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Original

Are calcium and fiber beneficial for poorly controlled diabetic patients?

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Abstract

No nutritional protocol for poorly controlled diabetic patients receiving well-managed drug treatment is currently available.

***Objective:* Aims were to compare dietary consumption of calcium and fibers with lipid profile and glycosilated hemoglobin HbA1c .**

***Methodology:* This was a prospective observational study. Patients with poorly controlled diabetes were consecutively recruited.A food-frequency questionnaire and tests for lipid profile, HbA1c, and C reactive protein were collected, along with clinical and anthropometric assessment.**

***Results:* Patients (N = 114, age 65.7 ± 6.5 years, 75.4% females, BMI 29.0 ± 5.3 kg/m^2) were often insulin-dependent (32.5%) and with systemic inflammation (C-reactive protein 4.2 ± 3.9 mg/L). Diet was energy restricted (1,365 ± 565 kcal/day) and mostly adequate but with suboptimal fiber (15.4 ± 8.6 g/day) and very low calcium (592.4 ± 204.4 mg/day). Calcium and fiber in the diet correlated with serum lipids, whereas fiber alone displayed a protective association regarding diabetes (HBA1c, insulin use) and arterial hypertension.**

***Conclusions:* Calcium and fiber ingestion exhibited correlations with important markers of metabolic status and cardiovascular risk. Future studies should address enhancement of these ingredients by means of dietary changes and supplements.**

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Key words: *Calcium. Fibers. Uncompensated diabetes. Type 2 diabetes. Elderly patients. Food frequency questionnaire.*

¿SON CALCIO Y FIBRAS BENEFICIOSOS PARA PACIENTES DIABÉTICOS MAL CONTROLADOS?

Resumen

Ningún protocolo nutricional es presentemente disponible para pacientes diabéticos mal controlados recibindo terapia farmacológica bien estructurada.

***Objetivo:* Una comparación entre consumo dietético de cálcio y fibras, y concentraciones de lípidos y hemoglobina glicosilada HbA1c fue efectuada.**

***Metodología:* Este fue un estúdio prospectivo observacional. Pacientes con diabetes mal controlada fueron consecutivamente recrutados. Las variables fueron cuestionário de frecuéncia alimentária, evaluación clínica y antropométrica, y valores séricos de lípidos, HbA1c, proteina C reactiva (PCR).**

***Resultados:* Los pacientes (N = 114, edad 65,7 ± 6,5 años, 75,4% mujeres, IMC 29,0 ± 5,3 kg/m^2) eran con moderada frecuencia insulino-dependentes (32,5%) y también sistemicamiente inflamados (PCR 4,2 ± 3,9 mg/L). La dieta era pobre en calorias (1,365 ± 565 kcal/d) pero globalmente acceptable, aún que baja en fibras (15,4 ± 8,6 g/d) y muy baja en cálcio (592,4 ± 204,4 mg/d). El cálcio e la fibra de la dieta se correlacionaran con valores lipídicos, pero solo la fibra estuvo asociada a mejor panorama de diabetes (HbA1c, uso de insulina) y de hipertensión arterial.**

***Conclusiones:* La ingestión de cálcio y fibra estuvieron correlacionadas con importantes marcadores de estado metabólico y riesgo cardiovascular. Estúdios futuros son recomendados con empleo de mayores proporciones de estes ingredientes en forma de dieta o suplementos.**

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Palabras clave: *Calcio. Fibras. Diabetes descompensada. Diabetes tipo 2. Pacientes viejos. Cuestionario de frecuencia alimentaria.*

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Introduction

Optimal HbA1c levels are achieved in 53% of adult type 2 diabetes (t2dm) patients only, and failures may be more numerous in the aged population.[1,2] Dietary tools for the management of diabetic patients have mostly been devised before the advent of modern pharmacologic alternatives, and in the best of circumstances the role of alimentation has been an adjuvant one, comparable to exercise and other lifestyle changes. In the case of drug resistant diabetic patients,[3,4] a gap in therapeutic guidelines is highlighted.

A beneficial role for fibers in t2dm and hypercholesterolemia has been announced for more than three decades,[5] and in the last 10 years, also calcium ingestion has been associated with some protective effects against obesity, insulin resistance and dyslipidemia.[6-9] Yet, no study could be found with elderly poorly-controlled diabetic cases.

This investigation was performed to scrutinize the possible influence of dietary calcium and fibers on plasma lipoprotein profile. The hypothesis was that useful associations would be encountered, paving the way for therapeutic interventions in such refractory population.

Methods

Ethical procedures

Each subject provided written informed consent. The research protocol was approved by the institutional Ethics Committee.

Population

The study population was composed by outpatient subjects diagnosed with t2dm according to the American Diabetes Association/ADA.[10] Criteria of inclusion were males or females ≥ 60 years old, with or without comorbidities, insulin-dependent or managed by oral agents, and exhibiting glycated haemoglobin (HbA1c ≥ 7% despite medically supervised pharmacologic treatment).[4,5] Criteria of exclusion were sepsis, shock, coma or organ failures, trauma , surgery, cardiovascular event or hospitalization in the last two months, exacerbation of inflammatory diseases (Crohn's disease, ulcerative colitis, rheumatoid arthritis), use of antibiotics, corticosteroids, immune modulators, cancer radio or chemotherapy, dietary or vitamin-mineral supplements in the last two months, or refusal to participate in the protocol.

Experimental design

This was a prospective observational cohort study with no randomization, and no pharmacologic or dietetic intervention was part of the protocol.

Stratification

Patients were stratified according to gender, age (60-65 years versus > 65 years old) and obesity (BMI ≥ 30 versus BMI < 30 kg/m^2).

Dietary assessment

A 72-item food-frequency questionnaire which was validated by Lima et al.[11] for Brazilian foods, ingredients and cooking methods was selected. Portions were estimated with the help of photographs, and the presence of a spouse or relative was requested for cross-checking all answers. Informations were collected for both weekdays and weekends, and nutrients were adjusted for total energy before analysis . Findings concerning macronutrients, total fiber and calcium were calculated by Dietsys software, version 4.0 (National Cancer Institute, Bethesda, MD, USA), adapted for nonstandard or regional nutrients and portions whenever required.

Anthropometric measurements

Weight, height, waist circumference and waist/height ratio were calculated.

Definitions

Disease and comorbidity diagnosis was based on current treatment. Patients who reported regularly walking at least 150 minutes/week were considered physically active.

Biochemical variables

Fasting blood samples were drawn for HbA1c, lipid fractions and C-reactive protein and processed by automated methods.

Statistical analysis

Numerical variables were compared by Student's "t" test or by analysis of variance (ANOVA), employing log transformation when appropriate. Analysis of covariance (ANCOVA) was selected to control for gender, age, BMI and other variables. Dietary intake was calculated as mean ± SD and also divided into quartiles . Chi Square test was used for discrete variables. The SPSS Package for Windows, version 11.0, (SPSS Inc., Chicago, IL, USA) was employed, and a significance level of 5% ($P < 0.05$) was adopted.

Table I
General features of the population

Variable	*Results*
Age (years)	65.7 ± 6.5
Gender (males)	24.6% (28/114)
Arterial hypertension	68.4% (78/114)
Smoking	3.5% (4/114)
Alcoholism	1.8% (2/114)
Physical activity	28.1% (32/114)
Aspirin use	13.2% (15/114)
Insulin-dependence	32.5% (37/114)
BMI (kg/m^2)	29.0 ± 5.3
Waist circumference (cm)	96.9 ± 10.3
Waist/height ratio	0.63 ± 0.10
Weight (kg)	68.5 ± 12.3
Height (cm)	154 ± 8
Total cholesterol (mg/dL)	209 ± 48
Triglycerides (mg/dL)	180 ± 109
VLDL (mg/dL)	36.1 ± 21.9
HDL (mg/dL)	48.3 ± 11.1
LDL (mg/dL)	124 ± 37
HBA1c (%)	8.6 ± 1.5
C-reactive protein (mg/L)	4.2 ± 3.9

Results

All contacted patients agreed to the study and there were no exclusions. General features of the consecutively enrolled 114 patients are listed in table I.

Mean body mass index was in the overweight range and 36.9% of the subjects were obese (BMI > 30 kg/m^2). Only four participants were smokers and two admitted moderate alcohol consumption, therefore these variables were disregarded for statistical purposes. Insulin-dependence was identified in 32.5% of the cohort, all others receiving oral drugs. C-reactive protein was elevated (normal < 3mg/L) and HbA1c was > 7%, as defined in inclusion criteria.

Age, waist circumference, body mass index (BMI), physical activity, arterial hypertension and insulin dependence were similar according to gender. Nevertheless, HbA_{1c} concentration was lower in men compared to women (8.8 ± 1.5 and 7.8 ± 0.4, respectively, P = 0.022). Older patients (> 65 years) exhibited lower LDL concentration despite similar BMI (130 ± 35 *vs* 118 ± 37 mg/dL, P = 0.047), and CRP in obese cases was higher , without statistical confirmation (5.1 ± 3.1 versus 3.7 ± 4.2 mg/dL, P=0.065). Differences in dietary pattern could not be demonstrated .

Daily energy intake was 1,365 ± 565 kcal/d, corresponding to roughly 20 kcal/kg/day. Dietary carbohydrates, fat, and saturated fat as a proportion of total calories were 54.2 ± 9.8 %, 27.1 ± 6.2%, and 8.4 ± 3.2% respectively. Protein percentage was 20.4 ± 6.4%, with an absolute intake of about 1 g protein/kg/day. All values were within the accepted bounds except for saturated fats (< 7%, ADA).[10]

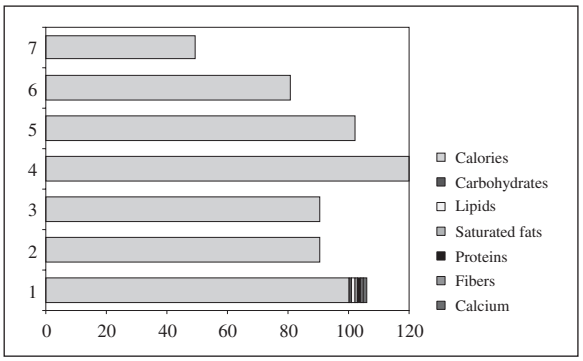

Fig. 1.—Adequacy of the ingested diet. Calories (item 1) and macronutrients (items 2, 3, 5) were within the recommended limit, represented by the 100% line. Saturated fats (item 4) exceeded the allowance by 20% whereas fibers (item 6) and especially calcium (item 7) were insufficient for the needs of the population.

Fiber intake was 15.4 ± 8.6 g/day, and for calcium the value was just 592 ± 204 mg/day, without differences in gender, age or BMI distribution . Daily calcium was below recommendations for the aged population (< 1,200 mg/d) in all quartiles. Cutoffs of calcium consumption quartiles were < 323.5; 323.5 to < 411.7; 411.7 to < 565.9 and 565.9 mg/ day respectively . Fiber ingestion was better, meeting the ideal 14 g/1,000 kcal in the highest quartile of the population (cutoff point ≥ 19.7 g/day)[10,12] (fig. 1).

Carbohydrates which represented the main energy source, along with total calories, negatively correlated with total and LDL cholesterol, though lipids failed to exhibit direct association as expected. These variables including lipids exhibited reverse correlation with HbA1c but there was some gender interaction, males displaying both somewhat higher intake and significantly lower HbA1c (table II). Macronutrients also correlated between themselves, including calcium and fiber.

High calcium intake seemed advantageous for total and LDL cholesterol profile when all patients were examined. Stratification confirmed a favorable effect for those with BMI > 30 kg/m^2. Fiber-rich diet was endowed with even more beneficial links, correlations encompassing arterial hypertension, insulin dependence, lipid fractions and HbA1c. Though all results were significant, interaction with calcium occurred.

Discussion

The most effective dietetic intervention for diabetes remission is calorie restriction compatible with substantial and sustained weight loss, especially with the help of bariatric or metabolic surgery. In a recent series with morbidly obese persons we documented 85.7%

Table II
Correlations of macronutrients, calcium and fiber

Macronutrients/ All patients	*Calories*	*Carbohydrates*	*Lipids*
All patients			
Total cholesterol		-0.241 (p = 0.009)	
LDL-cholesterol	-0.189 (p = 0.047)	-0.250 (p = 0.008)	
HBA1c	-0.213 p = 0.029	-0.191 p = 0.045	-0217 p = 0.028
Calcium	*All*	*BMI ≥ 30*	
Total cholesterol	-0.197 p = 0.041	-0.284 p = 0.049	
LDL-cholesterol	-0.201 p = 0.039		

Fibers	*All*	*BMI ≥ 30*	*BMI < 30*	*Age > 65*	*Age 60-65*
Hypertension			-0.277 p = 0.033	-0.418 p = 0.001	
Total cholesterol	-0.244 p = 0.009	-0.310 p = 0.038			
LDL-cholesterol	-0.249 p = 0.008	-0.291 p = 0.049		-0.351 p = 0.048	
HBA1c				-0.409 p = 0.024	
Insulin use	-0.185 p = 0.049				

Obs: Only significant correlations shown; results were confirmed by multivariate analysis.

long-term response of diabetes, consistent with 60-90% success registered by others.[13,14]

Energy restriction deserves theoretical consideration for current patients because most were overweight or obese. Nevertheless, dieting alone without additional lifestyle, pharmacologic or surgical interventions, will hardly achieve lasting impact on carbohydrate and lipid homeostasis. Even individuals undergoing aggressive interventions such as Roux-en-Y gastric bypass may recover part of the lost weight five or more years later.[14,15]

Drastic dietary restriction embodies another risk, namely deficiency of fiber and micronutrients, potentially negating some of its benefits. In the current series low-calorie alimentation was already present (mean of 1,365 kcal/day, or 20 kcal/kg/day), in line with the reduced metabolic requirements of elderly people, and the universal advice to combat weight gain in t2dm. Depending on the regimen, even in the 1,300-1,500 kcal/day range inadequacies for fiber, vitamins, minerals and trace elements have been recorded,[16] and further decreases could elevate the risks.

Fibers already represent a mainstay in the management of chronic diseases.[10,12] In the current series most expected correlations for fibers were confirmed, including total and LDL-cholesterol, and need for insulin. Only selected groups exhibited a positive impact regarding arterial hypertension as well as HbA1c concentration, suggesting that age, body mass and perhaps additional factors modulate the metabolic effect of dietary fiber.

Calcium input, or indirectly consumption of milk and dairy foods, is much less studied and reports about diabetes protection are controversial. A negative relationship between high calcium intake combined with vitamin D, and HbA1c along with body weight, was demonstrated in diabetics[9] but benefits were questionable in metabolic syndrome.[17] The mechanisms underlying this pathway are not completely understood, but could involve parathyroid hormone and 1,25-dihydroxycholecalciferol ($1,25(OH)_2D_3$) , and result in lipogenesis and decreased fat oxidation within adipose tissue.[6,7,9,17] In weaning rats release of adiponectin by visceral adipocytes is also impaired.[8]

Canadian guidelines for the management of hypertension endorse low-fat dairy foods.[18] In contrast, several large trials failed to register a protective effect of calcium and vitamin D against t2dm as well as metabolic syndrome, and specific directives regarding calcium ingestion for such populations are lacking.[7,17]

Part of the inconsistencies should be attributed to interaction between calcium, fiber and other nutrients. Indeed, many foodstuffs interact with each other , and the impact of some may be overwhelming. In European studies scrutinizing up to 25 nutritional measurements, just a handful of meal components nominally bread, plant foods, dairy products, meat and oils largely explained the variations of all such nutrients.[19] Depending on adopted diet and statistical model, high intake of certain components might overshadow the influence of calcium.

A threshold-effect has also been advocated , only patients with serious calcium depletion being candidates for reversible changes.[17] In this sense, further interventional studies are advisable not only to confirm current evidence, but also to pinpoint the ideal contexts for supplementation.

This is to the best of our knowledge, the first study to address the therapeutic implications of dietary components in inadequately controlled t2dm of older persons. The strength of focusing fiber and calcium is that wholesale lifestyle and macronutrient shifts, required for sustained weight loss and metabolic changes, represent a nearly insurmountable challenge in such circumstances. Frailty, malnutrition and hypoglycemia could be triggered by harsh or unbalanced regimens,[1] or at least high drop-out rates.[1,4] In contrast enhancement of a few key ingredients is less cumbersome to implement and easier to adhere to, thus potentially representing a more practical alternative.

Conclusions

Calcium and fiber in the diet correlated with serum lipids, whereas fiber alone displayed a protective asso-

ciation regarding diabetes (HBA1c, insulin use) and arterial hypertension. Future studies should address enhancement of these ingredients by means of dietary changes and supplements

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