Universidade Federal do Rio Grande do Sul
Faculdade de Medicina
Programa de Pós Graduação em Ciências Médicas: Endocrinologia
Área de Concentração Nutrição e Metabolismo
Mestrado e Doutorado

Qualidade da dieta a partir do Índice de Alimentação Saudável e controle glicêmico em pacientes com Diabetes Melito tipo 2

Nutricionista Juliana Peçanha Antonio

Orientadora: Profª Drª Nutr. Jussara Carnevale de Almeida
Co-orientadora: Profª Drª Mirela Jobim de Azevedo

Porto Alegre, junho de 2012.

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"Grandes realizações são possíveis quando se dá importância aos pequenos começos."

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Formato da Dissertação

Esta dissertação de Mestrado segue o formato proposto pelo Programa de Pós - Graduação em Ciências Médicas: Endocrinologia da Universidade Federal do Rio Grande do Sul, sendo apresentada da seguinte forma:

1. Breve referencial teórico a cerca do tema proposto

2. Artigo original referente à elaboração do Índice de Alimentação Saudável para pacientes com Diabetes (IASD), submetido para publicação no periódico *American Journal of Clinical Nutrition*, redigido conforme as normas do periódico.

3. Artigo original referente à avaliação da qualidade da dieta habitual a partir do IASD e associação com metabolismo da glicose de pacientes com Diabetes Melito tipo 2, a ser submetido para publicação em periódico internacional (Qualis A1, Medicina II).

Sumário

Lista de abreviaturas

DM: Diabetes Melito

HbA1C: Hemoglobina glicada

IAS: Índice de Alimentação Saudável

IASD: Índice de Alimentação Saudável para o Diabetes

DHEI: *Diabetes Healthy Eating Index*

ADA: *American Diabetes Association*

A1C: *Glycated hemoglobin*

BMI: *Body Mass Index*

UAE: *Urinary Albumin Excretion*

HDL-cholesterol: *high density lipoprotein cholesterol*

LDL-cholesterol: *low density lipoprotein cholesterol*

SD: *standard deviation*

IRT: *Item Response Theory*

ANOVA: *Analysis of variance*

OR: *odds ratio*

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Diet Quality and Glucose Control in Patients with Type 2 Diabetes

REFERENCIAL TEÓRICO

O Diabetes Melito é uma doença crônica que acomete parte significativa da população mundial - cerca de 366 milhões de pessoas; 8,3% de prevalência global (1). No Brasil, a prevalência do diabetes no ano de 2011 foi de 12,4 milhões de pessoas e estima-se que para o ano de 2030 ocorra um aumento para 19,6 milhões de pessoas com a doença (1). O diabetes constitui um importante problema de saúde pública em razão da elevada prevalência e morbi-mortalidade (2), além dos custos envolvidos no seu tratamento (3).

O diabetes tipo 2 é a forma mais comum de diabetes e ocorre geralmente na vida adulta, estando associado à obesidade em cerca de 80% dos casos. A hiperglicemia sustentada, resultado da resistência à ação da insulina e da incapacidade pancreática em suplantar essa resistência, associada a fatores genéticos e ambientais é uma das principais responsáveis pelo desenvolvimento das complicações crônicas microvasculares, neuropáticas e, possivelmente, macrovasculares (3).

A redução das complicações crônicas do diabetes é usada como alvo terapêutico no tratamento da doença e as incidências de retinopatia, nefropatia e neuropatia estão diretamente associadas com o grau de hiperglicemia (3). Modificações no estilo de vida a partir de um plano alimentar saudável e individualizado com a prática regular de exercícios físicos associadas ao tratamento farmacológico (3) são recomendados para o manejo rigoroso da hiperglicemia, embora este controle intensivo possa aumentar em duas vezes o risco de episódios graves de hipoglicemia (4). Flutuações agudas nos valores de glicemia também podem estar envolvidas na patogênese das complicações crônicas do diabetes (5), sugerindo-se que as decisões do tratamento não devem se basear exclusivamente nos valores de hemoglobina glicada (HbA1C), mas também nos valores de glicemia de jejum e glicemia pós-prandial (5-8).

Ensaios clinicos reforçam a relação entre a progressiva deterioração do perfil glicêmico e o aumento gradual nos valores de HbA1C em pacientes com diabetes tipo 2 (6-8), demontrando que os valores da glicemia de jejum parecem ter papel principal na sustentação da hiperglicemia diária e contribuem com 76-80% do total desta, independente dos valores de HbA1C (7). Neste sentido, o manejo da glicemia de jejum pode ser utilizado como alvo terapêutico inicial (8), afinal, o aumento dos seus valores, juntamente com a HbA1C, deve-se a uma redução linear na função das células beta-pancreáticas com progressivo declínio da secreção e ação insulínica (8).

A hiperglicemia basal pode ser identificada pelos valores de glicemia média a partir de valores de HbA1C (3) e/ou, mais recentemente sugerida, por diversas medidas de glicemia coletadas ao longo do dia (9). Apesar da HbA1C ser amplamente utilizada para avaliar a adequação do tratamento do diabetes (9), o teste está sujeito a limitações em indivíduos com alterações no *turnover* eritrocitário, além de não informar sobre a variabilidade glicêmica ou episódios de hipoglicemia (3). Por outro lado, os valores da HbA1C são fortemente correlacionados com os valores estimados de glicemia média em pacientes com diabetes tipo 1 e tipo 2 (R^2 = 0,79; P <0,0001) (9), sugerindo-se então, que a glicemia de jejum possa ser utilizada na avaliação do controle glicêmico destes pacientes. De acordo com a ADA, a manutenção dos valores de glicemia abaixo de 140-180 mg/dl correspondem a valores de HbA1C de 7,0-8,0% e são considerados aceitáveis, desde que essas metas sejam mantidas com segurança, ou seja, evitando episódios de hipoglicemia (valores de glicemia <70 mg/dl) (3). Portanto, na prática clinica, o alvo terapêutico de valores de glicemia de jejum no intervalo entre 70-180 mg/dl costuma ser almejado no manejo não farmacológico, principalmente nos pacientes com controle glicêmico razoável.

As modificações no estilo de vida preconizadas pela *American Diabetes Association* englobam perda de peso, atividade física regular, hábitos alimentares saudáveis e automonitoramento da glicemia (3). Em relação aos componentes da dieta, o controle na quantidade e tipo de carboidratos ingeridos, a redução da ingestão de colesterol e de gordura total (especialmente um consumo inferior a 7% do valor calórico diário de ácidos graxos saturados) e minimizar a ingestão de ácidos graxos *trans*-insaturados são recomendados. Além disso, limitar o consumo de bebidas açucaradas, aumentar o consumo de fibras da dieta (14 g para cada 1000 kcal ingeridas) e de alimentos que contenham cereais integrais (metade da ingestão de grãos) também são encorajados em um planejamento alimentar individualizado que inclua a otimização das escolhas alimentares (3).

Na prática clínica nutricional, a avaliação da ingestão alimentar é freqüentemente realizada para fundamentar e monitorar o aconselhamento dietético com o intuito de promover saúde, prevenir doenças e suas complicações e alterar o estado nutricional do paciente, quando necessário (10). Em epidemiologia nutricional, a avaliação do consumo alimentar de indivíduos ou grupos é fundamental para o estabelecimento de padrões alimentares e para determinar a relação de causalidade entre dieta e doenças (11). No entanto, a complexidade da dieta humana representa um grande desafio para qualquer estudo que contemple sua relação com a doença (12). A avaliação do consumo alimentar pode ser realizada a partir de inquéritos retrospectivos ou prospectivos como: recordatórios de 24-48 horas, questionários de freqüência alimentar, história dietética, diários e registros alimentares estimados ou com pesagem direta de alimentos (10).

Índices dietéticos têm sido propostos para avaliar a qualidade global da dieta de indivíduos ou populações a partir das informações obtidas com os inquéritos alimentares. Estes índices levam em consideração o atendimento às recomendações nutricionais e podem refletir a situação da ingestão de diversos componentes da dieta em uma única variável (13). Diferentes índices dietéticos têm sido elaborados e/ou adaptados de acordo com as recomendações nutricionais de populações específicas e seus guias alimentares: Índice de

Nutrientes, Escore de Variedade da Dieta, Escore de Diversidade da Dieta, Índice de Qualidade da Dieta, Índice de Alimentação Saudável (IAS) e Escore da Dieta do Mediterrâneo Alternativo (13).

Dentre os índices dietéticos, destaca-se o IAS (14) que foi elaborado para a população saudável e engloba a ingestão de grupos alimentares, nutrientes e variedade alimentar ao estimar a qualidade global da dieta. O IAS foi proposto pelo Departamento de Agricultura dos Estados Unidos com o objetivo de monitorar os hábitos alimentares da população norte-americana e também como um instrumento útil na educação nutricional e na melhoria da saúde (13). Este índice vem sendo revisado a cada cinco anos para estar de acordo com as diretrizes nutricionais atualizadas (15). Estudo transversal com uma amostra de americanos adultos comparou os hábitos alimentares de amostras populacionais americanas avaliadas em 1994-1996 (n = 15,011) e em 2001-2002 (n = 9,032) a partir da última versão do IAS (16). Uma redução significativa no consumo dos componentes "frutas *in natura*", "vegetais" e "grãos integrais" e aumento de ingestão dos componentes "laticínios", "óleos" e "sódio" foi observada, porém se alterar a qualidade global da dieta entre os períodos [58,2% (56,6 – 59,9%) *vs.* 58,2% (57,2 – 59,2%)] (16). Em outro estudo transversal, o aumento em um ponto na qualidade da dieta avaliada pelo IAS foi associado com a redução de 0,1% nos valores de hemoglobina glicada em 8.159 americanos saudáveis (17).

Apesar de ser amplamente aplicado para a população saudável, estudos que utilizaram o IAS para avaliar a qualidade da dieta de pacientes com diabetes (18,19,20) ou indivíduos com glicemia alterada (21) ainda são pouco freqüentes na literatura. Dos estudos publicados, somente um, do tipo transversal e publicado recentemente, relacionou a qualidade da dieta dos pacientes com diabetes e desfechos de saúde/doença (19). O estudo de Mangou e colaboradores (19) teve como objetivo avaliar quais características clínicas estavam relacionadas com qualidade da dieta considerada adequada (definida por valores de IAS de 80 a 100%) em 151 pacientes gregos com diabetes tipo 2 a partir de análise de componentes principais do IAS (19). O hábito de fumar e consumir álcool, ser do gênero feminino, a presença de doença cardiovacular, úlcera péptica, obesidade e de sindrome do pé diabético contribuiram para a presença de um IAS de pelo menos 80%. Das comorbidades associadas ao diabetes, somente a presença de nefropatia diabética contribuiu para menores valores de IAS (19). Outros três estudos com o IAS foram realizados em amostras limitadas de pacientes chineses (18) ou brasileiros (20,21). Nestes estudos, foi observado que uma maior proporção de pacientes necessitava de melhorias na qualidade de suas dietas: 52,2% (20) e 80% dos pacientes (18). Ainda, cabe ressaltar que não foram consideradas as recomendações nutricionais específicas na avaliação da qualidade da dieta em nenhum dos estudos citados (18-21).

Até a presente data não foram encontrados na literatura estudos que avaliem a qualidade da dieta habitual e sua possível associação com o controle metabólico em pacientes com diabetes. Para a avaliação da qualidade da dieta destes pacientes é importante considerarmos as recomendações nutricionais específicas para o tratamento da doença. A hipótese da presente dissertação é que uma dieta com baixa qualidade está associada a um pior controle metabólico, em especial controle glicêmico, em pacientes com diabetes tipo 2. O estabelecimento da existência dessa associação, a partir de um índice dietético elaborado especificamente para pacientes com diabetes possibilitará um melhor direcionamento do aconselhamento dietoterápico a este grupo de indivíduos.

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Capítulo I

The Diabetes Healthy Eating Index (DHEI)

Development of Healthy Eating Index for patients with type 2 diabetes

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[4]Abbreviations used: DHEI, Diabetes Healthy Eating Index; ADA, American Diabetes Association; A1C, Glycated hemoglobin; UAE, Urinary Albumin Excretion; IRT, Item Response Theory; DASH, Dietary Approach to Stop Hypertension.

ABSTRACT

Background: Dietary indexes are used to evaluate the diet quality in general population but have not a tool adapted for specific recommendations for diabetes.

Objective: To construct a dietary index that allows assessing diet quality according to compliance with dietary recommendations for diabetes.

Design: Cross-sectionally, 201 outpatients with type 2 diabetes (61.4±9.7 years; A1C 7.3±1.3%) underwent 3-day weighed-diet records, clinical and laboratory evaluations. The constructed Diabetes Healthy Eating Index (DHEI) assessed diet quality according to compliance with diabetes dietary recommendations using ten components: diet variety, "fresh fruits", "vegetables", "carbohydrates and fiber sources", "meats and eggs", "dairy products and saturated fatty acids", and "oils, fats and nuts", "total lipids", "cholesterol", and "*trans*-unsaturated fatty acids". Each component performance was evaluated by Item Response Theory analysis. Diet quality was scored from 0 to 100%.

Results: The DHEI components which had the greatest difficulty regarding compliance with dietary recommendations were: "carbohydrates and fiber sources", "diet variety", "dairy and saturated fatty acids", and "oils, fats, and nuts". Also, the more informative components of dietary quality were "vegetables", "diet variety", "dairy and saturated fatty acids", and "total lipids". The diet quality in this sample was 39.8±14.3% (95%CI 37.8-41.8%) and only 55 patients (27.4%) had a total DHEI score ≥50%.

Conclusions: In patients with type 2 diabetes, the DHEI evaluate the overall diet quality according to compliance with diabetes dietary recommendations. This novel index can represent in clinical practice an easy and truthful tool for the assessment and management of diet in diabetic patients.

INTRODUCTION

Diabetes mellitus is a major public health problem, due to its high prevalence, morbidity and mortality, besides the high costs involved in treatment (1). The intensive control of hyperglycemia and hypertension, mainly using a pharmacological approach, reduced the development of micro- and, possibly, macrovascular chronic diabetic complications (2,3,4). However, a recent meta-analysis suggested that, in patients with type 2 diabetes the benefit to risk ratio of intensive glucose lowering treatment remains uncertain (5). In this sense, the best strategy for glucose lowering in people with type 2 diabetes should be reviewed and a non-pharmacological approach should be reinforced.

Life style changes have been recommended as an important intervention in diabetes management by the American Diabetes Association (ADA) and include weight loss, regular physical activity, healthy diet and behavior, and diabetes self-management education (6). The dietary advice supported by ADA is monitoring the amount and type of carbohydrates, reduction of total dietary fat intake (saturated fatty acids, especially, should not exceed 7% of daily calories), cholesterol, and *trans*-unsaturated fatty acids. Furthermore, an increased intake of dietary fiber (14 g fiber/ 1.000 kcal) and foods containing whole grains (one-half of grain intakes) is also reinforced (6,7).

The assessment of food consumption in clinical practice is often carried out to develop and implement nutritional advice to promote health, prevent illness, and improve the nutritional status (8). Dietary indexes are tools developed to evaluate the overall diet quality of populations and can reflect the intake of various dietary components (food groups, nutrients, and diversity or variety) in a single variable (9). The Healthy Eating Index is the most frequently used dietary index (10) for the general population (11). This index evaluates the compliance with food groups and specific nutrient intakes according to dietary guidelines (12) and has been developed for different populations such as the Canadian, Australian (12), and Brazilian (13). Some authors have already evaluated the Healthy Eating Index in patients with diabetes (14-16). However, in those studies this index was not adapted to include the specific dietary recommendations for diabetes (6,7). In this context, the present study aimed to construct a dietary index that allows assessing diet quality according to compliance with dietary recommendations for diabetes.

SUBJECTS AND METHODS

Study and patient selection criteria

This cross-sectional study was conducted in patients with type 2 diabetes defined as patients over 30 years of age at onset of diabetes, no previous episode of ketoacidosis or documented ketonuria and, if insulin users, the treatment with insulin began only after five years of diagnosis (17). Outpatients who consecutively attended the Endocrine Division of the Hospital de Clínicas de Porto Alegre, Brazil and had not received any dietary counseling by a registered dietitian during the previous 12 months were recruited. Patient selection was as follows: age <80 years, BMI <35 kg/m^2; serum creatinine <176 µmol/l; normal liver and thyroid function tests. The study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving patients were approved by the Hospital Ethics Committee. Written informed consent was obtained from all patients.

Among 323 eligible patients, six patients had poor adherence to drugs treatment for diabetes. Therefore, 317 patients underwent a clinical and laboratory evaluation. Sitting blood pressure was measured twice to the nearest 2 mm Hg after a 10-min rest, using a standard sphygmomanometer (phases I and V of Korotkoff). Hypertension was defined as blood pressure ≥140/90 mm Hg, measured on two occasions, or the use of antihypertensive drugs (18). According to a random spot urine sample or 24-h urinary albumin excretion (UAE) patients were classified as normoalbuminuric (UAE <17 mg /l or <30 mg/ 24-h), microalbuminuric (UAE between 17 to 174 mg /l or 30 to 299 mg/ 24-h), or macroalbuminuric (UAE >175 mg /l or >300 mg/ 24-h) (19). Micro- and macroalbuminuria were always confirmed (19). Fundus examination was performed through dilated pupils and diabetic retinopathy was graded as present or absent (20). The economic status was evaluated by a Brazilian questionnaire (21). The medications used were collected from the last visit in patients' medical records (close to the dietary assessment). Patients were classified as current smokers or not (former and nonsmokers) and self-identified as white or non-white. The frequency of exercise according to activities during a typical day was graded (22). The body weight and height of patients were obtained with an anthropometric scale, with measurements recorded to the nearest 100 g for weight and to the nearest 0.1 cm for height. The BMI was then calculated (23). Waist circumference was measured midway between the lowest rib margin and the iliac crest, near the umbilicus measured once to the nearest 1 cm (24). Flexible, non-stretch fiberglass tape was used for this measurement.

Blood samples were obtained after a 12-h fast. Plasma glucose was determined by a glucose oxidase method, creatinine values by Jaffe’s reaction, A1C test (reference range 4·7–6·0 %) by HPLC (Tosoh 2.2 Plus HbA_{1c}; Tosoh Corporation, Tokyo Japan), total cholesterol and triglycerides by enzymatic colorimetric methods, and HDL-cholesterol by the homogeneous direct method. LDL-cholesterol was calculated using Friedewald’s formula: LDL-cholesterol = total cholesterol - HDL-cholesterol - (triglyceride/5) (25). UAE was measured by immunoturbidimetry (Ames-Bayer, Tarrytown, NY, USA) and urinary urea was measured by an enzymatic ultraviolet method.

Dietary Intake Assessment

The patient’s usual diet was assessed by mean of 3-day weighed-diet record technique (two non-consecutive weekdays and one weekend day) as previously standardized (26). A detailed explanation and demonstration of the technique was given to each subject by the nutritionist. In our research group, the within-person coefficient of variation for estimate of energy and macronutrients intake from 3-day weighed-diet record was <12% (27). Compliance with the weight-record technique was confirmed by comparison between the protein intake estimate from weighed-diet records and the 24-h urinary nitrogen output. To be included in the current study, patients had to have an acceptable ratio between the two protein intake estimates: from 0.79 to 1.26 (27). Values out of this range were considered "under- or over-reporting" (27) and so, 117 patients were excluded. Nutritional composition from diet records was calculated by *Nutribase Clinical*® 2007 USDA SR (28).

Diet quality

The combination of foods and the intake of nutrients according to current dietary recommendations for diabetes were both considered to assess the overall diet quality. Initially, we took into account the Health Eating Index (10) for general population. In addition, food groups described in the Brazilian Dietary Guidelines (29) and the dietary recommendations according to ADA (6,7) were considered to construct the Diabetes Healthy Eating Index (DHEI). DHEI was based on ten dietary components: 1. Variety = number of food items reported in 3-day weighed-diet records; 2. "fresh fruits" = all fruits and fruit juices (portions by 1000 kcal/day); 3. vegetables = intake of vegetables raw and cooked (portions by 1000 kcal/day); 4. "meats and eggs" = red and white meat, processed meats, and eggs (portions by 1000 kcal/day); 5. "oils, fats and nuts" = oil for cooking, butter, margarine and nuts (portions by 1000 kcal/day); 6. total lipids (% of total energy); 7. cholesterol (mg/day); 8. *trans*-unsaturated fatty acids (% of total energy); 9. "carbohydrates and fiber sources" = this composite component that considers the relation between the proportion of whole grains and beans (fiber sources) and the sum of total carbohydrates sources (refined and whole grains, sugar, sweets, and beans); and 10. "dairy products and saturated fatty acids" = this composite component that considers the intake of portions by 1000 kcal/day of dairy products (milk, yogurt and cheese) and the proportion of energy intake from saturated fatty acids. A food item was considered when the intake reported was at least 50 % of calories from a specific portion of the food group.

The compliance of each individual component with dietary recommendations was classified as “Poor” (zero score), “Regular” (a half score), and “Good” (one score point) and used criteria are detailed in **Table 1**, as well as the portions considered in each food group**.** The overall diet quality was scored from 0 to 100%.

Statistical analysis

Results were expressed as mean ± SD, median (interquartile range) or as number (%) of patients with the analyzed characteristic. Values were considered statistically significant if *P* values were lower than 0.05 (two-tailed).

The assessment of each DHEI component was performed in *a posteriori* analysis based on the Item Response Theory (IRT) (30). Briefly, the IRT is a set of mathematical models that represent the probability that an individual give a certain response to an item as a function of the parameters of the item and the latent trait (here the dietary quality) of the respondent. The Graded Response Model, which is appropriate to polytomous items, was used in this paper (30). The item response category characteristic curves describe the individual’s probability to answer each category given his/her latent trait. The item information curves allow analyzing how much a component of the DHEI contains the information to measure the dietary quality. IRT was performed with program R (Development Core Team, 2008) (31) using the ltm library (32). A detailed description of the interpretation of results according to IRT and their respective graphics are accessible in the **Online Supplemental Material.**

RESULTS

The main clinical and laboratory characteristics of patients with type 2 diabetes are described in **Table 2**. The patient’s age was 61.4 ± 9.7 years, 52.7 % were females, 72.1 %

were overweight, 39.5 % were from the lower middle class, diabetes duration was 12.1 ± 7.7 years, and A1C test were 7.3 ± 1.3 %. The 3-day total daily energy intake was 1859.4 ± 473.6 kcal and the overall DHEI was 39.8 ± 14.3% (95%CI 37.8-41.8%) and only 55 patients (27.4%) had a total DHEI score ≥50%.

The DHEI components were grouped into two clusters according clinical criteria and their effect in diabetes health. The first cluster included the components considered as fiber sources (“fresh fruits”, “vegetables”, “carbohydrates and fiber sources”) and the diet variety component. The second cluster included the components considered food from animal sources and fats: “meats and eggs”, “dairy and saturated fatty acids”, “oils, fats and nuts”, “total lipids”, “cholesterol”, and “*trans*-unsaturated fatty acids”. The characteristic curves items and item information curves of each cluster of DHEI components are shown and also minutely described in **Supplemental Figures 1 and 2.** The components with the best discrimination were “vegetables”, “diet variety”, “dairy and saturated fatty acids” and “total lipids”. Regarding to item difficulty to compliance with dietary recommendations, the DHEI components which had the greatest difficulty were “carbohydrates and fiber sources”, “diet variety”, “dairy and saturated fatty acids”, and “oils, fats, and nuts”. Furthermore, the components with more information to measure the dietary quality were “diet variety”, “vegetables”, and “total lipids”.

The frequencies of compliance with dietary recommendations are illustrated in **Figure 1.** Most patients had poor or regular compliance with the components assessed by DHEI. Good compliance was observed in the following items: “variety” with 86.1% of patients, “*trans*- unsaturated fatty acids” with 53.2% of patients, “cholesterol” with 45.3% of patients, “vegetables” with 37.8% of patients, “total lipids” with 29.9% of patients, and “fresh fruits” with 21.4% of patients. Only 7.0% of patients obtained good compliance regarding “meats and eggs”, 6.5% of patients in “dairy and saturated fatty acids”, 6.0% of patients in “fiber sources”, and 0.5% of patients in “oils, fats and nuts” items.

DISCUSSION

The DHEI was built with ten components and this is the first tool for the assessment of diet quality in patients with diabetes according to specific dietary diabetic recommendations. We observed that in the present sample of outpatients with type 2 diabetes some DHEI components showed an increased difficulty in the compliance with dietary recommendations, namely “carbohydrates and fiber sources”, “diet variety”, “dairy and saturated fatty acids”, and “oils, fats, and nuts”. Further, the components with the most informative components of dietary quality were “vegetables” and “diet variety”, “dairy and saturated fatty acids”, and “total lipids”. Regarding overall diet quality, the diet of most patients (73.6 %) was lower than 50% and needing improvement.

The first cluster could be defined by fiber sources and these components have been associated with glycemic control (33), blood pressure values (34), and metabolic syndrome prevalence (35) in patients with type 2 diabetes. In this way, the item “carbohydrates and fibers sources” was elaborated considering the importance of the balance between refined grains and whole grains intake for diabetes metabolic control (6,7). Furthermore, the dietary components of the second cluster, have been associated with lipid profile (6,36) and renal function (37,38) in diabetes. The “dairy and saturated fatty acids” item is another composite component due to consumption of low or non-fatty dairies, emphasized by the DASH diet plan, play a role in lowering cardiovascular disease (39). The consumption of nuts by our patients is low, only 4.0% of patients ate peanuts and then they were grouped within oils and fats component, as recommended by Brazilian Dietary Guidelines (29). However, since nuts are good sources of health nutrients, especially unsaturated fatty acids, vegetable proteins, minerals, and antioxidants (39), in other patients samples, the nuts intake may be analyzed as a separate item.

Dietary indexes are useful tools in clinical practice because they allow evaluating the overall diet quality using different items in the diet (9). However, as far as we know, there was no standard reference to evaluate diet quality, especially in patients with diabetes. We did not find any study that validated dietary indexes. In the present study, the DHEI was adapted to diabetes dietary recommendations (6,7) and, therefore, comparison with others are almost precluded.

In this sample, most of the patients with type 2 diabetes had their diet quality needing improvement and they had the most difficulty in complying with the dietary recommendations to eat foods high in fiber, minerals, vitamins, and with lower caloric density such as "fresh fruits", "vegetables", and "carbohydrates and fibers sources". However, they reported that it became easier to comply with the recommendations restricting the consumption of foods rich in fat and calories such as "*trans*-unsaturated fatty acids", "cholesterol", and "total lipids". In fact, patients followed more recommendations for items in which the foods are labeled as "forbidden" than foods whose consumption should be encouraged, the healthy foods. This peculiarity could be related to previous medical advice, because our patients had not received any dietary counseling by a registered dietitian in the previous year.

In our study, if the cut-off points of overall diet quality proposed by the original HEI (10) were considered, we would find 38.3% of patients with low diet quality (<51 score of diet quality), 61.7% of patients with intermediate diet quality (51-80 score of diet quality), and none patient with good diet quality (>80 score of diet quality). Even, if we consider the cut-off point (>80) of overall diet quality proposed in the study of Greek patients with diabetes (16), we also would not find any patient with a good quality diet. We know that the value 50% does not characterize a diet with good quality, but in this study, only one patient obtained a score higher of 75%. Therefore, we had to consider lower cut-off points when compared with other populations and it should be reviewed on a larger sample with diabetes patients.

In conclusion, the DHEI evaluate the overall diet quality in patients with diabetes taken into account the compliance with dietary recommendations specific for these patients. It can simplify dietary advice focusing on dietary components for which the adherence needs to be improved. However, the actual validity of the cut-offs for DHEI should be tested in other samples of patients with diabetes, considering possible associations with metabolic control parameters and even with hard clinical outcomes, such as chronic diabetes complications.

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Table 1. Diabetes Healthy Eating Index (DHEI) components and criteria used to evaluate compliance with dietary recommendations for diabetes

	Components (daily intake)	Portion[1] (kcal)	Compliance Criteria * Poor	Regular	Good
FIRST CLUSTER	1. Diet variety: number of items	-	<6	6 to 16	>16
	2. Fresh fruits (portion per 1000 kcal)	70	<1.0	1.0 to 1 ½	>1 ½
	3. Vegetables (portion per 1000 kcal)	15	<1.0	1.0 to 1 ½	>1 ½
	4. Carbohydrates and fiber sources (portion per 1000 kcal): Grains, sugar and sweets Whole grains and Beans (fiber sources)	150	<3	<3 BUT at least 50% by fiber sources	>3 AND at least 50% from fiber sources
SECOND CLUSTER	5. Meat and eggs (portion per 1000 kcal)	190	>1.0	½ to 1.0	<½
	6. Dairy products (portion per 1000 kcal) AND saturated fatty acids (% of energy)	120	<0.75 portion/day of dairy OR saturated fatty acids intake >10.5% of energy	>½ portion of dairy AND saturated fatty acids <7.0% of energy OR >0.75 portion of dairy AND saturated fatty acids from 7.0 to 10.5% of energy	1.0 to 2.0 portions/day of dairy AND saturated fatty acids <7% of energy
	7. Oils, fats and nuts (portion per 1000 kcal)	73	>1.0	½ to 1.0	<½
	8. Total lipids (% of energy)	-	≥45%	30% to 45%	<30%
	9. Cholesterol (mg/day)	-	≥300	200 to 300	<200
	10. *Trans*-unsaturated Fatty Acids (% of energy)	-	≥1.5%	1.0 to 1.5%	<1.0%

* The criteria compliance taken into account are the American Diabetes Association dietary recommendations (6,7), the Brazilian Dietary Guidelines (29), and the original Healthy Eating Index (10).

TABLE 2

Clinical and laboratory characteristics of 201 patients with type 2 diabetes

Characteristics	
Age (years)	61.4 ± 9.7
Females	106 (52.7%)
Whites	176 (87.6%)
Lower middle class	162 (39.5%)
Duration of diabetes (years)	12.1 ± 7.7
Hypertension	127 (64.8%)
Systolic pressure values (mm Hg)	134 (123-150)
Diastolic pressure values (mm Hg)	80 (74.3-90)
Current smoking	24 (11.9%)
Sedentary	122 (61.6%)
Micro- or macroalbuminuric	57 (28.4%)
Diabetic retinopathy	177 (36.3%)
BMI (kg/m^2)	28.5 ± 4.4
Overweight (BMI >25 kg/m^2)	145 (72.1%)
Waist circumference (cm)	
Females	99.2 ± 11.1
Males	100.0 ± 10.4
Diabetes treatment	
Diet	11 (5.5%)
Oral agents	124 (61.7%)
Insulin or insulin plus oral agents	66 (32.8%)
Hypolipidemic agents	36 (18.0%)
Fasting plasma glucose (mmol/l)	7.9 (6.5-9.5)
A1C test (%)	7.3 ± 1.3
Total cholesterol (mmol/l)	5.18 ± 1.14
HDL-cholesterol (mmol/l)	
Females	1.36 ± 0.33
Males	1.22 ± 0.32
LDL-cholesterol (mmol/l)	3.13 ± 0.94
Triglycerides (mmol/l)	1.49 (1.12-2.16)
Serum creatinine (µmol/l)	73.8 (62.8-87.5)

Data are means ± SD, median (interquartile range) or number of patients (%) with analyzed characteristics. LDL-cholesterol was not calculated in two patients who had triglycerides values >4.48mmol/l.

ONLINE SUPPLEMENTAL MATERIAL

The Interpretation of Characteristic Curves Item

The assessment of each Diabetes Healthy Eating Index (DHEI) component was performed in *a posteriori* analysis based on the Item Response Theory (IRT). The IRT is a set of mathematical models that represent the probability that an individual gives a certain response to an item as a function of the parameters of the item and the latent trait (here the dietary quality) of the respondent. The Graded Response Model, which is appropriate to polytomous items, was used in this paper. Usually, the sample of patients is believed to be representative of a more general population, and the latent variable is then considered as a random variable that often is assumed to follow a normal distribution. We used the metric standard score, which is anchored in the mean (value 0) and variation on a scale of values between -4 and +4. In this model, each item is characterized by two parameters: discrimination (*a*) and difficulty (*b*). The discrimination parameter is represented by the inclination of the curve at the point of inflection. The higher *a* values, the higher inclination, indicating the good discrimination of the food component. The difficulty parameter indicates that further the curve is displaced from the mean, more difficult is for the subject to meet the nutritional recommendations for a particular item (in this paper).

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Sébille V, Hardouin JB, Le Néel T, Kubis G, Boyer F, Guillemin F, Falissard B.Methodological issues regarding power of classical test theory (CTT) and item response theory (IRT)-based approaches for the comparison of patient-reported outcomes in two groups of patients - a simulation study. BMC Med Res Methodol. 2010;25:10-24

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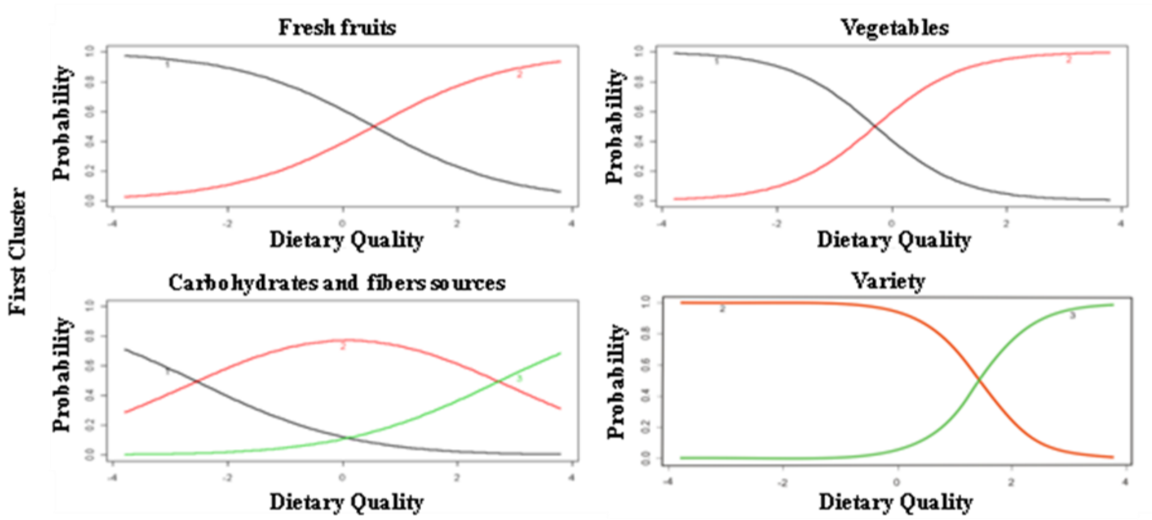
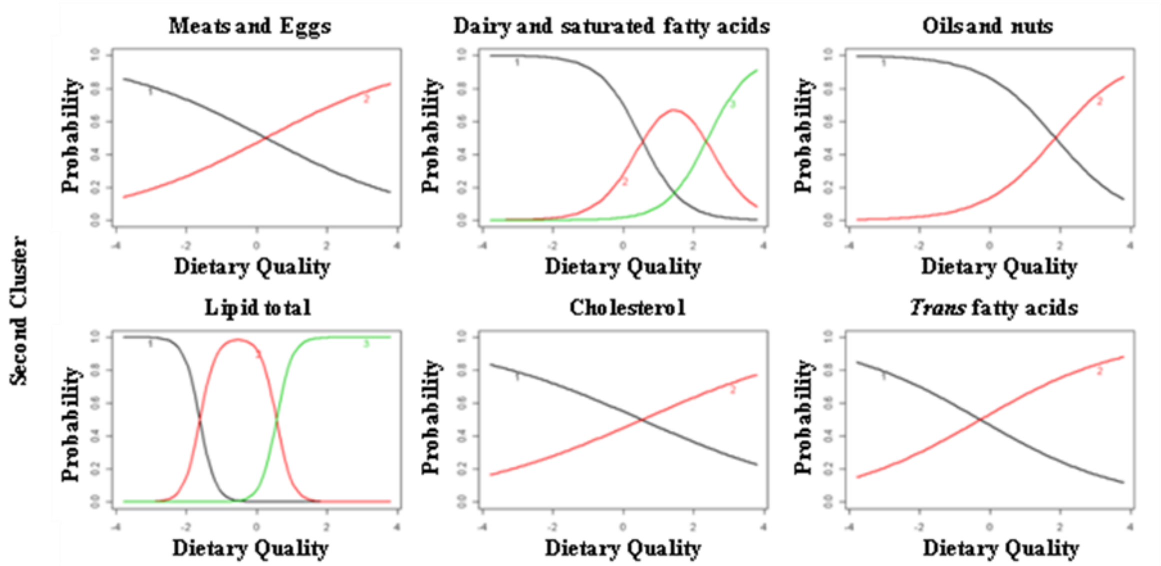
Interpretation of Supplemental Figure 1: The horizontal axis represents the measure of the latent trait (dietary quality) and the vertical axis represents the probability of the patient achieving the recommendation for a particular component. The components with the best discrimination were “vegetables”, “diet variety”, “dairy and saturated fatty acids” and “total lipids”. Regarding item difficulty for compliance with dietary recommendations, the DHEI components which had the greatest difficulty were “carbohydrates and fiber sources”, “diet variety”, “dairy and saturated fatty acids”, and “oils, fats, and nuts”.

Interpretation of Supplemental Figure 2: The item information curves allowing analysis of how much a component of the DHEI contains the information to measure the dietary quality. The most informative items are those with greater values in vertical axis: in the first cluster were “diet variety” and “vegetables” and in the second cluster was “total lipids”.

Panel A



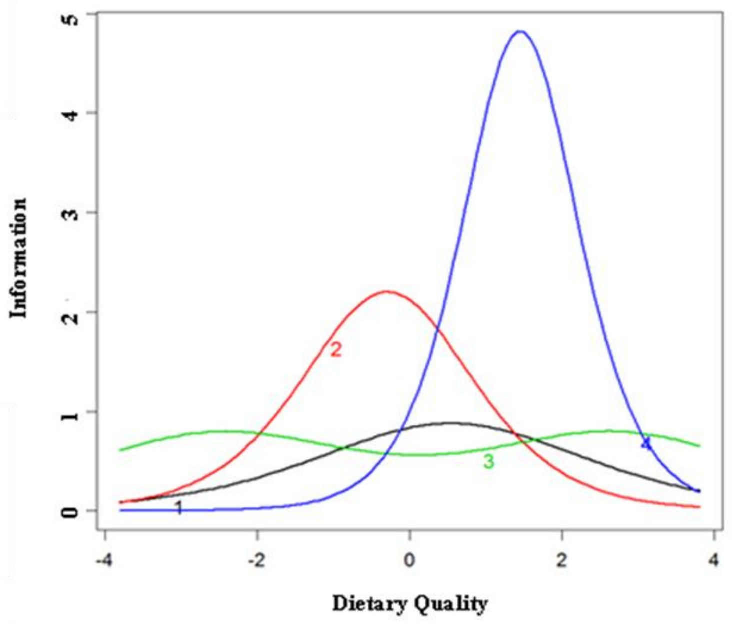
Panel B



Supplemental Figure 1. The Characteristic Curves Item of each component of Diabetes Healthy Eating Index (DHEI). Components were grouped into two clusters according to the Item Response Theory: First cluster as "fiber sources components and diet variety" (Panel A) and Second cluster as "animal foods and fat components" (Panel B). Compliance with dietary recommendations is illustrated as: line 1 (black) = poor, line 2 (red) = regular, and line 3 (green) = good. Data from 201 outpatients with type 2 diabetes.

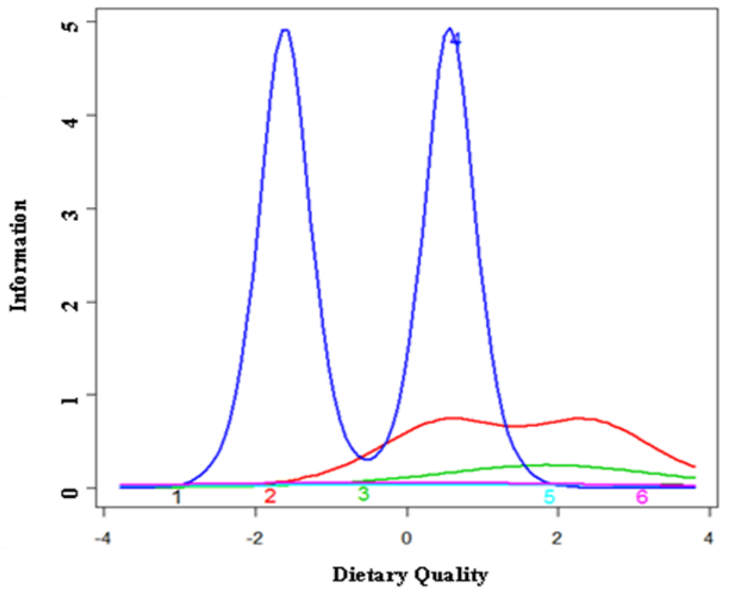
First Cluster: fiber sources and variety

1 = Fresh fruits   2 = Vegetables   3 = Carbohydrates and fiber sources   4 = Diet variety



Second Cluster: fat sources

1 = Meats and eggs 2 = Dairy and saturated fatty acids 3 = Oils, fats and nuts
4= Total Lipids 5 = Cholesterol 6 = *Trans*-unsaturated fatty acids



Supplemental Figure 2. The Item Information Curves of components clusters of Diabetes Healthy Eating Index (DHEI) performed in 201 patients with type 2 diabetes.

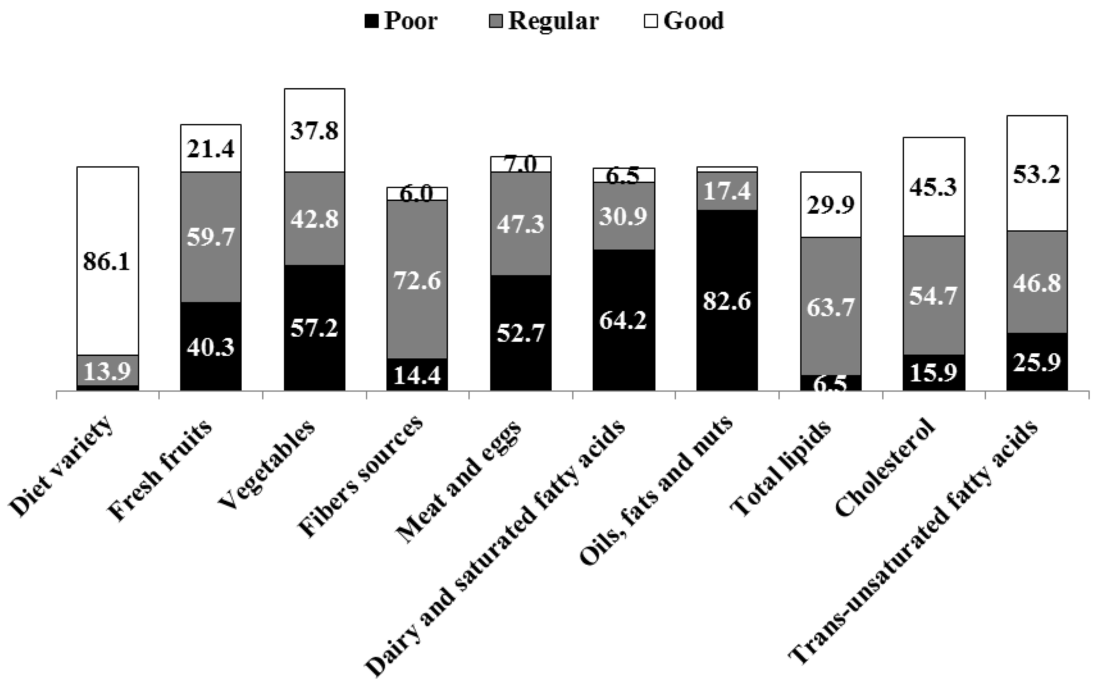


Figure 1. The frequency of compliance with nutritional recommendations in the components assessed by Diabetes Healthy Eating Index (DHEI) in 201 patients with type 2 diabetes. Black column = poor compliance; the gray column = regular compliance; the white column = good compliance.

Capítulo II

Diet Quality and Glucose Control in Patients with Type 2 Diabetes

Diet Quality and Glucose Control in Patients with Type 2 Diabetes

Running title: Diet quality and glucose control in diabetes

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ABSTRACT

Objective: To evaluate possible associations between diet quality and glucose control in patients with type 2 diabetes.

Research design and methods: In this cross-sectional study, diet quality and compliance with current diabetes recommendations for patients with type 2 diabetes were evaluated by the Diabetes Healthy Eating Index (DHEI). According to DHEI scores patients were divided into three groups: low quality (DHEI<50%), intermediate (DHEI=51-59%), and good (DHEI>60%). Variables were compared by ANOVA, Kruskal-Wallis, or Chi-square test. Logistic regression models were performed with "abnormal fasting plasma glucose" (<3.9mmol/l or >10.0mmol/l) as the dependent variable, adjusted to gender, diabetes treatment, overweight, and serum creatinine.

Results: A total of 200 outpatients with type 2 diabetes (61.4±9.7 years; 12.2±7.7 years of diabetes; A1C=7.3±1.3%) were evaluated. The proportion of patients with "abnormal fasting plasma glucose" was lower in the good diet quality group than in the low/intermediate group (12.8% *vs.* 87.2%; *P*=0.022). The good diet quality group had less chance of having abnormal fasting plasma glucose as compared to the low diet quality group (OR=0.259; 95%CI=0.079-0.846; *P*=0.025). Non-compliance with dietary recommendations for "vegetables" (OR=2.222; 95%CI=1.091-4.526; *P*=0.028) and "carbohydrates and fiber sources" (OR=5.345; 95%CI=1.161-24.603; *P*=0.031) increased the chance for the presence of "abnormal fasting plasma glucose".

Conclusions: In these patients with type 2 diabetes, good diet quality as evaluated by DHEI was associated with reduced frequency of abnormal fasting plasma glucose. The consumption of vegetables and whole grains should be reinforced in order to improve glucose control.

Diabetes mellitus is a major public health problem, due to the high prevalence, morbidity and mortality, and the high costs associated with its chronic complications (1). The incidence of diabetic microvascular and neuropathic complications, as well as non-fatal myocardial infarction, has been positively associated with hyperglycemia (2, 3).

Lowering A1C levels around the normal range has been recommended in patients with diabetes in order to reduce the development and progression of chronic complications (2). However, in patients with type 2 diabetes, this approach can significantly increase the rate of severe hypoglycemia, weight gain, cardiovascular events, and mortality (4). These findings are especially relevant, since cardiovascular disease is the most frequent cause of death in patients with type 2 diabetes (5). Accordingly, a recent meta-analysis suggested that the benefit to risk ratio of intensive glucose lowering treatment in type 2 diabetes remains uncertain due to the increase of hypoglycemic events (6). Additionally, acute blood glucose fluctuations could be involved in the pathogenesis of chronic diabetic complications (7, 8). In this sense, the best pharmacological strategy to lower glucose in people with type 2 diabetes has been continuously evaluated (9) and lifestyle changes, specifically dietary intervention, should be reinforced in the management of patients with diabetes (2).

Current dietary recommendations for patients with diabetes include the monitoring of the amount and type of carbohydrates (whole grains and fiber intake are reinforced) and reduction of total dietary fat - especially saturated fatty acids, cholesterol, and *trans*-unsaturated fatty acids (2, 10). Beyond and before dietary advice, the assessment of food consumption in clinical practice must often be carried out to evaluate the patients’ actual usual diet. An accurate dietary evaluation allows implementing nutritional advice to promote health, prevent illness, and improve the nutritional status (11). However the complexity of the human diet represents a daunting challenge to anyone contemplating a study of how it relates to disease (12). Dietary indexes were developed to evaluate the overall diet quality of populations and can reflect the intake of various dietary components (food groups, nutrients, and diversity or variety) in a single variable (13). The most frequently used dietary index is the *Healthy Eating Index* (14) which was created for the general population (15).

The Diabetes Healthy Eating Index (DHEI) (16) was recently constructed for patients with type 2 diabetes since it also takes into account the current dietary recommendations for diabetes. Only one study conducted in Greek type 2 diabetic patients evaluated diet quality using an eating index, but a general dietary index was used (17). Furthermore, the relationship between diet quality and glycemic control indices in patients with diabetes is almost unexplored. Therefore, the aim of the current study was to evaluate possible associations between diet quality by DHEI and glucose control in patients with type 2 diabetes.

RESEARCH DESIGN AND METHODS

Study and patient selection criteria

This cross-sectional study was conducted in patients with type 2 diabetes defined as patients over 30 years of age at onset of diabetes, no previous episode of ketoacidosis or documented ketonuria and, if insulin users, the treatment with insulin began five years after diagnosis (18).

Outpatients who consecutively attended the Endocrine Division of the Hospital de Clínicas de Porto Alegre, Brazil, and had not received any dietary counseling by a registered dietitian during the previous 12 months, were recruited. Patient selection was as follows: age < 80 years, BMI <35 kg/m^2; serum creatinine <176 µmol/l; normal liver and thyroid function tests. Our study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving patients were approved by the Hospital Ethics Committee. Written informed consent was obtained from all patients.

Among 323 eligible patients, six patients had poor adherence to drug treatment of diabetes according to medical prescription. Therefore, 317 patients underwent clinical and laboratory evaluation. To evaluate the glucose control, patients were classified according to their fasting plasma glucose into two groups: with or without abnormal fasting plasma glucose. According to ADA criteria from hypo- and hyperglycemia episodes (2), abnormal fasting plasma glucose was defined in the presence of values <3.9 mmol/l or >10.0mmol/l.

Clinical evaluation

Sitting blood pressure was measured twice to the nearest 2 mmHg after a 10-min rest, using a standard sphygmomanometer (phases I and V of Korotkoff). Hypertension was defined as blood pressure ≥140/90 mmHg, measured on two occasions, or the use of antihypertensive drugs (19). According to 24-h urinary albumin excretion (UAE) patients were classified as normoalbuminuric (UAE <30 mg/24-h), microalbuminuric (UAE between 30 and 299 mg/24-h), or macroalbuminuric (UAE >300 mg/24-h) (20). Micro- and macroalbuminuria were always confirmed (20). Fundus examination was performed through dilated pupils and diabetic retinopathy was graded as present or absent (21). Information about medications used was collected from the last visit in patients' medical records (next the dietary assessment) and the economic status was evaluated by a standardized Brazilian questionnaire (22). Patients were classified as current smokers or not (former and nonsmokers) and were self-identified as white or non-white. Physical activity was graded in levels according to activities during a typical day based on a standardized questionnaire (23) adapted to local habits. Four levels were defined, ranging from sedentary lifestyle to high physical activity. The body weight and height of patients were obtained with an anthropometric scale, with measurements recorded to the nearest 100 g for weight and to the nearest 0.1 cm for height. The BMI was then calculated (24). Waist circumference was measured midway between the lowest rib margin and the iliac crest, near the umbilicus measured once to the nearest 1 cm (25). Flexible, non-stretch fiberglass tape was used for this measurement.

Dietary intake

The patient's usual diet was assessed by means of 3-day weighed-diet record technique (two non-consecutive weekdays and one weekend day) as previously standardized (26). Compliance with the weight-record technique was confirmed by comparison between the protein intake estimate from weighed-diet records and the 24-h urinary nitrogen output. To be included in the current study, patients had to have an acceptable ratio, between the two protein intake estimates, from 0.79 to 1.26 (27), and values out of this range were considered "under- or over-reporting" (27). Nutritional composition from diet records was calculated by *Nutribase Clinical*® 2007 USDA SR (28).

Diet quality

The evaluation of the diet quality was assessed according to the DHEI as previously validated (16). Briefly, diet quality was evaluated using ten components grouped into two clusters: 1st cluster = "variety", "fresh fruits", "vegetables", and "carbohydrates and fiber sources"; 2nd cluster = "meat and eggs", "dairy products and saturated fatty acid", "oils, fats and nuts", "total lipids", "cholesterol", and "*trans*-unsaturated fatty acids". Each individual component was classified according to compliance with the current diabetes recommendations (2, 10) as "Poor" (zero score), "Regular" (a half score), and "Good" (one score point). Afterwards, the overall diet quality was scored from 0 to 100% and classified as "low diet quality" (DHEI values <50%), "intermediate quality" as diet that needs improvement (DHEI values between 50 to 60%), and "good diet quality" (DHEI values >60%).

Laboratory measurements

Blood samples were obtained after a 12-h fast. Plasma glucose was determined by a glucose oxidase method, creatinine values by Jaffe's reaction, A1C levels (reference range 4·7–6·0 %) by HPLC (Tosoh 2.2 Plus HbA1C; Tosoh Corporation, Tokyo Japan), total cholesterol and triglycerides by enzymatic colorimetric methods, and HDL-cholesterol by the homogeneous direct method. LDL-cholesterol was calculated using Friedewald's formula: LDL-cholesterol = total cholesterol - HDL-cholesterol - (triglyceride/5) (29). UAE was measured by immunoturbidimetry (Ames-Bayer, Tarrytown, NY, USA) and urinary urea was measured by an enzymatic ultraviolet method.

Statistical analysis

Results are expressed as mean ± SD, median (interquartile range) or as number (%) of patients with the analyzed characteristic. The Gaussian distribution of variables was tested by the One-Sample Kolmogorov-Smirnov test. The patient´s characteristics were compared using Chi-square or Fisher's exact test (adjusted standardized residual was adopted) and ANOVA or Kruskal-Wallis followed by post hoc multiple comparison tests. Multiple logistic regression models were done to assess the possible associations of diet quality (overall and compliance with each DHEI component) with abnormal fasting plasma glucose (fasting plasma glucose values <3.9 mmol/l or >10.0mmol/l) as the dependent variable. Analyses were adjusted to possible confounding variables selected according to clinical relevance or their significance (*P* <0.10) at univariate analyses. *P* values <0.05 (two-sided) were considered as statistically significant and analyses were performed using PASW 18.0 (SPSS Inc., Chicago, IL, USA).

RESULTS

Among 317 patients with good compliance with drug treatment, 117 patients were excluded because they did not perform the plausible weighed-diet records. Then, the diet quality of 200 outpatients with type 2 diabetes was studied. Clinical and laboratory characteristics of patients with type 2 diabetes according to DHEI classification are shown in **Table 1.**

A lower proportion of patients with good diet quality were overweight as compared to patients with poor or intermediate diet quality. Also, the proportion of patients using diabetes combination therapy (insulin or insulin plus oral agents) in the group of good diet quality was lower than low quality diet group. Fasting plasma glucose was lower in patients with good than patients with low and intermediate diet quality, although the difference did not reach statistical significance (*P* = 0.069). However, a lower proportion of patients with abnormal fasting plasma glucose occurred in the good diet quality group (6/52; 12.8 %) as compared to patients belonging to low and intermediate diet quality groups (41/163; 87.2 %; *P* = 0.022]. Serum creatinine was higher in patients with low diet than intermediate diet quality, but not different from good diet quality group, although the difference did not reach statistical significance (*P* = 0.058). Other evaluated characteristics did not differ among patients with low, intermediate, and good diet quality.

Figure 1 shows data on the proportion of good compliance with dietary recommendations for each individual component of DHEI grouped into two clusters: 1st - fiber sources and variety; 2nd - fat sources (16). Since only ten patients (19.2%) had good compliance with “dairy products and saturated fatty acids”, in this item the proportion of regular compliance was evaluated instead of good compliance. Patients who had good diet quality had a greater proportion of compliance with nutritional recommendations for all components evaluated by DHEI when compared to patients from the low diet quality group (*P* <0.02 for all analyses). Furthermore, compliance with “carbohydrates and fiber sources”, “dairy products and saturated fatty acids”, and “total lipids” components was different between the three groups of patients (*P* for trend <0.001).

Logistic regression models were constructed to evaluate the association of diet quality with abnormal fasting plasma glucose (dependent variable), using low diet quality as the reference group **(Table 2).** The patients from the good diet quality group had almost 74.1% less chance of having an abnormal fasting plasma glucose (OR = 0.259; 95% CI = 0.079-0.846; *P* = 0.025). Considering individual DHEI components, non-compliance with dietary recommendations for "vegetables" (OR = 2.222; 95% CI = 1.091-4.526; P = 0.028) and "carbohydrates and fiber sources" (OR = 5.345; 95% CI = 1.161-24.603; P = 0.031) increased the chance for the presence of an abnormal fasting plasma glucose. All models were adjusted to gender, overweight, diabetes treatment, and serum creatinine. The inclusion of diabetes duration as a covariate did not modify these results.

CONCLUSIONS

Patients with type 2 diabetes who had good diet quality (DHEI values >60 %) were more compliant with nutritional recommendations than patients with a low quality diet (DHEI values <50 %; P for trend <0.02 for all analyses), regarding all DHEI components. The proportion of patients with "abnormal fasting plasma glucose" was lower in the good diet quality group than in the low/intermediate group. Thus, the good quality group has less chance of having hypo- or hyperglycemia in fasting state when compared to the low diet quality group, adjusted by confounders. Considering the individual DHEI components, non-compliance with "vegetables" and "carbohydrates and fiber sources" dietary recommendations was positively associated with abnormal fasting plasma glucose.

In the current study, we tested in patients with type 2 diabetes compliance with specific nutritional recommendations and the possible association of this compliance with abnormal fasting plasma glucose, defined as highest (>10.0 mmol/l) or lowest (3.9 mmol/l) glucose levels. There is growing evidence that acute glucose fluctuations could also be involved in the pathogenesis of chronic complications of diabetes (7, 8), especially in patients with glycated hemoglobin values almost within the recommended ADA targets (2), as our patients. In this sense, it has been suggested that treatment decisions should not be exclusively based on A1C values, but should also take into account various glycaemia indices (30). Actually, in the present study, non-compliance with dietary recommendations, for overall diet or specific components, was positively associated with abnormal fasting plasma glucose, even considering that glycated hemoglobin did not differ among groups with different quality diets. The relevance of using fasting plasma glucose as the outcome in our study is reinforced by the observation that increasing fasting plasma glucose represents the second step of the key stages in the deterioration of glucose control in type 2 diabetes and has been of interest for implementing anti-diabetes treatment (31). Diet quality was also associated with glycemic control in healthy subjects, as assessed by the Healthy Eating Index (32).

Our results suggest that dietary advice for patients with type 2 diabetes should strongly include the recommendation to consume vegetables, carbohydrates and fibers, in order to improve fasting plasma glucose levels. Therefore, the constructed DHEI can be a useful tool to plan specific nutritional advice for patients with diabetes. The benefit of these dietary components on fasting plasma glucose probably reflects their effect on glycated hemoglobin. Vegetables and whole grains are rich sources of fibers (33) and have a low to moderate glycemic index (34). It is known that diets rich in fibers and with a low glycemic index reduce glycated hemoglobin (35, 36). Furthermore, the high intake of fibers was associated with improvement of glycemic (37) and blood pressure (38) control and reduction of metabolic syndrome prevalence (39) in patients with type 2 diabetes.

In conclusion, in this sample of patients with type 2 diabetes, a good quality diet, as evaluated by DHEI, was associated with reduced frequency of abnormal fasting plasma glucose. The consumption of vegetables and whole grains probably should be encouraged in order to reduce abnormal fasting plasma glucose and improve glucose control. However, the effectiveness of this advice to reduce the abnormal glucose metabolism and/or diabetes complications needs to be tested in future clinical trials. In this sense, the DHEI will be a usefully tool to plan specific nutritional advice for patients with diabetes, but these data needed to be confirmed in different samples of patients with diabetes.

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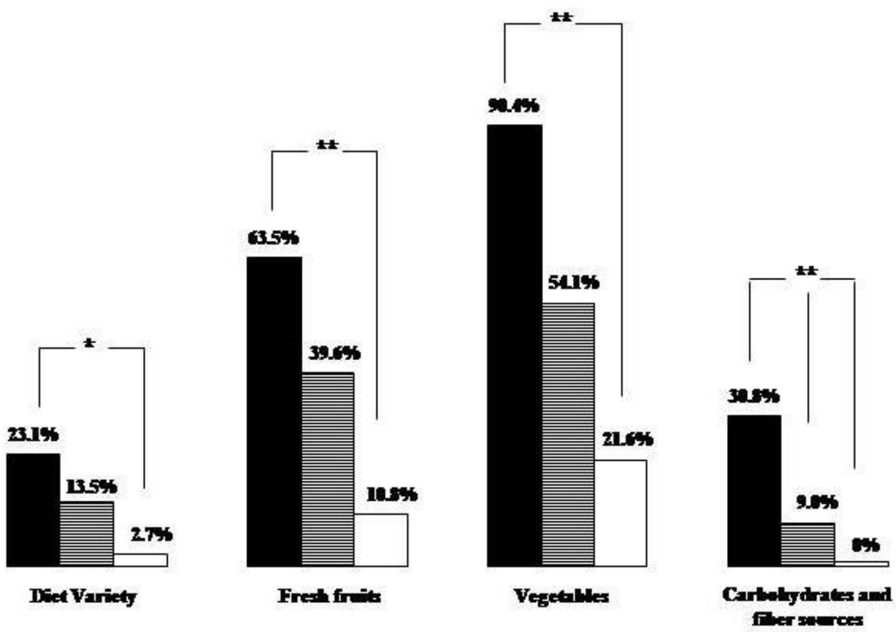
Table 1. Clinical and laboratory characteristics of patients with type 2 diabetes according to the Diabetes Healthy Eating Index (DHEI) score (n = 200)

Characteristics	Diet quality			*P*
	Low	**Intermediate**	**Good**	
	DHEI <50 %	**DHEI** = 50-60 %	**DHEI** >60 %	
N	37	111	52	-
Age (years)	60.3 ± 10.6	61.2 ± 9.0	62.7 ± 10.5	0.498
Females	17 (45.9%)	55 (49.5%)	34 (65.4%)	0.107
White	34 (91.9%)	95 (85.6%)	46 (88.5%)	0.586
Lower middle class	9 (31.0%)	39 (41.9%)	16 (40.0%)	0.210
Duration of diabetes (years)	12.6 ± 7.5	12.3 ± 8.3	11.6 ± 6.4	0.836
Hypertension	29 (80.6%)	91 (82.0%)	43 (84.3%)	0.894
Systolic blood pressure (mm Hg)	138 (129-150)	132 (123-150)	140 (120-152)	0.681
Diastolic blood pressure (mm Hg)	80 (79-90)	80 (74-90)	80 (73-90)	0.542
Current smoking	5 (13.2%)	17 (15.3%)	2 (3.8%)	0.106
Sedentary	21 (55.8%)	71 (64.5%)	29 (56.9%)	0.356
Micro- and macroalbuminuria	9 (24.3%)	33 (29.7%)	14 (26.9%)	0.801
Diabetic retinopathy	15 (42.9%)	40 (41.7%)	18 (40.0%)	
BMI (kg/m^2)	28.4 ± 4.6	28.9 ± 4.3	27.3 ± 4.3	0.100
Overweight (BMI >25 kg/m^2)	28 (75.7%)	86 (77.5%)	31 (59.6%)	0.052
Waist circumference (cm)				
Females	99.4 ± 10.4	101.0 ± 10.3	96.1 ± 12.3	0.131
Males	100.0 ± 11.3	101.0 ± 10.0	96.7 ± 9.4	0.235
Diabetes treatment				
Diet	4 (10.8%)	5 (4.5%)	1 (1.9%)	
Oral agents	16 (43.2%)	69 (62.2%)	39 (75.0%)	0.033
Insulin or insulin plus oral agents	17 (45.9%)	37 (33.3%)	12 (23.1%)	
Hypolipidemic agents	7 (18.4%)	19 (17.1%)	10 (19.6%)	0.920
Fasting plasma glucose (mmol/l)	8.2 (6.7-10.6)	8.3 (6.4-9.8)	7.5 (6.4-8.5)	0.069
A1C (%)	7.4 ± 1.2	7.4 ± 1.4	7.1 ± 1.1	0.606
Total cholesterol (mmol/l)	4.95 ± 1.05	5.32 ± 1.07	5.15 ± 1.10	0.174
HDL-cholesterol (mmol/l)				
Females	1.40 ± 0.28	1.36 ± 0.33	1.35 ± 0.37	0.860
Males	1.20 ± 0.28	1.21 ± 0.30	1.17 ± 0.29	0.882
LDL-cholesterol (mmol/l) *	2.90 ± 0.90	3.20 ± 0.90	3.10 ± 1.00	0.187
Triglycerides (mmol/l)	1.43 (1.12-1.89)	1.50 (1.12-2.30)	1.50 (1.18-2.04)	0.727
Serum creatinine (µmol/l)	79.6 (70.7-88.4)	70.7(61.9-79.6)	79.6 (70.7-88.4)	0.058

Data are means ± SD, median (interquartile range) or number of patients (%) with analyzed characteristics.
* LDL-cholesterol was not calculated in two patients who had triglycerides values >4.48 mmol/l.

First Cluster: fiber sources and variety



Second cluster: fat sources

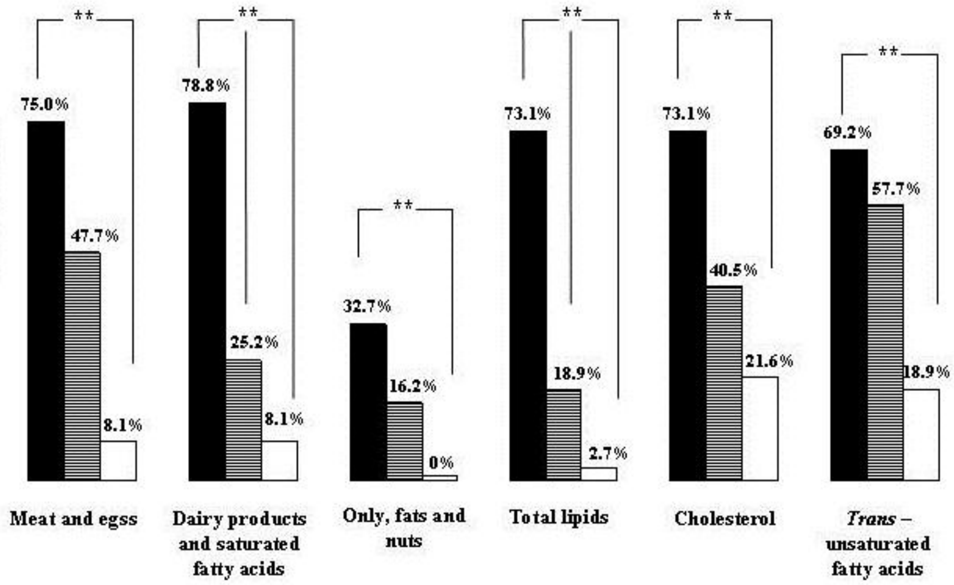


Figure 1. Proportions of good compliance with current dietary recommendations in 200 outpatients with type 2 diabetes according to the Diabetes Healthy Eating Index (DHEI) classification (16): Black column = good diet quality; Grid column = intermediate quality; White column= low quality. * *P* <0.02; ** *P* <0.001; Chi-square test (adjusted standardized residual). For "dairy products and saturated fatty acids", the proportion of regular compliance instead of good compliance is shown.

Table 2. Logistic regression models using abnormal fasting plasma glucose as the dependent variable

Variable	OR	95% CI	*P*
Compliance to individual component			
Diet variety	1.945	0.615 - 6.155	0.258
Fresh fruits	0.881	0.432 - 1.797	0.728
Vegetables	2.222	1.091 - 4.526	0.028
Carbohydrates and fiber sources	5.345	1.161 - 24.603	0.031
Meat and eggs	0.981	0.477 - 2.021	0.959
Dairy products and saturated fatty acids	1.153	0.556 - 2.389	0.702
Oils, fats and nuts	1.601	0.602 – 4.258	0.346
Total lipids	1.430	0.645 – 3.167	0.379
Cholesterol	1.305	0.637 - 2.676	0.467
Trans-unsaturated fatty acids	0.954	0.476 - 1.910	0.894
Overall diet quality			
Low quality (45 ± 1.86 % score)	1.00	-	-
Needs improvement (53.4 ± 2.82 % score)	0.827	0.340 - 2.011	0.675
Good quality (64.2 ± 3.95 % score)	0.259	0.079 - 0.846	0.025

Data are Odds Ratio (OR) and 95% confidence interval

Each model was adjusted to gender, overweight, diabetes treatment and serum creatinine.

Glucose values of <3.9 mmol/l or >10.0 mmol/l were classified as abnormal plasma glucose.