake pattern developed for 8,000kJ, total estimates for energy, carbohydrate, protein, fat, and each fat type were calculated from 'rounded' Ready Reckoner estimates and from the original unrounded means, and the differences compared.

2.5 Variation due to individual food choices

The variation in intakes for total energy and macronutrients that might be expected from food choices within the restraints of the food group intake pattern was also assessed. This was achieved by taking the sum of variances from each food group for carbohydrate, protein, fat and each fat type, respectively. The square root of the sum of variances provided a total standard deviation (SD) for each macronutrient variable and, in turn, a SD for total energy intake. In this way, energy and macronutrient distributions from all possible food combinations to meet the prescribed pattern of intake were determined.

The steps undertaken to achieve the assessments of the effects of rounding and variation due to individual food choices in *2.4* and *2.5*, respectively, are outlined below:

(i) A total mean estimate in grams for each macronutrient and fatty acid in the overall food pattern was determined from the sum of the original means for each of the included food groups

(ii) The SD of each estimate determined in (i) was calculated using the formula:

$$SD_{[\text{total grams}]} = \sqrt{(x_1\ SD^2_1 + x_2\ SD^2_2 + x_3\ SD^2_3 + \ldots + x_n\ SD^2_n)}$$

Where, SD = standard deviation

x_1 = number of serves from food group 1

SD^2_1 = variance for the total mean (grams) from food group 1

(iii) The total grams ±SD determined in (i) and (ii), respectively, for each macronutrient variable were converted to energy (kJ) using Atwater Factors outlined in 2.1.

(iv) The resultant energy±SD for total carbohydrate, protein and fat determined in (iii) were summed to give the total energy and SD for the overall diet.

The coefficient of variation (CV) for each macronutrient variable and total energy were calculated from mean total energy±SD determined in (iv). CV<15% was the arbitrary estimate of reasonable variation for intakes of total energy and each macronutrient and fat type from the food group intake pattern.

Results

1. Development of food groups as sources of macronutrients and fat types

1.1 Identification of foods to include in the food groups

Major food groups commonly consumed by the study sample were rank ordered to reveal 24% of protein intake came from meat, 42% of carbohydrate came from cereal-based foods, and 18% of fat from oils and margarines. Cereal-based foods also made major contributions to the protein (21%) and fat (11%) fractions of the diet, while milk and yoghurt made secondary contributions to both protein (15%) and fat (11%). Combining milk, yoghurt, meat and cheese provided most of the fat intake - predominantly saturated fat.

1.2 Categorisation of the included foods based on macronutrient composition

Three hundred and forty eight common food items composing 75% of the total macronutrient content of the diets of the study sample were categorised according to macronutrient composition to form nine sub-categories and 13 final food groups (Fig 1). Corresponding mean estimates for macronutrient content of individual portion sizes within each food group are provided in Table 2.

[INSERT TABLE 2]

1.3 Estimation of food group variation

For each of the 13 food groups, within-list variation was low: CV<15% for primary macronutrients (data not shown); and SD <2g, although the number of foods listed varied from 1 to 89 (Table 2). The vegetables group was the exception to this with greater variation within very low macronutrient content. For this food group, serving size modification aimed at reducing the variation for energy (CV<15%) as the main dietary variable rather than macronutrient content (data not shown). Standard deviation and range for individual foods within each list compared well with those reported in the literature [17], our results demonstrating, in most cases, a narrower data set. Therefore, mean estimates for each of the

reference food groups were considered representative of the energy and macronutrient content of individual food items listed within each group.

1.4 Comparison with core food groups

Food guides [9,10] generally refer to five core-food classifications (bread/cereals, vegetables, fruit, milk, meat and equivalents) outlined in Table 3. In addition, the AGHE refers to a broad variety of extra 'foods to limit'. In contrast, our categorisation process derived 13 food groups, 10 of which were determined to be appropriate for the nutritional management of diabetes. Hence, foods listed in the reference food groups identifying table sugar/sugar-rich foods, full-fat milk and high-fat meat/fast foods provided a more specific list of 'foods to limit'. Further, differences between our food groups and the guides were: the inclusion of carbohydrate-rich starchy vegetables with cereal-based starches such as bread rather than with other vegetables with low carbohydrate content; cheese was listed as a protein-rich food with meat rather than with milk, and these groups were sub-categorised to address differences in the amount and type of fat they contain; and finally, the inclusion of high-fat foods such as oils, spreads and nuts, again with sub-groups for proportional differences in the type of fat. Although more discriminating between foods, our final set of food groups were consistent with core food guide classifications in that a minimum number of servings across the food group intake pattern would ensure overall nutritional adequacy. In terms of glycaemic control, equivalent carbohydrate content per serving and the inclusion of all carbohydrate-rich foods within three food groups (starch, fruit and milk) supports advice for the even distribution and type of carbohydrate in meals throughout the day.

[INSERT TABLE 3]

2. Determination of a recommended food group intake pattern

2.1 Construction of a food group intake pattern to meet nutrient targets

Rounded mean estimates corresponding to each list of foods provided a "ready reckoner" of energy and macronutrient compositions as well as fibre content for the final set of food groups (Table 4). Subsequent food group assemblage using 'rounded' ready reckoner estimates achieved an intake pattern corresponding to that defined in Table 3. Therefore, in theory the prescribed food group pattern achieved the nutrient proportions targeted (provided in brackets): 8290kJ (8000kJ), 67g total fat 30%E (30%E), 15g SFA 7%E (<10%E), 22g PUFA 10%E (10%E), 106g protein 22%E (20%E) and 235g carbohydrate 46%E (50%E).

[INSERT TABLE 4]

2.2 Matching dietary advice to the recommended food group intake pattern

Food-based advice was constructed in terms of the required number of daily servings from each of the reference food groups included in the recommended intake pattern (Table 3). In terms of glycaemic control, foods of low glycaemic effect corresponded well to existing fruit and milk groups. More discriminating advice would largely be confined to the starch group with reference to preferred food choices such as wholegrain, high fibre and/or low GI [8]. Equivalent serving amounts from the starch, fruit and milk groups would enable even distribution of carbohydrate throughout the diet.

2.3 Nutritional adequacy of the food group intake pattern

The recommended intake pattern was at least equivalent to the minimum number of servings outlined in core food guides (Table 3) [9,10]. A random selection of food items to represent the food groups in the recommended intake pattern provided at least 75% of intakes recommended [18,21] for other nutrients outlined in the Methods section (data not shown).

2.4 Comparison with unrounded estimates of dietary intake

Calculation of the same 8,000kJ food pattern using original mean estimates from Table 2 for each of the included food groups resulted in small differences in total energy and

macronutrient intakes compared to those achieved using ready reckoner estimates from Table 4 and presented in *2.1* (and in brackets here): 7980.9±365.5kJ (8290kJ), 65.0±4.1g (67g) total fat, (13.4±2.9g (15g) SFA, 21.6±2.6g (22g) PUFA), 102.5±5.8g (106g) protein and 239.6±7.2 (235g) carbohydrate. The effect of rounding, therefore, was considered minimal and justified the use of simplified estimates for ease in the development of a prescribed dietary intake.

2.5 Variation due to individual food choices

Estimations of variation from all possible food combinations suggest individual choices to match the model would be reasonably close to dietary targets, particularly for total energy intake (7980.9±365.5kJ). The CV for each macronutrient variable (carbohydrate=3.0%, protein=5.7%, fat=6.3%, MUFA=10.7%, PUFA=12.0% and for total energy=5%) was <15% set as clinically acceptable. Greater variation was determined for SFA (CV=21.7%). The estimate for total energy was (SD±365.5kJ, CV=5%).

Discussion

There are many contexts in which dietary advice needs to be formulated. In the clinical context, as in nutrition research, methods need to be clearly defined so there is some assurance of nutritional goals. Food groups based on exchange lists of foods support this process by enabling selections from a range of foods to meet both energy and nutrient requirements. Published exchange lists, however, have demonstrated some large within-list variations [17] and may not address all the requirements for macronutrient manipulation. For the purposes of achieving low-fat, energy controlled diets and recommended proportions of each type of fat in the diet, this paper tests an advice strategy based on the development of a set of macronutrient-based reference food groups and a recommended intake pattern. The advice was subsequently shown to adequately address targets for the type of fat consumed within a nutritionally adequate, energy controlled diet. Further, being a reference framework, the general principles would apply to all, but when it came to specific foods a number of food combinations could be used, allowing increased flexibility for individual food preferences and health and lifestyle objectives. The structured advice approach, however, ensures consistent and accurate targeting of nutrients regardless of these individual differences.

While the categorization process has inherent limitations [21], these mainly stem from the criteria used to categorise foods. In this case, the criteria for food group development were taken from the macronutrient parameters to be used in the development of the overall diet. Thus, the resultant food groups were used as building blocks for the construction of an intake pattern to meet predetermined dietary targets, and therefore were considered appropriate. As the focus of dietary advice is on foods and concerns relative amounts of macronutrient intakes, a recommended intake pattern was developed from food categories using one criterion at a time and reference standards used to ensure total energy requirements,

macronutrient proportions and overall nutritional adequacy. Within this framework, the type and distribution of carbohydrate were also addressed in line with existing strategies to support glycaemic control.

Working from foods commonly consumed by a local sample of women with GDM, major food sources of macronutrients were determined. In this way, the significance of secondary sources of macronutrient intake was uncovered and the importance of attending to multiple food components underscored. This resulted in a greater final number of food groups compared with core food guide classifications outlined in existing food guides [9,10]. Corresponding food lists differentiated well between foods with substantially different relative proportions of macronutrients and the type of fat, for example, cows milk versus soymilk and meat versus oily fish, where the distinction between SFA-rich and PUFA-rich foods was apparent. In contrast, existing food guides [7,9,10] do not differentiate well between foods in which fat is the secondary macronutrient contribution, mainly high protein foods, such as milk, meat, and nuts (in lists where nuts are included as a high protein food even though the main macronutrient is fat). ADA exchange lists now sub-categorise exchangeable edible fat sources based on the major fat type. However, bearing in mind edible fat alone can account for just 30% of total daily fat intake [22], the application of ADA Exchange Lists is less likely to have an impact. For example, a weight loss intervention based on the USDA Food Guide Pyramid and ADA exchange lists showed reductions in total and SFA intakes, but with little change in the proportion of PUFA in the diet [14]. Our greater number of food groups assured targets for the type of fat, meeting the challenge for achieving both nutritional adequacy and appropriate dietary fat profile. Where not all food groups were included in the sample pattern, a substantial number of servings from PUFA-rich food sources were necessary, highlighting the importance of advice for the regular consumption of some

foods and not others. While goals for the relative proportions of different types of dietary fat may also be met through judicious food choices, the present guidance systems are too blunt to make this assumption.

Specificity of the study sample, the relatively small number of foods listed and the fact that estimates were based on a single food pattern may limit the generalisability of results. However, a single dietary pattern was important to demonstrate an 'ideal' template on which to base advice for consistent dietary outcomes. This lends itself to substantiation research in which a structured approach enables a single nutrient or food to be tested within the overall diet plan [23]. Although the number of listed foods was limited, mean estimates for macronutrient content corresponded to those reported for exchange lists using a greater number of foods [17]. Further, variation due to any combination of individual food choices from within the recommended food pattern was low and likely narrower than existing advice systems that demonstrate wider variation within individual food categories [9, 17]. The advice system was therefore judged as adequate for consumption of different types of fat in the proportions defined by current recommendations, and particularly supportive of total diet advice for controlling energy intake (SD±365.5kJ within an 8,000kJ diet plan). Greater variation for saturated fat (likely due to the increased number of staple foods containing this type of fat) was readily overcome in the construction process by ensuring the upper estimate of SFA variation (+2SD) was below the target level (<10% of energy). For any system, however, encouraging consumption of a wide variety of foods from within and across food groups reduces the risk of consumption patterns that lie at the extreme ranges of energy and macronutrient intakes as well as ensures nutritional adequacy [15].

One of the biggest challenges in addressing macronutrient-referenced dietary goals is to provide valid and feasible advice on foods to consume. By confirming the theoretical achievement of nutritional goals, this paper has outlined a systematic approach to dietary advice based on food groups that differentiate between foods based on primary and secondary macronutrient content. Having done so, the approach has demonstrated a methodology that can be used for other plans according to requirement. While all foods may not fall clearly into any one group, the structured nature of the approach facilitates a level of capability for the achievement of macronutrient targets. The advice system, therefore, is appropriate not only in the diabetes context, but for the treatment of other clinical features of the Metabolic Syndrome, including CVD and overweight, as well as general healthy eating strategies, and in controlled diets for investiagions of single nutrient/food effects. Acceptance of the advice system by practitioners and its feasibility in clinical practice and in diverse ethnic groups or for dietary interventions other than diabetes would be of interest and provides the basis for future research.

In practice, the approach has been successfully used in randomised controlled trials involving subjects with Gestational Diabetes Mellitus [24] and Type 2 Diabetes Mellitus (T2DM) [25] and was found to be easy to implement with high acceptance by both groups. This was borne out in the adequate achievement of targets for each type of fat by intervention groups receiving advice based on the recommended food group intake pattern, which were significantly different from control groups receiving general low fat advice (usual practice). The clinical effectiveness of the advice system was also confirmed in T2DM subjects through significant improvements in cholesterol outcomes compared to the control group [26]. Importantly, all groups maintained good glycaemic control, verifying the shift in focus away from glycaemia to a broader focus on overall metabolic health without detrimental effects.

Conclusion

In recognition of the need for evidence-based approaches to advice, this study has developed a systematic approach for the dietary treatment of diabetes. This system successfully combined specific macronutrient recommendations with existing guidelines and practices to address the type and distribution of carbohydrate-rich foods as well as the type of fat within the overall diet. Importantly, the significance of differentiating between foods of varying macronutrient content was demonstrated in a theoretical dietary model. Advice would refer to daily servings from a set of reference food groups in the recommended intake pattern. Equivalent serving amounts from carbohydrate-rich foods within the starch, fruit and milk groups and differentiating wholegrain, high fibre, and/or low GI choices within the starch group would support existing practices for glycaemic control [7,8]. PUFA-rich foods, however, also required specific attention and regular intakes for the achievement of recommended proportions for each type of fat in the diet. Usual eating patterns would determine relative amounts of significant foods such as oily fish, soy foods and/or oils and nuts developed in proportion with individual energy needs. Thus, this study provides theoretical support for food groupings based on macronutrient content and their specific pattern of intake to ensure nutrient targets, and confirms their appropriateness to guide advice in the treatment of diabetes.

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Table 1 Rank order of the highest percentage (%) contribution of common food groupings to approximate 75% of the macronutrient intake of 16 women with gestational diabetes mellitus (GDM)

Food Groupings	**Protein** % total intake	**Food Groupings**	**Carbohydrate** % total intake	**Food Groupings**	**Fat** % total intake
Meat	23.8	Cereals/bread	42.1	Oil/margarine	18.0
Cereals/bread	21.1	Fruit	16.9	Meat	11.7
Milk/yogurt	14.9	Sugar-rich	12.7	Cereals/bread	11.3
Fish	7.4			Milk/yogurt	11.1
Vege/legumes	6.6			Cheese	9.9
				Fast food	7.8
				Nuts	4.5
Total intake:	*73.8*		*71.7*		*74.3*

Table 2 Mean, standard deviation and range for the macronutrient content of recommended serve sizes from all foods of each food group

Macronutrient		**Carbohydrate (g)**			**Protein (g)**			**Fat (g)**		
Food List	No.	Mean	SD[a]	Range	Mean	SD[a]	Range	Mean	SD[a]	Range
Vegetables ½ cup cooked/1 cup raw	33	2.3	±1.1	0-4[b]	1.9	±0.9	1-4	0.0	±0.0	0-0
Starchy foods 1 slice/ ½ cup	89	14.9	±1.8	11-19[c]	3.1	±1.5	1-10	0.8	±0.7	0-2
Fruit 1 piece	38	15.2	±1.4	13-18[d]	1.2	±0.8	0-3	0.1	±0.3	0-1
Table sugar 1 tspn/5g	1	5.0	±0.0	0-0	0.0	±0.0	0-0	0.0	±0.0	0-0
Milk (low/reduced fat) 1 cup	12	14.6	±1.6	12-17[e]	10.8	±0.9	10-12	1.9	±1.9	0-4
Milk (full fat) 1 cup	5	15.2	±0.8	14-16	11.8	±1.9	10-15	11.4	±0.6	11-12
Soymilk (full fat) 1 ¼ cup	1	15.0	±0.0	15-15	11.0	±0.0	11-11	12.0	±0.0	12-12
Meat(lean/low fat) 30g/1 oz	68	0.1	±0.4	0-2	7.2	±0.7	6-8[f]	1.8	±1.1	0-4
Meat (medium fat) 30g/1oz	30	0.4	±0.8	0-3	7.2	±0.8	6-9[g]	5.7	±0.8	5-7
Meat (high fat) 30g/1oz	24	0.5	±1.0	0-3	7.0	±0.8	6-8	9.3	±1.3	8-12
Oily fish, soybeans 30g/1oz	6	0.5	±0.8	0-2	7.2	±0.4	7-8	3.5	±0.6	3-4
MUFA-rich 1 tspn/5g	24	0.5	±0.6	0-2	0.4	±0.9	0-2	5.2	±0.5	5-6[h]
PUFA-rich 1 tspn/5 grams	17	0.2	±0.5	0-2	0.2	±0.4	0-1	5.1	±0.3	5-6[i]

ADA published values [17]: [a] 0-4.7; [b] 1-14; [c] 11-23; [d] 11-20; [e] 11-17; [f] 5-9; [g] 5-11; [h] 3-5; [i] 3-6

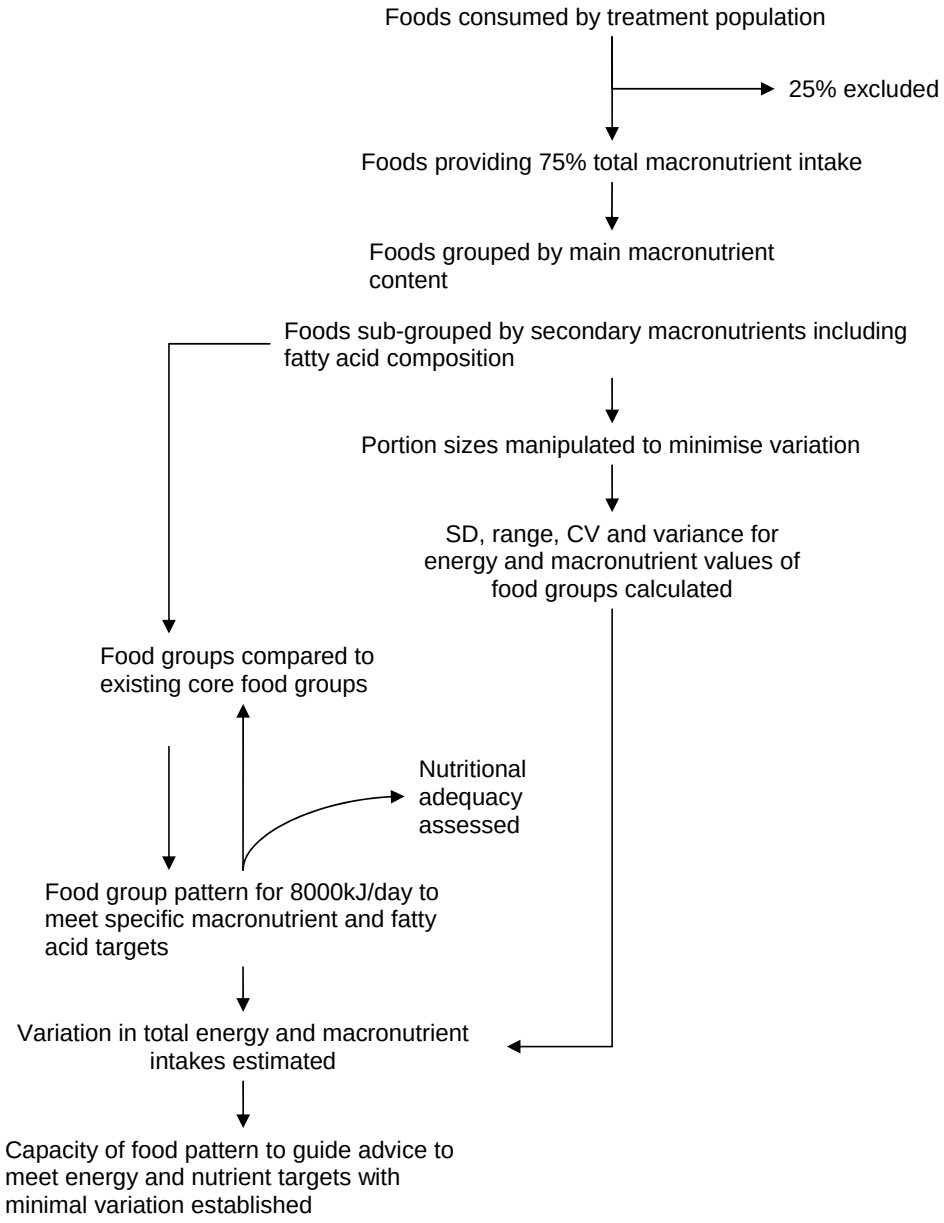
Table 3 Comparison of existing food guidance systems and macronutrient-based reference food groups used to construct a pattern of intake to guide advice for diabetes treatment

Core Food Guide[a,b] Classification	**Average Serve size**	**USDA[a] Serves/day**	**AGHE[b] Serves/day**	**Reference Diet Model[c] Serves/day**	**Macronutrient-based Reference Food Groups**
All vegetables, legumes	½ cup cooked	3-5	4-8	5	**VEGETABLES** Excludes potatoes, corn, legumes
Bread, cereals, rice, pasta, noodles	1 slice ½ cup	6-11	8-14	9	**STARCH** Plus potatoes, corn, legumes (not soybeans)
All fruit	1 medium	2-4	2-4	4	**FRUIT**
Milk, yogurt, cheese	1 cup	2-3	2-4	2	**MILK** (low/reduced fat) Excludes cheese **SOY MILK** (full-fat)[d]
Meat, fish, poultry, eggs, nuts, legumes/ dry beans	Cooked meat equivalent 2-3oz[a] 65-100g[b] 30g(1oz)[c]	2-3	1-1.5	5	**MEAT** (lean/low fat) Excludes oily fish, nuts, legumes Includes cheese (medium fat) Includes eggs and cheese **OILY FISH/SOY BEANS[d]**
'extra foods' including margarine, oils, sweets, biscuits, snack foods & alcohol	Limited[a] 145kcal[b] 1tsp fat[c] 10g nuts[c]	Limit	0-3	3	**MUFA** Includes oils, spreads, nuts[e]
				5	**PUFA** Includes oils, spreads, nuts[d]
				Limit	- sugar-rich foods - milk/yogurt(full fat) - meat/fast food (high fat)

[a] F Food Guide Pyramid [10]
[b] A Australian Guide to Healthy Eating [9]
[c] PaPattern of intake developed from Reference Food Groups to provide approximately 8,000kJ
[d] H High in PUFA
[e] H High in MUFA

Table 4 'Ready Reckoner' format for energy and macronutrient content of food groups

FOOD CATEGORIES	Serving	CHO	PTN	FAT	Energy		SFA	MUFA	PUFA	Fibre
	Size	*Gram*	*Gram*	*gram*	*kJ*	*(kcal)*	*gram*	*gram*	*gram*	*gram*
VEGETABLES	½ cup	2	2	0	80	(20)	0	0	0	3
Carbohydrate										
STARCH Bread, Cereals, Vegetables, Legumes	1 slice/ ½ cup	15	3	1	335	(80)	0	0	0	1-3
FRUIT	1 piece	15	1	0	285	(70)	0	0	0	2
MILK Low/reduced fat Milk, yogurt	1 cup	15	10	2	500	(120)	1	1	0	0
SOY MILK (full-fat)	1 ¼ cup	15	10	12	845	(200)	1	3	7	0
Protein										
MEAT Lean/low fat Meat, Fish, Cheese	30g (1oz)	0	7	2	195	(45)	1	1	0	0
Medium fat Meat, Cheese, Egg	30g (1oz)	0	7	5	335	(80)	3	2	0	0
OILY FISH/SOYBEANS	30g (1oz)	0	7	4	260	(60)	1	1	2	0
Fat										
MUFA Oils/Spreads/Nuts	5g (1tsp)	0	0	5	200	(50)	1	3	1	0
PUFA Oils/Spreads/Nuts	5g (1tsp)	0	0	5	200	(50)	1	1	3	0


Foods consumed by treatment population
25% excluded
Foods providing 75% total macronutrient intake
Foods grouped by main macronutrient content
Foods sub-grouped by secondary macronutrients including fatty acid composition
Portion sizes manipulated to minimise variation
SD, range, CV and variance for energy and macronutrient values of food groups calculated
Food groups compared to existing core food groups
Nutritional adequacy assessed
Food group pattern for 8000kJ/day to meet specific macronutrient and fatty acid targets
Variation in total energy and macronutrient intakes estimated
Capacity of food pattern to guide advice to meet energy and nutrient targets with minimal variation established

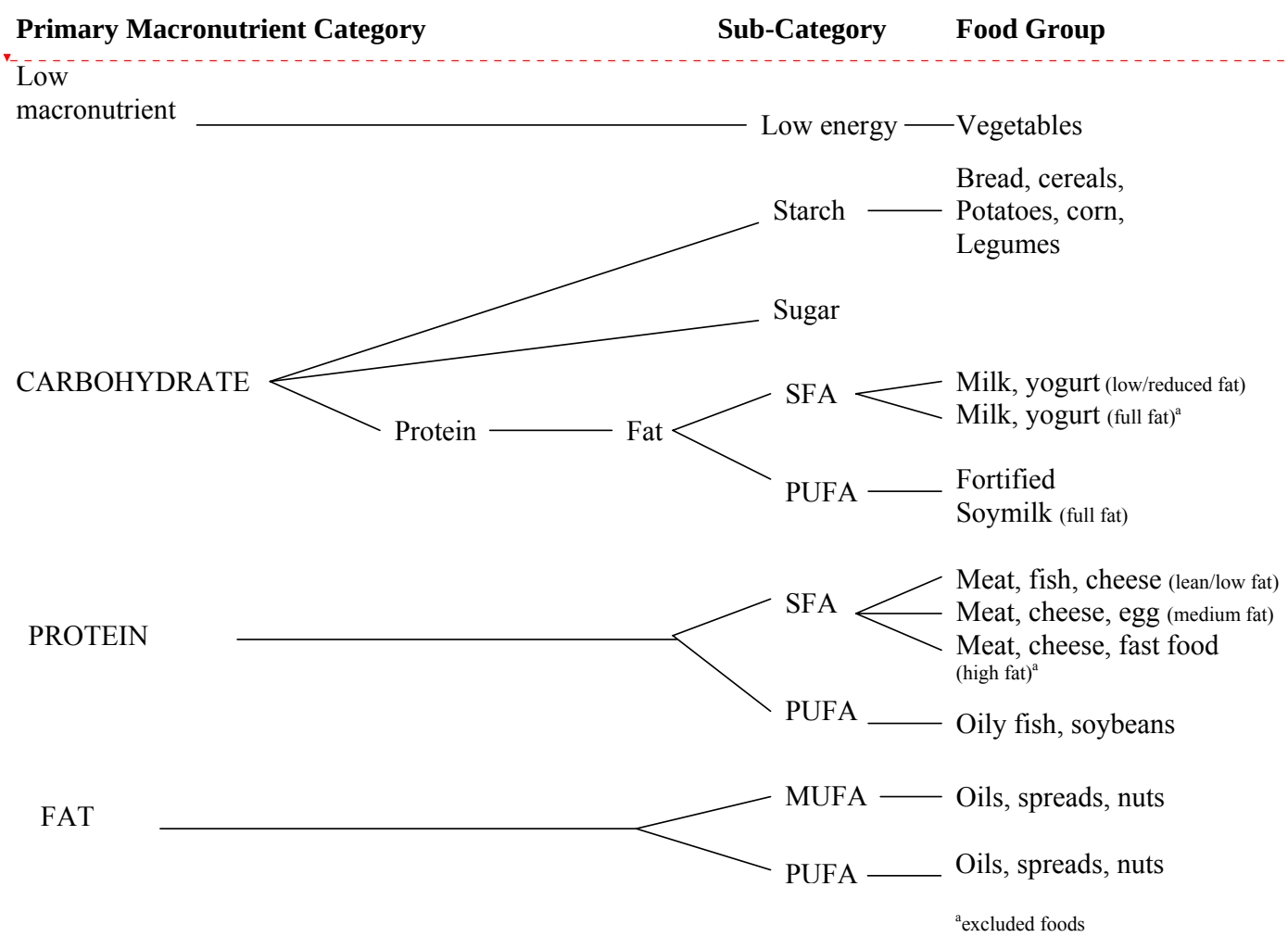


Fig.2 Categorisation of individual food portions based on equivalent content for macronutrients and the type of fat