Dietary habits and incidence of noninsulin-dependent diabetes mellitus in a population study of women in Gothenburg, Sweden[1-3]

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ABSTRACT Dietary intake as initially estimated in a cross-sectional study has been related to the 12-y incidence of diabetes mellitus in a prospective study of 1462 women. In addition, all 50-y-old women (n = 352) were subjected to an intravenous glucose tolerance test. Because of the sampling procedure and a high participation rate the participants were representative of middle-aged women in the general population. No differences of statistical significance were observed concerning intake of energy and different nutrients. Neither did the number of meals nor the longest time between meals differ between women who developed diabetes and those who did not. Women with impaired glucose tolerance who developed diabetes did not differ from those who did not develop diabetes, concerning dietary intake. Body mass index was significantly higher in women who developed diabetes compared with other women. No specific dietary recommendations can be based on the results of this study. *Am J Clin Nutr* 1989;49:708–12.

KEY WORDS Dietary habits, diabetes, incidence, population study, prospective study, women

Introduction

Noninsulin-dependent diabetes mellitus (NIDDM) is a common disease in adult individuals and a prevalence of 5–10% has repeatedly been reported in elderly people (1). The total risk of developing manifest diabetes according to life table expectancy has been calculated to be 10–15% in Sweden (2).

In addition to family predisposition (3), obesity (4), arterial hypertension and antihypertensive drugs (5), and dietary habits (6) have been considered factors in the incidence of NIDDM.

A prospective population study of women aged 38–60 y in Gothenburg, Sweden has been ongoing since 1968–69 (7). The aim of the present study was to correlate dietary habits with the development of NIDDM during the 12-y follow-up period.

Subjects and methods

Study population

A population study of 1462 women in five age strata, aged 38–60 y, was carried out in Gothenburg, Sweden between 1968 and 1969 (**Table 1**). Because of the sampling technique and a high participation rate (90.1%) the participants were representative of women in the general population of the ages studied (7). This population sample was restudied in 1974–75 (8) and 1980–81 (9).

The present study deals with the 12-y follow-up between 1968 and 1969 and 1980 and 1981 (Table 1). Information concerning the prevalence and incidence of diabetes was obtained from the majority of nonparticipants by telephone interview or letter. Therefore, altogether 1406 of 1462 women in the follow-up study in 1974–75 (97.9% of all survivors) and 1351 of the 1462 women in the study in 1980–81 (97.4% of all survivors) were interviewed.

Those women who had not developed diabetes either at the time of the initial study or during the follow-up period were usually used as a reference group. When studying the number of meals and intake of bread, milk, fruit, potatoes, cakes, and biscuits, the reference group was selected as follows: for each woman who developed diabetes, two women were included as control subjects, one of whom according to date of birth and birth number was just before and the other one just after the woman who had developed diabetes.

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TABLE 1
Participants in the initial study carried out in 1968–69 and in the follow-up study in 1980–81

	1968–69		1980–81	
Age	Subjects	Participation rate	Subjects	Participation rate*
y	*n*	%	*n*	%
38	372	91.4	308	82.8
46	431	90.0	332	77.0
50	398	91.3	325	81.7
54	180	88.7	140	77.8
60	81	83.5	49	60.5
Total	1462	90.1	1154	78.9

* Of those investigated in 1968–69.

A total of 1361 (93%) of the 1462 women studied in 1968–69 participated in a 24-h dietary recall interview (10). Dietary history was obtained from a randomized subsample comprising 418 women (10).

Methods

In each of the three studies in 1968–69, 1974–75 and 1980–81 the women were interviewed and examined comprehensively (7–9). The women were recalled at intervals of a quarter of an hour between 0700 and 0945. The interview included questions concerning history of diabetes and type of antidiabetic treatment.

The participants passed the examination stations, the order of which was described previously (7). At one of these stations a 24-h recall was obtained. A comprehensive dietary history was recorded on a second occasion. The dietary interviews (24-h recall and dietary history) were managed by three dietitians of whom one was responsible for 80% of the interviews. Further details about the 24-h recall and dietary history recording were presented previously (10, 11). Nutrient intakes were calculated from the data collected by use of a computer system modified by one of the participating dietitians according to Westin (12). The system was based mainly on the food composition tables of Abramson (13). The dietary data obtained in the interviews were validated by determining 24-h urinary nitrogen excretion on a subsample of 755 participants (10, 14).

Each participant was asked whether or not she had diabetes, as were most of the nonparticipants in the follow-up studies. If a doctor had stated that she had diabetes, we accepted this diagnosis. Blood glucose concentration was determined from venous blood with the patient in the fasting state. In the initial study it was determined by a ferric cyanide reduction method (15) and later on by a glucose oxidase method. Women with blood glucose values ≥ 6.0 mmol/L who were not known to have diabetes were referred to a special diabetes unit for further investigation. Subjects were defined as having diabetes if they had two fasting venous or capillary whole blood glucose values ≥ 7.0 mmol/L. This was in accordance with the recommendations of the World Health Organization (16).

The 50-y-old women underwent an intravenous glucose tolerance test for the measurement of the early insulin response (0–8 min) in 1968–69. Further details concerning that test and methods used for glucose and insulin analyses were presented previously (3). The glucose tolerance was expressed as a k-value, representing the disappearance of blood glucose in percent per minute (17). The early insulin response was calculated according to Thorell et al (18). The majority of the 50-y-old women who were defined as risk individuals for diabetes were advised to improve their dietary habits, namely to reduce body weight if overweight and to reduce sugar intake (19).

Body height in 1968–69 measured to the nearest 0.5 cm with the subject in the standing position without shoes; in 1974–75 and in 1980–81 to the nearest 0.1 cm. Body weight was measured at the three examinations to the nearest 0.1 kg by use of a balance scale. The women wore only briefs when being weighed. Body mass index was calculated as wt/ht^2 (kg/m^2).

Statistical methods

Conventional methods were used to calculate mean values and SD. Student's *t* test was used to test the hypothesis of no difference in mean values between two groups. Relative risk and confidence limits of relative risk were calculated according to the Mantel-Haenszel estimation (20, 21). Associations between graded or continuous variables were tested by means of Pitman's nonparametric permutation test (22). An extension of Mantel-Haenszel's procedure to permutation tests (20) was used to adjust for confounding variables. Two-tailed tests were used and p values of < 0.05 were considered to be statistically significant.

Results

Prevalence and incidence of diabetes mellitus

Twelve women (0.8%) had diabetes mellitus at the time of the initial study in 1968–69 (**Table 2**). One of these women had an earlier unrecognized disease. Forty-three women (3.1%) developed NIDDM during the 12-y follow-up period between 1968 and 1969 and 1980 and 1981 (Table 2). The mean incidence of diabetes mellitus during the follow-up period was 255 of 100 000/y for the whole group and 408 of 100 000/y for women aged ≥ 50 y between 1968 and 1969.

Among the 50-y-old women who in 1968–69 underwent an intravenous glucose tolerance test, 89 of them

TABLE 2
Prevalence of diabetes at the time of the initial study in 1968–69 and the 12-y incidence of noninsulin-dependent diabetes mellitus

	Prevalence in 1968–69 in relation to treatment at that time	Incidence between 1968 and 1969 and 1980 and 1981 in relation to treatment in 1980–81
	n	*n*
No treatment	1	11
Diet only	5	6
Antidiabetic tablets	3	19
Insulin	3*	5
Total	12	41†

* Two had insulin-dependent diabetes mellitus.

† Two women, who had developed diabetes, died during the 12-y period and are here excluded.

TABLE 3
Intake of energy and different nutrients in women who developed diabetes during the 12-y follow-up period and in a reference group of women according to the 24-h recall and the dietary history, respectively*

	Women who developed diabetes	Reference group	Statistical significance
24-h recall (diabetics, n = 37†; reference group, n = 1210)			
Energy (kcal/d)	1459 ± 450	1570 ± 549	NS
Protein (% of total energy)	14.2 ± 3.3	15.1 ± 3.7	NS
Fat (% of total energy)	40.7 ± 6.6	40.3 ± 8.1	NS
Carbohydrates (% of total energy)	43.4 ± 7.0	43.4 ± 8.3	NS
Dietary history (diabetics, n = 20; reference group, n = 391)			
Energy (kcal/d)	1924 ± 744	2040 ± 515	NS
Protein (g/d)	66.7 ± 19.4 [14.2]‡	72.8 ± 16.9 [14.6]	NS
Fat (g/d)	84.4 ± 38.8 [40.5]	87.3 ± 27.4 [39.5]	NS
Carbohydrates (g/d)	212 ± 86 [45.3]	228 ± 64 [45.9]	NS

* $\bar{x}$ ± SD.
† Missing data on six women.
‡ Numbers in brackets denote the percent of total energy.

were considered as having an increased risk to develop diabetes (k value < 1.00 and/or an early insulin response [ER] within the two lowest decentiles [≤ 294 pmol/L]). Twelve (17%) of those 70 women belonging to this group who were followed up in 1980–81 developed diabetes during the follow-up period, 7 of 41 women with a k value < 1.0 and ER ≤ 294 pmol/L (41%), 5 of 40 women with a k value ≥ 1.0 and ER ≤ 294 pmol/L (13%), and none of 13 women with a k value < 1.0 and ER > 294 pmol/L (0%).

Intake of energy and different nutrients

The upper part of **Table 3** shows the initial intake of energy and different nutrients in percent of total energy in 1968–69 as reported in the 24-h recall in women who developed diabetes during the follow-up period compared with the reference group. No statistically significant differences were observed.

The results presented in the lower part of the table refer to the subsample of women who were subjected to the dietary history questionnaire, in which 20 women developed diabetes. No significant differences were observed but there was a tendency toward a lower intake of energy and different nutrients in women who developed diabetes compared with the reference group.

In the 12 women, who according to the intravenous glucose tolerance test were considered as having an increased risk to develop diabetes and who also did develop diabetes during the follow-up period, the intake of energy according to the dietary history at the time of the initial study was 2227 ± 763 kcal/d ($\bar{x}$ ± SD) compared with 2245 ± 563 kcal/d for the 77 women who did not develop diabetes (NS). Corresponding figures for intake of fat per day were 87 ± 29 and 92 ± 33 g/d, respectively (NS).

Number of meals and intake of different food stuffs

Table 4 shows a comparison between women who developed diabetes during the follow-up period and a reference group with respect to some other variables dealing with dietary habits: number of meals per day; the longest period between the meals; intake of bread, milk, fruits, potatoes, and cakes and bisquits. There were no differences of statistical significance.

Body mass index

Table 5 shows means of body mass index in women who developed diabetes and in the reference group. The body mass index was significantly higher on all occasions in women who developed diabetes during the follow-up period compared with other women. However, body mass index was unchanged at the follow-up study in the group of women who developed diabetes whereas it tended to increase in the reference group.

Table 6 shows means of body weight at the time of the initial study in 1968–69 and at the time of the 6-y follow-up in 1974–75 in these women at risk. It seemed that the dietary advice given had some long-term influence on body weight change in the overweight women.

Discussion

When comparing intake of energy and different nutrients in women who developed diabetes during the follow-up period with those women who did not, age was not taken into consideration. This was not considered necessary because there were no obvious differences in energy or nutrient intake between women in the different age groups studied (10).

The information about dietary habits was obtained from a 24-h recall and from a more comprehensive dietary history interview. In addition, mean intake of protein as calculated from the interviews and from the 24-h urinary N excretion were compared. This was the first time in a population study that an attempt was made to validate the data from the dietary interview by means of an independent biological method (10, 14). The N intake

TABLE 4
Dietary data obtained from the 24-h recall in 1968–69 in women who later on developed diabetes and in a reference group

	Women who developed diabetes*		Reference group†		Statistical significance
	Value‡	*Range*	*Value‡*	*Range*	
Number of meals	4.30 ± 1.11	3–6	4.58 ± 1.06	2–8	NS
Longest period between meals (h)	12.1 ± 2.5	8–17	11.9 ± 2.3	6.5–18	NS
Intake of bread (g/d)	65 ± 31	12–120	65 ± 42	0–234	NS
Intake of milk (g/d)	161 ± 153	0–600	210 ± 175	0–700	NS
Intake of fruits (g/d)	114 ± 222	0–1275	128 ± 137	0–601	NS
Intake of potatoes (g/d)	142 ± 98	0–300	144 ± 95	0–300	NS
Intake of cakes and bisquits (g/d)	34 ± 35	0–138	44 ± 39	0–171	NS

* $n = 40$; missing data on three women.
† $n = 80$.
‡ $\bar{x} \pm$ SD.

according to the dietary history agreed with the excretion of N as measured in a 24-h collection of urine (14). Energy intake (Table 3) and different nutrients reported in the 24-h recall were consistently lower but the nutrient density figures for protein, fat, and carbohydrate were in agreement with corresponding figures from the dietary history (10). This was the reason why the intake of different nutrients according to the 24-h recall (Table 3) was reported only as percent of total energy. Our results indicate that the 24-h recall method underestimated quantity, which has probably been overlooked in many previous studies, but not quality of the food consumed.

It was not possible to estimate the intake of fibers from the dietary recordings in 1968–69. However, as seen in Table 4, there were no differences in consumption of bread, fruits, and potatoes, the main sources of dietary fibers in the Swedish diet, between those who developed diabetes and those who did not.

We did not observe any significant differences in energy or nutrient intake between women who developed diabetes during the period and women who did not. However, there was a tendency toward a lower intake of energy and thus of the energy yielding nutrients in the diabetes group; the same tendency was observed for both data obtained from the 24-h recall and the dietary history. This might be somewhat strange because there is a correlation between overweight and incidence of diabetes (23). Possibly, the women in the diabetic group had a lower physical intake than other women. A low physical activity means a lower energy need or a tendency to become overweight or both. We have no data on physical activity of the women that would permit a comparison between diabetic and other women. However, on the basis of information obtained in different studies, there is not always a correlation between recorded intake of energy and nutrients and actual body weight (24). Also, in our population study there was a tendency toward a reversed correlation.

It is well known that overweight women have obvious problems in reducing body weight, at least permanently, despite permanent or periodic slimming, which indicates a highly variable supply of energy and different nutrients from time to time.

The majority of women classified as risk individuals for diabetes were recommended to follow a slimming diet and met with a dietitian for 12 mo (19). There was substantial reduction in body weight in many of the obese women. However, these women had not main-

TABLE 5
Body mass index in women who developed diabetes during the 12-y follow-up period compared with initially nondiabetic women who did not develop diabetes during the follow-up*

Time of examination	Women who developed diabetes	Reference group	Statistical significance
	kg/m²	*kg/m²*	
1968–69	29.7 ± 6.5 [43]	23.9 ± 3.5 [1372]	$p < 0.001$
1974–75	29.7 ± 6.3 [37]†	24.4 ± 3.8 [1246]	$p < 0.001$
1980–81	29.0 ± 7.0 [41]‡	24.9 ± 3.9 [1117]	$p < 0.001$

* $\bar{x} \pm$ SD. Number of subjects given in brackets.
† Missing data on six women.
‡ Missing data on two women (death).

TABLE 6
Body weight as recorded at the time of the initial study in 1968–69 and at the time of the 6-y follow-up in 1974–75 in women who in 1968–69 at age 50 y were classified as risk individuals*

Initial body mass index	1968–69	1974–75
	kg	*kg*
≤20	51.4 ± 3.0 [5]	50.3 ± 3.1 [5]
>20 ≤ 25	61.0 ± 4.6 [43]	61.4 ± 5.4 [43]
>25 ≤ 30	72.7 ± 6.1 [24]	72.7 ± 7.1 [24]
>30	92.7 ± 15.4 [7]	90.2 ± 11.4 [7]

* $\bar{x} \pm$ SD. Number of subjects given in brackets.

tained this weight reduction by the end of the 6-y follow-up. Thus, it seems urgent to continue a weight reduction program if a reduction of body weight is to be maintained.

There is an obvious association between increased body weight and increased risk of diabetes; therefore, a recommendation against becoming overweight might be given. However, on the basis of the results from this prospective study, no recommendation with respect to different nutrients seems to be justified.

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