

# Evaluation of dietary intake in a Danish population: the Inter99 study

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## Abstract

**Background:** During the past few decades there has been a worldwide increase in the prevalence of obesity and type 2 diabetes, and this may partly be due to an unfavourable dietary composition.

**Objective:** To evaluate the dietary intake of Danish men and women against the dietary recommendations, and to assess the daily glycaemic index (*dGI*) and the daily glycaemic load (*dGL*) of the diet.

**Design:** Baseline data from the Danish population-based Inter99 study were used. Dietary intake of 6635 men and women between 30 and 60 years of age was assessed through a food frequency questionnaire. The dietary intake was evaluated against the Nordic Nutrient Recommendations and the Danish food-based guidelines. Estimation of *dGI* and *dGL* was based on existing food tables.

**Results:** Men in the Inter99 study had higher intakes of all fat types, protein, carbohydrate, dietary fibre, alcohol and fish ( $\text{g day}^{-1}$ ) compared with women, whereas women had higher intakes of fruit and vegetables ( $\text{g day}^{-1}$ ) compared with men. The *dGI* did not differ substantially between the genders, but men had a higher *dGL* than women. The recommendations for total, saturated, monounsaturated and polyunsaturated fat, carbohydrates, dietary fibre, fish, fruit and vegetables was met by less than 50% of the Inter99 population.

**Conclusions:** The dietary composition in the Danish middle-aged population is not satisfactory compared with the recommendations, which may have detrimental consequences for health. The values of *dGI* and *dGL* were reasonable, but higher than estimates found in other studies.

**Keywords:** *dietary assessment; dietary recommendations; food frequency questionnaire; glycaemic index; glycaemic load*

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## Introduction

During the past few decades an increase in the prevalence of overweight, obesity and type 2 diabetes has been reported worldwide (1–4), and it is assumed that the prevalence of these conditions will increase in the future (5). Lifestyle factors such as diet and physical inactivity play a major role in the development of these metabolic complications (6, 7).

In 1996 the Nordic Council and Nordic Council of Ministers published the Nordic Nutrient Recommendations, with the aim of providing nutrient-related guidelines for a diet, which considers the physiological needs of the individual and thereby

reduces the risk of diet-related illnesses. In addition, in Denmark the Danish Ministry of Food, Agriculture and Fisheries has formulated food-based dietary guidelines regarding the intake of alcoholic beverages, fish, fruit and vegetables, which are mainly regarded as a simple message to the population (8). There are no recommendations with regard to glycaemic index (GI) and glycaemic load (GL), but some observational studies suggest that diets with high GI and GL are independently associated with increased risk of type 2 diabetes and cardiovascular diseases (7, 9). Other epidemiological studies have found associations, in particular, between the intake of total and saturated fat and obesity, type 2 diabetes and cardiovascular diseases (7, 10). Dietary composition in a population may

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therefore affect the progression of disease to a certain degree.

The aim of this study was to evaluate the dietary intake of Danish men and women against the Nordic Nutrient Recommendations 1996 and the Danish food-based guidelines regarding intake of macronutrients, fruit and vegetables, fish and alcoholic beverages. A specific objective was to assess the daily glycaemic index and the daily glycaemic load in the diet of this population.

## Study design and methods

### *Study population and design*

The Inter99 study is a population-based non-pharmacological intervention study aimed at reducing the risk of cardiovascular disease and type 2 diabetes. The study population comprised 61 301 individuals born in 1939–1940, 1944–1945, 1949–1950, 1954–1955, 1959–1960, 1964–1965, and 1969–1970 living in 11 municipalities in the south-western part of Copenhagen County. All individuals were drawn from the Civil Registration System. An age- and gender-stratified random sample of 12 934 eligible people was drawn from the study population. A total of 6906 participated in the screening programme. The participation rate was highest in the age groups of 40–55-year-olds (53.2–54.2%) and lowest in the 30-year-olds (33.8%). Of the 6906 participants, 122 were excluded because of alcoholism, drug abuse or linguistic barriers and 149 participants did not fill in the food frequency questionnaire (FFQ), leaving 6635 individuals for the dietary analyses. The aim, data collection and non-dietary baseline results of the cohort study have been reported elsewhere (11).

### *Data collection*

All participants underwent a physical health examination and filled in a self-administered FFQ and a standard questionnaire on health and lifestyle.

The FFQ was based on validated FFQs used in the two Danish studies. “Diet, Cancer and Health” (12) and “Better Health for Mother and Child” (13). The FFQ in the Inter99 study was modified to improve estimates of the intake of fatty acids, cholesterol and complex carbohydrates, but had fewer questions regarding fruit and vegetables. The habitual food and nutrient intake during 1 month before examination was estimated. All participants

completed the FFQ from March 1999 to January 2001.

The FFQ consisted of 198 food items and beverages; it included questions about breakfast foods; bread with sliced meat, fish, eggs, cheese, spread and vegetables; hot meals and accompaniments to hot meals; ready-prepared dishes and takeaway food; vegetables; salad dressing; sauce; fruits; snacks; cookies; candy and ice-cream; and beverages, including alcohol, but intake of soft drinks was not recorded. It also included questions about the type of fat used for food preparation and at the table. The participants could choose between seven and 11 possible responses, ranging from never to eight or more times per day.

The consumed quantity was obtained by multiplying portion size by the corresponding consumption frequency reported. Standard portion sizes for women and men, separately, were used in this calculation (14, 15). All food items in the FFQ were linked to food items in the Danish Food Composition Databank (16). For mixed meals standard recipes based on food items in the databank were developed at the Research Centre for Prevention and Health. In total, 244 food items were used, and these were divided into different food groups.

The GI for carbohydrate-containing food items was estimated using average GI values in the GI table by Foster-Powell et al. (17) with bread as reference food (GI = 100). For food items in the table of Foster-Powell et al. where different preparation methods had yielded different GI values (often with very wide ranges), the values were chosen dependent on the preparation methods described in the recipes. The daily average glycaemic index (*dGI*) for an individual was calculated by summing the products of the absolute available carbohydrate content in each food item eaten per day and the GI for each food item, divided by the total amount of available carbohydrate eaten (18, 19). The daily average glycaemic load (*dGL*) was the sum of the products of the available carbohydrate content in each eaten food item and the GI for each food item, divided by 100 (20). The calculation of *dGI* and *dGL* was based on 57 different GI values ranging from 16 to 147.

Estimation of amounts, energy percentages (*E%*) and energy intake for each subject in the Inter99 study was based on calculations in the software program FoodCalc version 1.3 (21).

Weight was measured to nearest 0.1 kg using either an electronic or a mechanical standard weight (Seca 707, Seca 710) with the participant wearing light indoor clothes without shoes. Height was measured to the nearest 0.5 cm with the participant wearing no shoes. Body mass index (BMI) was calculated as weight in kilograms divided by the height in metres squared, and basal metabolic rate (BMR) was estimated by use of Schofield's equation (22). Waist measurement was taken with a tape measure halfway between the lowest point of the costal margin and highest point of the iliac crest.

To assess misreporting of energy intake, Goldberg's equation was used (23). For each individual the reported energy intake (EI) was divided by the estimated BMR ( $BMR_{est}$ ). To avoid systematic underestimation of the energy intake used in the calculation of  $EI/BMR_{est}$  an average intake of soft drinks equal to  $302 \text{ kJ day}^{-1}$  ( $\sim 178 \text{ ml}$ ) for each participant was added to the total energy intake because of the missing questions about soft drinks in the FFQ. This average intake was based on 7 days' self-administered dietary records from the National Dietary Survey of Denmark 2001 for 952 men and women at 30–60 years of age (Fagt S, personal communication, 2003). Additional energy intake from soft drinks from the National Dietary Survey of Denmark 2001 was only used in the calculation of  $EI/BMR_{est}$ . The presented data on energy intake and macronutrients are therefore only based on the reported intakes from the Inter99 study.

#### Evaluation of the diet

Intake of macronutrients in energy percentages was evaluated against the Nordic Nutrient Recommendations (24), while intake of fish, alcoholic beverages, fruit and vegetables was evaluated against the Danish food-based guidelines (8, 25, 26).

The estimated  $dGI$  and  $dGL$  in the Inter99 study were compared with the American Nurses' Health study and the Health Professionals' Follow-up study, in which a semiquantitative FFQ was used to assess the dietary intake (18–20).

The intake of macronutrients in the Inter99 population was compared with the National Dietary Survey of Denmark 1995 (NDS 1995), which was a representative sample of the Danish population in 1995 (27). In NDS 1995 dietary data were collected by use of a short personal interview supplemented by a 7 day self-administered dietary

record with preprepared answering categories (27). Differences between Inter99 and the NDS 1995 population were considered essential if the difference in median intake was more than 10%. The age group in the NDS was wider, ranging from 15 to 80 years, compared with 30 to 60 years in the Inter99 study, and therefore weighted means of macronutrient intake for an age-matched subsample (25–64 years) of NDS 1995 were calculated. The dietary intakes in this subsample were not substantially different to the entire population of NDS 1995, except for intake of alcohol, for which the intake was higher in the subsample compared with the entire population. However, since only limited data were available from this subsample comparison of dietary intake was made between the Inter99 population and the entire NDS 1995 population.

#### Statistical methods

SAS 8.2 (SAS Institute, Cary, NC, USA) and R 1.8.1 (28) were used for data handling. Medians, percentiles, means and standard deviations were calculated. Since none of the dietary variables was normally distributed they were log-transformed, and the Student's *t*-test was used to test for significant differences between men and women. Trend tests were performed to test whether dietary intake differed across the age cohorts. A *p*-value of 0.05 was considered statistically significant.

## Results

#### The Inter99 population

Baseline characteristics of the Inter99 population are presented in Table 1. Table 2 shows the daily intake of energy in MJ, macronutrients, fish, fruit and vegetables in grams together with the estimated  $dGI$  and  $dGL$ . Even though  $dGI$  values were

Table 1. Baseline characteristics for the Inter99 population ( $n=6635$ )

	Men	Women
<i>n</i>	3223 (48.6)	3412 (51.4)
Age (years)	46.5 ± 7.8	45.8 ± 7.9
BMI ( $\text{kg m}^{-2}$ )	26.8 ± 4.0	25.9 ± 5.1
Waist circumference (cm)	93.2 ± 11.0	80.4 ± 12.3
$BMR_{est}$ (MJ)	7.82 ± 0.68	6.05 ± 0.53

Data for *n* are absolute values with corresponding percentages in parentheses. Data for age, body mass index (BMI), waist circumference and estimated basal metabolic rate ( $BMR_{est}$ ) are given as means with corresponding standard deviations.

Table 2. Daily intake of energy, macronutrients and selected food groups together with the estimated daily glycaemic index and daily glycaemic load for men and women in the Inter99 population

	Men (n=3223)	Women (n=3412)	p-value
Energy (MJ)	11.1 (9.0, 13.6)	9.1 (7.3, 11.4)	<0.001
Fat (g)	98.2 (74.3, 133.3)	74.3 (55.6, 103.0)	<0.001
Saturated fat (g)	37.7 (27.7, 53.5)	28.4 (20.5, 40.8)	<0.001
Monounsaturated fat (g)	32.9 (24.6, 45.5)	24.1 (17.7, 34.1)	<0.001
Polyunsaturated fat (g)	14.4 (10.6, 19.9)	11.1 (8.1, 15.4)	<0.001
n-3 fatty acids (g)	2.7 (1.9, 3.9)	2.0 (1.5, 2.9)	<0.001
Carbohydrate (g)	285.0 (228.6, 354.6)	256.6 (199.5, 328.8)	<0.001
Added sugar (g)	26.0 (14.1, 44.7)	28.7 (15.7, 49.6)	<0.001
Dietary fibre (g)	25.0 (18.9, 32.2)	23.0 (17.3, 29.7)	<0.001
Protein (g)	94.3 (77.8, 113.2)	78.1 (63.2, 95.3)	<0.001
Alcohol (g)	13.2 (5.0, 29.6)	6.1 (1.9, 13.5)	<0.001
Daily glycaemic index <sup>a</sup>	79 (75, 83)	80 (76, 83)	<0.001
Daily glycaemic load <sup>a</sup>	204 (160, 257)	185 (142, 241)	<0.001
Fish and fish products (g)	25.1 (13.6, 46.0)	20.3 (9.9, 33.6)	<0.001
Fruit and vegetables (g)	182.0 (102.5, 318.2)	301.6 (167.6, 504.9)	<0.001

Data are medians with corresponding 25th and 75th percentiles in parentheses.

<sup>a</sup> Bread was used as reference (glycaemic index of bread = 100) in the estimation.

almost equal for men and women, women had a significantly higher *dGI* than men ( $p < 0.001$ ). Men had a 10% higher *dGL* than women ( $p < 0.001$ ). Table 2 also shows that women had higher absolute intakes of added sugar, fruit and vegetables, whereas the men had higher absolute intakes of fish and all other macronutrients.

BMI and waist circumference, as well as the median intake in of alcohol, fish, fruit and vegetables ( $\text{g day}^{-1}$ ), increased across the age cohorts ( $p$ -values for trend  $< 0.001$ ). Conversely, median intakes of energy ( $\text{MJ day}^{-1}$ ), fat, carbohydrates and protein ( $\text{g day}^{-1}$ ), together with *dGI* and *dGL*, decreased with increasing age ( $p$ -values for trend  $< 0.001$ ).

Table 3 shows the intake of macronutrients expressed as energy percentages. Men had a rela-

Table 3. Intake of macronutrients in energy percentages for men and women in the Inter99 population

	Men (n=3223)	Women (n=3412)	p-value
Fat (E%)	34.6 (29.5, 41.2)	32.1 (26.6, 38.6)	<0.001
Carbohydrate (E%)	44.2 (38.3, 49.5)	48.3 (42.6, 54.6)	<0.001
Protein (E%)	14.5 (12.8, 16.3)	14.6 (12.8, 16.5)	0.236
Alcohol (E%)	3.6 (1.4, 7.5)	2.0 (0.7, 4.4)	<0.001

Data are medians with corresponding 25th and 75th percentiles in parentheses.

tively high intake of fat and alcohol, whereas women had a relatively high intake of carbohydrate compared with men. The intake of protein in energy percentages did not differ between the genders.

The calculated mean  $\text{EI/BMR}_{\text{est}}$  based on Goldberg's equation was 1.62 (SD = 0.68).

### The Inter99 population versus the dietary recommendations

Macronutrient intakes presented as energy percentages in the Inter99 population and NDS 1995 and the corresponding recommendations are shown in Fig. 1. Twenty-seven per cent of the men and 40% of the women (34% of the whole population) had a total fat intake below 30 E%, and the recommendation for saturated fat of maximum 10 E% was only met by 16% men and 28% women (22% of the whole population). Fifty-three per cent of the men and 42% of the women (47% of the whole population) met the recommendations for monounsaturated fat, and the recommendation for polyunsaturated fat was met by 46% of the men and 39% of the women (43% of the whole population). For intake of n-3 fatty acids, more than 96% of both men and women had intakes corresponding to the recommendations of  $> 0.5\text{E}\%$  (data not shown). The opposite tendency was observed with regard to carbohydrate

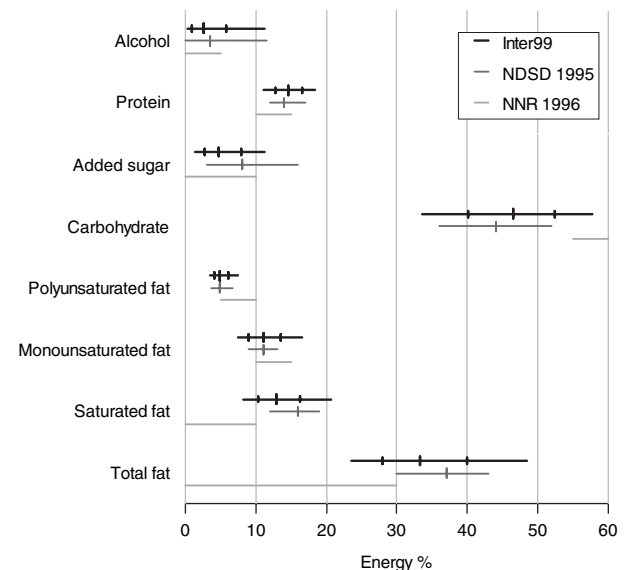


Fig. 1. Median dietary intake in the Inter99 population and in the National Dietary Survey of Denmark 1995 (NDS 1995). The endpoints of each line are the 10th and 90th percentiles, the small vertical lines represent 25th and 75th percentiles, and the middle vertical line represents the median. The macronutrient recommendations are from the Nordic Nutrient Recommendation 1996 (NNR 1996).

intake, where only 9% of the men and 24% of the women (16% of the whole population) had intakes above 55 E%. This corresponded to a relatively low intake of fibre (<25 g day<sup>-1</sup>) for 55% of the population (data not shown). A total of 86% of the study population met the recommendations for added sugar (92% of men and 82% of women). Ninety-three per cent had a protein intake above 10 E%, and 50% of the population had a protein intake in the recommended range of 10–15 E%. With respect to intake of alcohol, 61% of the men and 79% of the women (71% of the whole population) had an intake within the recommended 5 E%.

The median intake of fruit and vegetables in the Inter99 population was 230 g day<sup>-1</sup> (25th and 75th percentiles: 128 and 431) compared with the food-based guidelines of 600 g day<sup>-1</sup> (25). Only 6% of the men and 16% of the women (11% of the population) had a fruit and vegetable intake equal to or above 600 g per day. With respect to fish products the median intake was 164 g week<sup>-1</sup> (25th and 75th percentiles: 77 and 289), and a total of 52% of the men and 63% of the women (58% of the population) had an intake below the recommended intake of 200–300 g fish per week (8). The median intake of alcoholic beverages was 7.7 beverages per week for men (25th and 75th percentiles: 2.9 and 17.3) and 3.6 beverages per week for women (25th and 75th percentiles: 1.1 and 7.9). A total of 79% men and 88% women met the dietary guidelines of maximum 21 and 14 (26) alcoholic beverages per week, respectively.

#### *The Inter99 population versus the National Dietary Survey of Denmark*

Intake of monounsaturated fat, polyunsaturated fat, carbohydrate and protein differed by less than 10% from the intake reported in the NDS 1995. Furthermore, no difference in the median energy intake between Inter99 and NDS 1995 was found (10.1 vs 9.9 MJ day<sup>-1</sup>). The median intake of total fat, saturated fat, added sugar and alcohol was more than 10% lower in the Inter99 study compared with the NDS 1995 (Fig. 1) and the reported median intake of dietary fibre was 21% higher in the Inter99 study than in the NDS 1995 (24 vs 19 g day<sup>-1</sup>).

#### **Discussion**

The Inter99 study is the first epidemiological Danish study that has assessed *dGI* and *dGL* in a

relatively large population. The estimates of *dGI* and *dGL* tended to be higher in the Inter99 study than in the Nurses' Health study and the Health Professionals' Follow-up study from USA. In the Nurses' Health study and the Health Professionals' Follow-up study the median *dGI* were 71 and 73, respectively, and the median *dGL* were 144 and 160, respectively (18–20). The differences between *dGI* and *dGL* in the Inter99 study and the American studies are likely to reflect true differences between the American and Danish diets and to reflect time changes, as data from the American studies were collected in the 1980s. A further explanation may be methodological differences between the studies in the estimation of GI for different food items. In addition, some of the difference in the estimated *dGL* between the studies could be due to different degrees of carbohydrate underreporting in the studies. The estimates of *dGI* for men and women in the Inter99 study suggest that no clinically relevant differences exist between the genders. The statistical difference in *dGI* for men and women was just a result of the large population size. Therefore, the higher *dGL* observed for men reflects a higher carbohydrate intake. There are no recommendations with regard to *dGI* and *dGL*, but through more research and knowledge in this area, there may be a basis for recommendations considering these values.

Despite a reduction in the intake of dietary fat in the Danish population from 1995 to 1999 (27) the fat intake was still higher than recommended, and men in particular had a high intake of total fat and saturated fat compared with the recommendations. This gender difference is probably caused by men's higher intake of meat and fats (data not shown). The younger age groups, in particular, had high fat intakes, whereas those at 60 years of age met the recommendations to a higher degree. Meeting the recommendations for total and saturated fat is of major importance, since excess fat in the diet may lead to overconsumption of energy, followed by obesity, type 2 diabetes and cardiovascular disease (7, 10). The intake of polyunsaturated fat was only within the recommendations for a minority of the Inter99 population, while the intake of n-3 fatty acids was within the recommendations for most of the population. Intakes of these fatty acids are important concerning their possible protective effect in the prevention of type 2 diabetes and cardiovascular diseases (7, 10). The reported intake of dietary

fibre was also below the recommendations for more than 50% of the population, but the reported intake of added sugar was within the recommended limit for the majority of the population. Meeting the recommendations for intake of dietary fibre may improve blood glucose regulation and glycaemic control, and lower *dGI* and *dGL*, which in turn may lower the risk of developing insulin resistance, impaired glucose tolerance and type 2 diabetes (9).

In spite of an observed increase in the intake of fruit and vegetables over the past decade (29, 30), only 16% of the women and 6% of the men met the recommendations in the Inter99 study. The gender differences observed with respect to fruit intake may be explained by the fact that health campaigns have more of an effect on women than on men, and thus on average women eat a healthier diet with more fruit and vegetables (31). The fish intake was substantially lower than the recommended level for both men and women, especially in the younger age groups, despite the fact that the intake of n-3 fatty acids (*E%*) was met by most of the population. This reflects that there may not always be agreement between food-based guidelines and nutrient recommendations, and this may be caused by the fact that the intake of nutrients from a food group depends on both the amount of the food item consumed and the type and quality of the food. Disagreement between food-based guidelines and the nutrient recommendations was also observed for the alcohol recommendations, for which a higher proportion of the population met the recommendations for beverages per week compared with the recommendation in energy percentages.

In the Inter99 population a mean value for  $EI/BMR_{est}$  of 1.62 was found. Goldberg et al. (23) suggest that an average  $EI/BMR_{est}$  of 1.54 can be used as the cut-off limit for underreporting in populations above 2000 individuals. By use of this empirical approach, the present finding thus indicates that underreporting was not a major problem in this study.

In the comparison between the Inter99 population and the population from NDS 1995, differences were observed with respect to intake of total fat, saturated fat, alcohol, added sugar and dietary fibre. Differences in dietary intake between the studies may have numerous explanations, such as methodological differences in dietary assessment, changes in dietary patterns from 1995 to 1999 and differences in study populations.

The relatively low intake of added sugar in the Inter99 study compared with the NDS 1995 is probably caused by the fact that soft drinks, juice, some sweet products and some of the relatively new products, such as low-fat, carbohydrate-rich products and cider, were not included in the Inter99 FFQ. The exclusion of alcoholics in the Inter99 study could partly explain the relatively low alcohol intake in the Inter99 study compared with the NDS 1995. Moreover, it is assumed that alcohol consumption is underreported to a higher degree by use of dietary collection methods where long-term intake is reported (FFQ) compared with methods assessing the intake for only a few days (7 day food record). The higher intake of dietary fibre and lower intake of total and saturated fat in the Inter99 study may be due to differences in the choice of recipes used in the calculations of the diet, or to other methodological differences in the data collection method. The lower intake of fat in the Inter99 study may also reflect a time trend in the diet in the direction of greater availability and consumption of low-fat products (32). A time trend has also been observed for intake of fruit and vegetables from 1995 to 2001 (27, 29, 30). The limited number of questions regarding fruit, vegetables and juice may explain why the reported intake of fruit and vegetables in the Inter99 population did not reflect this time trend.

The Inter99 study offers an intervention based on lifestyle modification with diet, physical activity and smoking cessation to individuals at high risk of developing cardiovascular disease or diabetes. Hence, it is possible that those who were obese and overweight or had an unhealthy lifestyle were more likely to participate in the intervention programme for lifestyle modification than those who considered themselves to have a relatively healthy lifestyle (11, 33). This was also reflected by the mean BMI, which was 9% higher in the Inter99 population than in NDS 1995 (34). However, BMI in NDS 1995 was based on self-reported weight and height (34), and this would underestimate the true BMI. The representativeness of the Inter99 population has been studied by comparing morbidity in attenders versus non-attenders. This analysis revealed that attenders in the Inter99 study had lower morbidity based on hospitalizations than the whole invited population (33). This suggests that the Inter99 population is representative. However, owing to the higher response rate in

the 40–55-year-olds and a higher number of individuals invited at the age of 40–55 years (11) the dietary data may reflect the dietary intake of this part of the population to a higher degree.

In conclusion, it seems reasonable to suggest that the dietary intake of the Inter99 population is representative of the diet in the middle-aged Danish population. Reported dietary intake for the majority of this population met the recommendations for protein and n-3 fatty acids, but it did not meet the recommendations for total, saturated, monounsaturated and polyunsaturated fat, carbohydrate, dietary fibre, fish, fruit and vegetables. Because of limitations in data collection it was not possible to conclude whether the population met the recommendations with respect to intake of added sugar and alcohol. The dietary composition in the Inter99 population was in general not satisfactory compared with the Nordic and Danish dietary recommendations. For those groups that in general do not meet the recommendations, a problem may exist in their ability to maintain good health and to minimize the risk of diet-related illnesses.

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