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Quantity and Quality of Dietary Fat, Carbohydrate, and Fiber Intake in the German EPIC Cohorts

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Key Words
European Prospective Investigation into Cancer and Nutrition · Nutrient intake · Dietary recall, 24-hour · Fatty acids · Carbohydrates · Dietary fiber

Abstract
Aim: This evaluation aims to describe the quantity and quality of dietary fat, carbohydrate and fiber intake in both German cohorts participating in the European Prospective Investigation into Cancer and Nutrition (EPIC). ***Methods:*** Estimates are based on standardized computer-guided 24-hour dietary recalls from 1,078 women and 1,013 men in Heidelberg and 898 women and 1,032 men in Potsdam. In a subsample, plasma phospholipid (PL) fatty acids were analyzed as well. ***Results:*** Adjusted mean dietary intake estimates demonstrated that the contribution of fat as well as n–6 and n–3 polyunsaturated fatty acids (PUFA) to the total daily energy intake was higher in both women and men of EPIC-Potsdam compared to EPIC-Heidelberg. Surprisingly, the dietary n–6/n–3 PUFA ratio was lower in the Potsdam cohort. These results were confirmed by means of the PL fatty acid pattern. Besides the higher contribution of polysaccharides to total energy intake in EPIC-Heidelberg, women of the Heidelberg cohort revealed a significantly lower contribution of mono- and disaccharides (sucrose) to total energy intake. Although total fiber intake data were similar in both cohorts, analysis by food groups showed differences in dietary fiber intake originating from the food groups cereals, fruits and potatoes. ***Conclusion:*** The results demonstrate distinct differences in the dietary fat, carbohydrate and fiber intake between both German EPIC cohorts, which contribute to the exposure variation in the whole of EPIC.

Introduction

Diet has a major impact on modulating the risk and severity of a number of chronic diseases including cancer and coronary heart disease [1, 2]. Among the macronutrients, dietary fat has been studied extensively in recent decades, and both the quantity and quality of dietary fat intake have been considered [3]. Scientific knowledge on the role of fat and specific fatty acids is more advanced for coronary heart disease than for cancer [4–6]; thus, de-

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tailed recommendations on the quantity and quality of dietary fat intake have been made [7, 8]. Furthermore, the type of dietary carbohydrate, simple versus complex, might be important for disease risk. Through the development of obesity and insulin resistance, carbohydrate composition may indirectly affect a series of other diseases [9]. In addition, the type and amount of dietary fiber consumed may be of importance for the development of chronic diseases, though a lack of effect of dietary fiber in reducing the risk of colorectal cancer and the recurrence of colorectal adenomas has recently been noted [10–12]. This suggests a need to evaluate relevant components of dietary fiber that may affect disease risk. Unfortunately the available food composition data limit such attempts in dietary intake studies [13–15]. Consequently, knowledge on the most precisely assessed dietary intake level of the specific components of fat, carbohydrates and dietary fiber represents a prerequisite for valid risk estimation in epidemiological studies.

The present study evaluates the dietary intake data obtained in two German centers of the European Prospective Investigation into Cancer and Nutrition (EPIC), an international cohort study primarily aimed at the study of relationships between diet and the development of chronic diseases, particularly cancer [16, 17]. A comparative analysis of the food group intake data in both German cohorts revealed significant differences between the centers, e.g. for the intake of fruits, margarine, and wine [18], that might also result in differences in nutrient intake. In a first paper we reported on the intake of macronutrients, vitamins and minerals in the German EPIC cohorts [19]. In continuation of this work, this paper presents the results of a detailed analysis of the intake of dietary fat and fatty acids as well as different types of carbohydrates and fiber. In order to confirm the differences observed at the dietary intake level, the fatty acid intake results are compared to the plasma phospholipid (PL) fatty acid composition in a subpopulation.

Subjects and Methods

Two German cohorts, one in Potsdam and one in Heidelberg, contribute to the EPIC multi-center cohort study which consists of over 500,000 study participants from 10 different European countries [17]. EPIC has been implemented to further elucidate the association between diet and chronic disease, particularly cancer. Country-specific dietary assessment tools were applied to obtain dietary information in EPIC. To overcome methodological differences between study centers, it was necessary to calibrate the dietary assessment methods. As a calibration method, 24-hour dietary recalls were applied to a representative subsample of each EPIC cohort [20].

In Germany, dietary assessment of the entire cohorts by means of an identical self-administered food frequency questionnaire, a computerized lifestyle interview, and anthropometric measurements, was carried out between June 1994 and October 1998 in Heidelberg, and between August 1994 and September 1998 in Potsdam [16]. Additionally, 24-hour dietary recalls were obtained from a subsample (about 7%) of each study population between June 1996 and October 1998 in Heidelberg and between June 1996 and April 1998 in Potsdam using the software EPIC-SOFT [21]. In total, 2,121 recalls (1,033 from men, 1,088 from women) were obtained in Heidelberg and 2,173 recalls (1,163 from men, 1,010 from women) in Potsdam, which was about 91% of those approached in Heidelberg and 95% of those approached in Potsdam. The technique of computer-guided (EPIC-SOFT) face-to-face-interviews carried out by trained staff ensured a high degree of standardization and, therefore, good comparability of the results between centers. EPIC-SOFT was developed by the International Agency for Research on Cancer (Lyon, France) in cooperation with all EPIC study centers [22, 23]. Nutrient intake was calculated based on the German Nutrient Data Base BLS, version II.3 (BgVV, Berlin, Germany). Analysis of the food groups contributing substantially to the dietary fiber intake was done using the EPIC-SOFT food group definition.

All women aged 35–64 years and men aged 40–64 years were included in the present analysis. Due to the low number of recalls obtained on Fridays in Heidelberg, all Friday recalls were excluded. Finally, 24-hour recalls from 1,013 men and 1,078 women from Heidelberg and 1,032 men and 898 women from Potsdam were analyzed. The distribution of study subjects according to age and anthropometric data is given in table 1.

All anthropometric measurements followed standardized procedures [24]. Body height was measured to the nearest millimeter, body weight to the nearest 100 g using a digital scale, and body mass index (BMI) was calculated as body weight in kilograms divided by the square of body height in meters. Basal metabolic rate (BMR) was calculated based on the formulas of Schofield [25]. Energy intake was then divided by the estimated BMR to obtain a measure of relative energy intake that accounted for body weight and age.

According to standard procedures, plasma PL fatty acid analysis was performed in a randomly selected subsample consisting of 97 women and 95 men from Potsdam and 96 women and 95 men from Heidelberg [26]. Briefly, after lipid extraction (Folch-Sperry extract) phospholipids were purified by means of solid phase extraction, followed by transesterification. Fatty acid methyl ester (FAME) composition was determined by capillary gas chromatography with flame ionization detection.

Means, standard deviations, and medians were calculated for each study center stratified by sex. All descriptive measures for nutrient intake were adjusted for the day of the week recorded and the age of the participants. The age distribution of the general German population for 1996 provided by the Federal Statistical Office [27] was taken as standard.

The statistical significance of differences between the Potsdam and Heidelberg cohorts was tested using Student's two-sided t test for independent samples and the Mann-Whitney two-sided nonparametric test. Calculation of the weighting factor was performed using SAS System® for Windows™ (Release 8.00, SAS Institute Inc., Cary, N.C., USA). All other statistical calculations were performed by means of SPSS® for Windows™ Release 8.0.0 (SPSS Inc., Chicago, Ill., USA).

Table 1. Number and selected characteristics (mean ± SD) of women and men in the EPIC-Potsdam and EPIC-Heidelberg cohorts included in the dietary evaluation (24-hour recalls)

	Potsdam		Heidelberg	
	Women	Men	Women	Men
Number of subjects	898 (99)	1,032 (96)	1,078 (96)	1,013 (95)
Age, years	53 ± 8 (54 ± 6)	55 ± 7 (54 ± 6)	50 ± 9 (54 ± 5)	52 ± 7 (54 ± 6)
Age range, years	35–64 (44–64)	40–64 (44–63)	35–64 (45–64)	40–65 (45–64)
Weight, kg	70 ± 13 (67 ± 10)	83 ± 12 (84 ± 12)	68 ± 13 (70 ± 13)	83 ± 13 (83 ± 12)
Height, cm	162 ± 6 (162 ± 5)	175 ± 7 (175 ± 6)	164 ± 6 (163 ± 4)	176 ± 7 (176 ± 7)
BMI, kg/m^2	26.4 ± 4.6 (25.6 ± 3.7)	27.2 ± 3.6 (27.3 ± 3.6)	25.2 ± 4.8 (25.7 ± 4.9)	26.7 ± 3.7 (26.3 ± 3.4)
EI/BMR	1.30 ± 1.25 (1.32 ± 0.38)	1.44 ± 1.39 (1.37 ± 0.57)	1.35 ± 1.30 (1.37 ± 0.52)	1.39 ± 1.34 (1.45 ± 0.54)

The corresponding data of the subgroup selected for additional plasma phospholipid fatty acid analysis are given in parentheses. BMI = Body mass index; EI = energy intake; BMR = basal metabolic rate (calculated according to the formula of Schofield [25]).

Results

A higher mean energy intake was reported by men in EPIC-Potsdam than by their Heidelberg counterparts, while the opposite was true for women (table 2).

Regarding total fat intake (g/d), the results for both centers were comparable in women but not in men; men from EPIC-Potsdam revealed a significantly higher total fat intake (table 2). Similar results were obtained for the intake of saturated fatty acids and monounsaturated fatty acids. When expressed as percentage of total energy intake, the contribution of fat was significantly higher in both genders in the Potsdam cohort as compared to the Heidelberg cohort, particularly in men (40.3 versus 36.0% energy).

With regard to polyunsaturated fatty acids (PUFA), both a higher intake of n–6 PUFA (linoleic acid, 18:2 n–6) and n–3 PUFA (α-linolenic acid, C18:3 n–3, and eicosapentaenoic acid, C20:5 n–3) were observed in EPIC-Potsdam. In addition, the n–6/n–3 ratio was found to be lower in EPIC-Potsdam. These statistically significant differences were more pronounced in men than in women and independent of the chosen unit (g/d or % of total energy intake; table 2; fig. 1).

The results of the plasma PL fatty acid analysis confirmed the dietary n–3 PUFA intake results (table 3). The mean proportion (% FAME) of n–3 PUFA, eicosapentaenoic acid (C20:5 n–3), and docosahexaenoic acid (C22:6 n–3) were found to be significantly higher in women and men of the Potsdam cohort as compared to their Heidelberg counterparts, while the n–6/n–3 PUFA ratio was lower. However, no significant differences in plasma PL existed for linoleic acid (C18:2 n–6). The dietary intake results obtained from this subgroup were very close to the data for the whole group (data not shown). For better comparison, the fatty acid intake data were expressed in terms of percent of total fatty acid intake (table 3). Since the PL analysis was only performed for a smaller sample size, some differences between both centers (as found for the whole group) did not reach statistical significance. Yet significant results were obtained for the pooled (both genders) dietary intake data of n–6 PUFA, linoleic acid, n–3 PUFA, and α-linolenic acid. Notably, the lower dietary n–6/n–3 PUFA ratio found for female and male participants of the Potsdam cohort were confirmed by the results of plasma PL analysis.

Total carbohydrate intake (g/day) was not significantly different between centers, either in women or in men (table 2). Expressed in terms of its contribution to the total energy intake, carbohydrate intake was significantly higher in Heidelberg men and Potsdam women as compared to their sex-specific counterparts. Regarding carbohydrate subgroups, a significantly higher intake of polysaccharides was found in women and men of EPIC-Heidelberg than of EPIC-Potsdam (fig. 2). Concomitantly, women of the Heidelberg cohort revealed a lower intake of mono- and disaccharides (sucrose) than women of the Potsdam cohort.

The intake of dietary fiber and fiber subgroup showed no sex-specific differences between both German EPIC centers (table 4). Nevertheless, analysis of fiber intake by the main fiber-providing food groups revealed significant differences between the cohorts in Heidelberg and Potsdam. With consumption of fruits and potatoes, women and men in EPIC-Potsdam ingested more water-soluble (pectin) and water-insoluble dietary fiber (hemicelluloses, cellulose, lignin) than their Heidelberg counterparts. In the EPIC-Heidelberg cohort, however, the intake of dietary fiber originating from cereals and cereal products is distinctly higher than in EPIC-Potsdam.

Table 2. Adjusted[a] daily intake (mean, SD, median) of energy, fat, fatty acids, and carbohydrates in women and men in the EPIC-Potsdam and EPIC-Heidelberg cohorts as assessed by 24-hour recalls

	Women							Men						
	Potsdam (n = 898)			Heidelberg (n = 1,078)			p	Potsdam (n = 1,032)			Heidelberg (n = 1,013)			p
	mean	SD	median	mean	SD	median		mean	SD	median	mean	SD	median	
Total energy, kJ	7,537	2,568	7,225	7,860	2,759	7,548	b, c	10,719	3,550	10,438	10,387	3,806	9,980	b, c
kcal	1,801	614	1,727	1,879	659	1,804		2,562	848	2,495	2,483	910	2,385	
Total fat, g	76.1	34.5	73.1	78.0	38.0	73.7		116.8	51.5	111.1	100.9	48.1	94.3	b, c
% energy	37.4	9.6	37.6	36.6	9.1	36.8	c	40.3	9.5	40.7	36.0	9.4	36.5	b, c
Short-chain FA, g	1.7	1.3	1.5	2.0	1.4	1.8	b, c	2.3	2.0	1.7	2.2	1.7	1.8	
Medium-chain FA, g	1.5	1.0	1.3	1.6	1.1	1.5	b, c	2.1	1.4	1.8	1.9	1.4	1.7	b, c
SFA, g	31.9	16.1	29.8	33.7	17.9	31.0	b, c	48.1	23.7	43.6	42.4	22.7	38.6	b, c
% energy	15.6	5.1	15.2	15.7	5.1	15.6		16.5	5.2	16.0	15.1	5.0	14.8	b, c
MUFA, g	25.6	12.4	23.5	26.5	14.1	24.4		39.8	18.3	37.3	35.3	18.3	32.5	b, c
% energy	12.6	3.8	12.4	12.3	3.8	12.2		13.7	3.7	13.8	12.6	4.0	12.5	b, c
n–6 PUFA, g	11.7	7.6	10.1	11.0	9.3	9.2	c	18.8	12.8	16.2	14.5	10.5	12.2	b, c
% energy	5.8	3.1	5.3	5.3	3.3	4.5	b, c	6.5	3.5	6.2	5.3	3.0	4.6	b, c
C18:2 n–6, g	11.6	7.6	9.7	10.9	9.3	9.1	c	18.6	12.8	15.9	14.3	10.4	11.9	b, c
C20:4 n–6, g	0.14	0.16	0.10	0.16	0.19	0.10	b	0.23	0.25	0.17	0.23	0.25	0.15	
n–3 PUFA, g	1.72	1.07	1.51	1.53	1.08	1.29	b, c	2.59	1.96	2.22	1.88	1.28	1.59	b, c
% energy	0.88	0.52	0.78	0.74	0.45	0.64	b, c	0.91	0.58	0.81	0.69	0.45	0.59	b, c
C18:3 n–3, g	1.51	0.94	1.35	1.32	0.92	1.15	b, c	2.25	1.65	2.02	1.59	1.04	1.40	b, c
C20:5 n–3, g	0.08	0.23	0.01	0.07	0.23	0.01	c	0.13	0.38	0.02	0.10	0.30	0.02	b, c
C22:6 n–3, g	0.14	0.28	0.04	0.14	0.33	0.04		0.21	0.49	0.05	0.19	0.48	0.05	
n–6/n–3 ratio	7.21	3.73	6.59	7.99	5.59	6.95	b	7.69	4.05	7.07	8.55	5.03	7.57	b, c
MUFA/SFA	0.84	0.28	0.79	0.82	0.25	0.77	c	0.86	0.22	0.83	0.88	0.31	0.83	
PUFA/SFA	0.49	0.30	0.43	0.46	0.39	0.35	c	0.51	0.30	0.47	0.45	0.31	0.37	b, c
Total carbohydrates, g	196.0	77.9	189.0	198.6	76.1	188.9		242.2	87.8	232.4	247.3	107.4	231.9	
% energy	43.9	10.6	43.4	43.0	10.2	42.6	b, c	38.5	9.4	37.5	40.2	9.9	39.7	b
Monosaccharides, g	38.3	24.3	34.2	37.6	24.7	32.4		40.7	31.1	33.2	41.7	33.3	34.3	
% energy	8.8	5.6	7.7	8.3	5.2	7.4	b, c	6.6	5.1	5.4	6.9	4.7	5.9	
Glucose, g	16.2	11.0	14.1	15.9	10.8	13.4		17.4	15.4	13.7	18.1	15.7	14.0	
Fructose, g	21.5	14.3	19.1	21.0	14.6	18.0		22.8	17.5	18.5	22.8	18.5	18.7	
Disaccharides, g	65.7	41.8	56.7	62.4	42.0	54.2		68.9	45.1	58.7	68.3	55.8	54.9	
% energy	14.5	7.7	13.3	13.2	6.9	12.1	b, c	10.8	6.1	9.7	10.7	6.4	9.7	
Sucrose, g	55.0	37.9	46.6	51.5	39.4	42.7	b, c	57.0	41.9	46.4	56.8	52.2	45.0	
% energy	12.1	7.3	11.0	10.9	6.6	9.7	b, c	8.9	5.7	8.0	8.8	6.0	7.8	
Lactose, g	9.6	10.5	5.9	9.6	10.0	6.4		8.9	11.1	4.8	8.8	10.5	5.1	
Maltose, g	1.1	2.9	0.7	1.3	2.8	0.8		3.1	6.1	2.2	2.7	5.7	1.9	c
Oligosaccharides[d], g	1.9	5.0	0.5	2.9	7.4	0.6	b, c	12.4	17.5	3.5	11.5	18.8	1.1	c
% energy	0.4	1.2	0.1	0.6	1.2	0.1	b, c	1.9	2.5	0.4	1.8	2.6	0.2	
Polysaccharides, g	88.1	40.1	83.5	93.8	39.5	88.7	b, c	118.3	47.6	112.9	124.4	57.5	115.6	b, c
% energy	19.7	6.7	19.1	20.5	6.8	19.8	b, c	18.9	5.7	18.5	20.6	7.4	19.9	b, c

FA = Fatty acids; SFA = saturated FA; MUFA = monounsaturated FA; PUFA = polyunsaturated FA.

a Adjusted for age (according to the population of the Federal Republic of Germany, December 31, 1996) and weekday.

b Significantly different means in Potsdam and Heidelberg ($p < 0.05$) using Student's t test for independent samples.

c Significantly different distributions between Potsdam and Heidelberg ($p < 0.05$) using the Mann-Whitney test.

d Absorbable oligosaccharides.

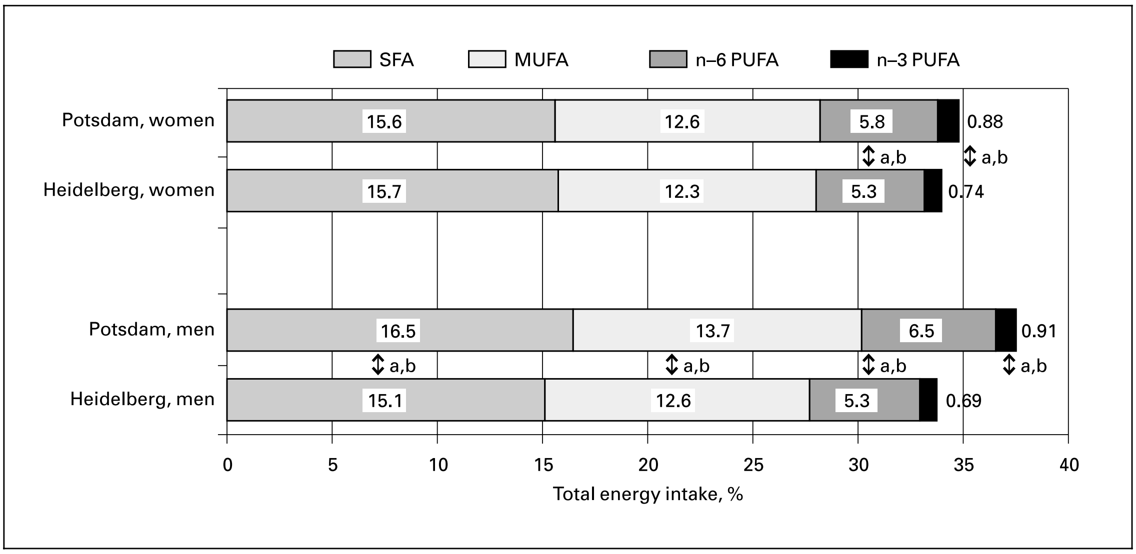

Fig. 1. Mean daily intake of fatty acid families, expressed as percent of total energy intake, as reported by women and men of the German EPIC cohorts in Potsdam and Heidelberg (assessed by 24-hour dietary recalls). [a] Significantly different means between centers, $p < 0.05$, t test. [b] Significantly different between centers, $p < 0.05$, Mann-Whitney test.

Table 3. Plasma phospholipid fatty acid composition (% FAME, mean ± SD) of a subgroup of women (n = 97) and men (n = 95) in EPIC-Potsdam and women (n = 96) and men (n = 95) in EPIC-Heidelberg as compared to their dietary intake estimates (24-hour recall) of the corresponding fatty acids and fatty acid families (% of total fatty acid intake)

	SFA	MUFA	n–6 PUFA	C18:2 n–6	C20:4 n–6	n–3 PUFA	C18:3 n–3	C20:5 n–3	C22:6 n–3	n–6/n–3 PUFA
Women										
Plasma phospholipid fatty acids, % FAME										
Potsdam	40.5 ± 1.1	12.5 ± 1.6	39.1 ± 2.7	22.8 ± 3.1	11.8 ± 1.7	7.7 ± 2.2[a]	0.22 ± 0.07	1.4 ± 1.0[a]	5.0 ± 1.4[a]	5.5 ± 1.6[a]
Heidelberg	40.6 ± 1.2	12.5 ± 1.7	39.7 ± 2.6	22.7 ± 2.8	12.2 ± 2.0	7.0 ± 1.8	0.20 ± 0.08	1.1 ± 0.7	4.6 ± 1.2	6.0 ± 1.6
Dietary fatty acid intake, % of total fatty acid intake										
Potsdam	45.1 ± 8.7	35.7 ± 4.6	16.5 ± 7.9	16.3 ± 7.9	0.22 ± 0.25	2.6 ± 1.2	2.1 ± 0.7	0.15 ± 0.37	0.27 ± 0.54	7.0 ± 4.0
Heidelberg	47.4 ± 8.4	35.5 ± 5.0	14.9 ± 8.9	14.7 ± 8.9	0.20 ± 0.19	2.2 ± 0.9	1.9 ± 0.6	0.09 ± 0.31	0.20 ± 0.40	7.5 ± 4.8
Men										
Plasma phospholipid fatty acids, % FAME										
Potsdam	41.4 ± 0.9	13.1 ± 1.9	38.0 ± 2.7[a]	22.5 ± 2.9	11.2 ± 1.9[a]	7.2 ± 1.6[a]	0.23 ± 0.10	1.3 ± 0.6[a]	4.6 ± 1.1[a]	5.5 ± 1.4[a]
Heidelberg	41.2 ± 1.2	12.8 ± 1.7	39.3 ± 2.5	22.8 ± 3.4	11.9 ± 2.1	6.4 ± 1.3	0.20 ± 0.09	1.1 ± 0.5	4.0 ± 0.9	6.4 ± 1.5
Dietary fatty acid intake, % of total fatty acid intake										
Potsdam	43.4 ± 8.3	36.5 ± 5.3	17.6 ± 8.0[a]	17.4 ± 8.0	0.22 ± 0.26	2.4 ± 1.0[a]	2.2 ± 0.9[a]	0.08 ± 0.18	0.15 ± 0.30	7.8 ± 3.6
Heidelberg	44.6 ± 9.0	37.5 ± 6.1	15.6 ± 8.1	15.3 ± 8.1	0.25 ± 0.25	2.1 ± 1.3	1.6 ± 0.5	0.17 ± 0.56	0.31 ± 0.74	8.6 ± 5.2
Total										
Plasma phospholipid fatty acids, % FAME										
Potsdam	41.0 ± 1.1	12.8 ± 1.8	38.5 ± 2.7[a]	22.6 ± 3.0	11.5 ± 1.8[a]	7.5 ± 1.9[a]	0.22 ± 0.08[a]	1.3 ± 0.8[a]	4.8 ± 1.3[a]	5.5 ± 1.5[a]
Heidelberg	40.9 ± 1.2	12.6 ± 1.7	39.5 ± 2.6	22.8 ± 3.1	12.0 ± 2.0	6.7 ± 1.6	0.20 ± 0.08	1.1 ± 0.6	4.3 ± 1.1	6.2 ± 1.5
Dietary fatty acid intake, % of total fatty acid intake										
Potsdam	44.2 ± 8.5	36.1 ± 4.9	17.1 ± 8.0[a]	16.8 ± 8.0[a]	0.22 ± 0.25	2.5 ± 1.1[a]	2.2 ± 0.8[a]	0.12 ± 0.29	0.21 ± 0.44	7.4 ± 3.8
Heidelberg	46.0 ± 8.8	36.5 ± 5.7	15.2 ± 8.5	15.0 ± 8.5	0.23 ± 0.23	2.1 ± 1.1	1.8 ± 0.5	0.13 ± 0.45	0.25 ± 0.59	8.0 ± 5.0

SFA = Saturated fatty acids; MUFA = monounsaturated fatty acids; PUFA = polyunsaturated fatty acids; FAME = fatty acid methyl esters.

[a] Significantly different means in Potsdam and Heidelberg ($p < 0.05$) using Student's t test for independent samples.

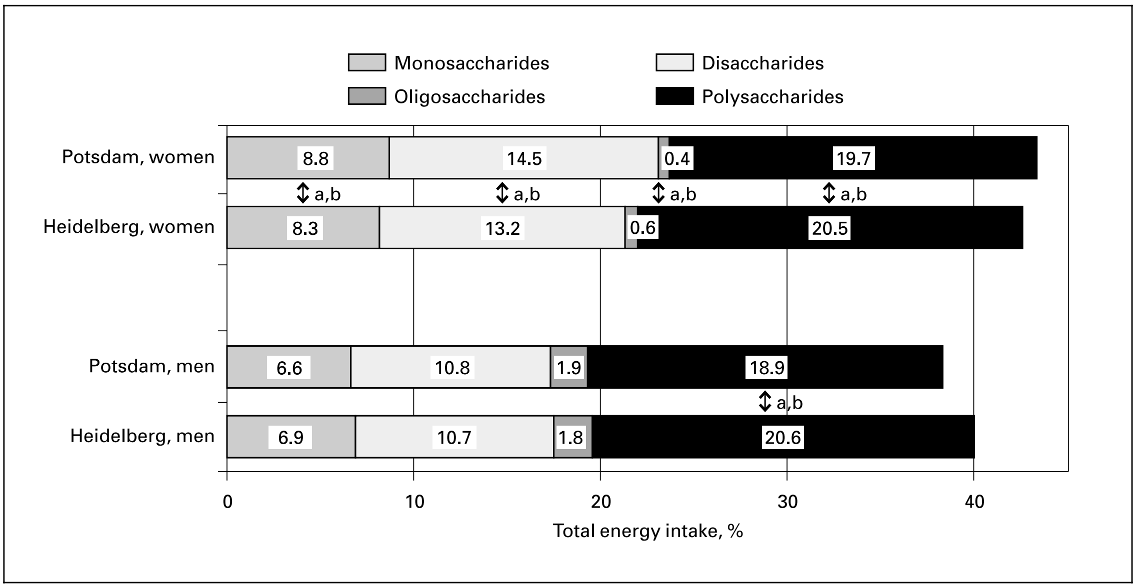

Fig. 2. Mean daily intake of carbohydrate families, expressed as percent of total energy intake, as reported by women and men of the German EPIC cohorts in Potsdam and Heidelberg (assessed by 24-hour dietary recalls). [a] Significantly different means between centers, $p < 0.05$, t test. [b] Significantly different between centers, $p < 0.05$, Mann-Whitney test.

Discussion

The present report focuses on quantitative and qualitative aspects of dietary fat and fatty acid, carbohydrate, and fiber intake in both German EPIC cohorts, located in Potsdam and Heidelberg. The applied assessment method – highly standardized 24-hour recalls – in combination with the German nutrient database BLS II.3 should allow a valid nutrient intake estimation at the group level for both cohorts. While results of a single 24-hour recall provide valid estimates of mean intake, the reader has to be aware that the descriptive variation measures given here do not reflect the true underlying variation of the usual nutrient intake in the group. Rather, it reflects the variation of nutrient intake of 1 day across the population [28].

Adjustment for age as well as week day enables direct comparison of the sex-specific results obtained in both EPIC centers. However, there are several methodological aspects that might have an impact on the direct comparability of the data from both studies, such as an interviewer effect or the unequal distribution of the recalls over all seasons [18, 19]. An important but as yet unsolved problem is the possibility of underreporting in 24-hour recalls. Since it has been shown that the ratio of energy intake (EI) to BMR (EI/BMR) is inversely related to obesity [29]; the given EI/BMR (table 1) ratio in combination with the relative body weight (BMI) suggests a higher proportion of underreporting in women from EPIC-Potsdam than Heidelberg. Underestimation of energy intake strongly affects absolute macronutrient intake data, an effect that was not observed with the energy-adjusted (residual method) data [29, 30]. Although energy adjustment by means of the energy density method, i.e. expressing intake data in percent of total energy intake, cannot completely eliminate this effect of underreporting, this common method was applied to the present data (indicated as percent energy in the tables and figures).

Due to the higher total fat intake, men of the Potsdam cohort revealed significantly higher intake values of both fatty acid families, saturated fatty acids and monounsaturated fatty acids, than found for EPIC-Heidelberg men. When expressed in terms of percent of total fatty acids, significant differences were no longer observed (see the results for the subgroup, table 3). On average, both cohorts exceeded the intake recommendations for total fat and saturated fatty acids [7, 8]. Although the mean energy intake data reported in the German Nutrition Survey 1998 [31] was in the range found here, the intake of fat (and its contribution to energy intake) was distinctly higher in the EPIC cohorts, while the opposite was found for carbohydrates and protein. However, the German

Table 4. Adjusted[a] total daily intake of dietary fiber and fiber subgroups as well as dietary fiber intake by food groups (providing >1 g total dietary fiber/day) in women and men in the EPIC-Potsdam and EPIC-Heidelberg cohorts as assessed by 24-hour recalls

	Women							Men						
	Potsdam (n = 898)			Heidelberg (n = 1,078)			p	Potsdam (n = 1,032)			Heidelberg (n=1,013)			p
	mean	SD	median	mean	SD	median		mean	SD	median	mean	SD	median	
Total intake, g/day														
Total dietary fiber	19.4	8.2	18.2	19.6	9.0	18.4		21.9	9.2	20.5	21.8	11.5	19.9	
Pectin	6.3	2.8	5.9	6.5	3.0	6.1		7.4	3.2	7.0	7.4	4.1	6.7	
Hemicellulose	7.5	3.3	7.1	7.6	3.6	7.0		8.4	3.7	7.8	8.5	4.5	7.6	
Cellulose	4.4	2.2	4.1	4.4	2.2	4.1		4.9	2.4	4.5	4.8	3.0	4.3	b
Lignin	1.1	1.1	0.9	1.1	1.2	0.8		1.1	0.9	0.8	1.1	1.1	0.8	
Total dietary fiber intake by food group, g/day														
Vegetables	3.51	3.84	2.48	3.50	3.32	2.70		3.14	3.22	2.28	3.33	3.90	2.27	
Potatoes	1.71	2.27	0.35	1.36	2.07	0.00	b, c	2.45	3.19	1.24	1.69	2.53	0.00	b, c
Fruits	4.64	4.54	3.35	4.37	5.10	3.20	c	4.50	4.88	3.20	3.65	5.32	1.89	b, c
Cereals	6.39	4.26	5.61	7.17	4.65	6.25	b, c	8.31	5.17	7.28	9.24	6.25	7.90	b, c
Cakes	1.13	1.84	0.00	1.21	1.90	0.00		1.27	2.35	0.00	1.33	2.80	0.00	
Water-soluble fiber (pectin) intake by food group, g/day														
Vegetables	0.99	1.34	0.56	0.95	1.06	0.59		0.87	1.05	0.53	0.90	1.24	0.49	
Potatoes	0.52	0.69	0.11	0.41	0.63	0.00	b, c	0.74	0.96	0.37	0.51	0.77	0.00	b, c
Fruits	1.46	1.54	1.05	1.41	1.72	0.93		1.40	1.62	0.88	1.16	1.79	0.64	b, c
Cereals	2.50	1.57	2.21	2.74	1.69	2.47	b, c	3.41	2.05	3.03	3.65	2.38	3.14	b, c
Cakes	0.39	0.63	0.00	0.43	0.67	0.00		0.42	0.72	0.00	0.46	0.88	0.00	
Water-unsoluble fiber intake by food group, g/day														
Vegetables	2.52	2.62	1.86	2.56	2.38	1.97		2.26	2.34	1.63	2.43	2.80	1.68	
Potatoes	1.19	1.59	0.25	0.95	1.44	0.00	b, c	1.71	2.23	0.86	1.18	1.76	0.00	b, c
Fruits	3.18	3.13	2.44	2.96	3.50	2.21	c	3.09	3.35	2.44	2.49	3.62	1.25	b, c
Cereals	3.88	2.76	3.30	4.44	3.06	3.71	b, c	4.90	3.20	4.23	5.60	3.96	4.68	b, c
Cakes	0.74	1.23	0.00	0.78	1.224	0.00		0.84	1.70	0.00	0.88	1.98	0.00	

[a] Adjusted for age (according to the population of the Federal Republic of Germany, December 31, 1996) and weekday.
[b] Significantly different means in Potsdam and Heidelberg ($p < 0.05$) using Student's t test for independent samples.
[c] Significantly different distributions between Potsdam and Heidelberg ($p < 0.05$) using the Mann-Whitney non-parametric test.

MONICA studies in Augsburg and Erfurt [32, 33] and the NVS/VERA study [34] reported estimates of the percent contribution of macronutrients to energy intake similar to the results presented here. Although the German EPIC cohorts do not reflect representative population samples, the cohorts represent possibly health conscious groups which most likely consider a healthy diet as important in their daily lives and therefore represent the target groups for public health intervention. The limitations in comparisons with results of other German studies were discussed in detail by Schulze et al. [19].

Several reports have described the striking increase in margarine consumption in former East Germany after the reunification which remained high in the following years [32, 33, 35–38]. In the two German EPIC cohorts with their dietary assessment periods between 1996 and 1998, a comparably large difference in margarine intake was found, e.g. the mean margarine consumption in men amounted to 36.8 and 7.6 g/day in EPIC participants in Potsdam and Heidelberg, respectively [18]. However, added fats and oils are only one of several main sources of dietary lipids. The results presented here on the nutrient level include all fatty acids regardless of the food source. They indicate a higher intake of linoleic acid and n–6 PUFA in EPIC-Potsdam which might, at least partly, reflect the high content of linoleic acid in plant-derived margarines (no addition of animal fat due to German legislation). Consequently, a higher ratio of n–6/n–3 PUFA would be expected. However, EPIC participants from Potsdam also revealed a significantly higher intake of n–3 PUFA, and thus surprisingly ending up with significantly lower n–6/n–3 PUFA ratios as compared to the Heidelberg cohort. This is an important result because of the ongoing discussion about the effect of a high intake of margarine and linoleic acid intake on the development of atopic diseases which showed distinctly increasing prevalence rates in East Germany after the reunification [37, 39]. The relation of both PUFA families in the diet has gained increasing attention due to their known metabolic interactions [1]. Consequently, the ratio of both PUFA families is considered in the PUFA intake recommendations as well. The German Nutrition Society [8] recommends a dietary n–6/n–3 PUFA ratio of <5/1. Although the mean intake data of n–6 and n–3 PUFA met or even exceeded the recommendations for each of the PUFA families [8], the desirable relation of n–6 and n–3 PUFA in the diet was not achieved in either cohort. Due to the dietary intake and the plasma PL results (see below), women and men of EPIC-Potsdam were closer to the recommendation than those of EPIC-Heidelberg.

In another investigation the dietary ratio of n–6/n–3 PUFA was estimated to be near 5/1 and to be higher for eastern than for western Germany [37] while the dietary intake of n–6 and n–3 fatty acids was higher in the former East Germany as compared to the former West Germany. In contrast to the present study, the calculations were based on food group consumption data and their mean fatty acid content.

In order to certify the dietary intake results, a valid biomarker of fatty acid intake, plasma PL fatty acid pattern [40, 41] was analyzed. The analytical results confirmed the dietary n–6/n–3 PUFA ratio estimates (table 3). However, the linoleic acid content of plasma PL shows rather low variation and hardly reflects small dietary modifications in linoleic acid intake [42, 43]. Accordingly, a significant difference in the linoleic acid content of plasma PL between the cohorts was neither found in men nor in women. In combination with the significantly lower arachidonic acid portion, the n–6 PUFA content in plasma PL was even significantly lower in men in EPIC-Potsdam as compared to men in EPIC-Heidelberg.

Except for linoleic acid, plasma PLs are sensitive to alterations in PUFA intake including α-linolenic acid, arachidonic acid, and especially eicosapentaenoic acid and docosahexaenoic acid [41, 43, 44]. Both latter fatty acids showed a higher portion in the plasma PL of the Potsdam cohort, reflecting a higher consumption of fish and marine products than found in the Heidelberg cohort [18]. If the traditionally higher fish intake on Fridays is more likely in Heidelberg, one might argue that exclusion of Friday recalls would lead to the observed differences in fatty acid intake, especially of eicosapentaenoic and docosahexaenoic acid (n–3 PUFA). However, when Friday recalls were included or excluded in a non-weighted analysis for both centers, no distinct differences in fatty acid intake were found.

With mean carbohydrate intake values of around 40% of total energy intake (men) or slightly above (women), intake recommendations [8] were not reached by either gender or cohort. Significant differences between both study centers were found for the total group of carbohydrates and also for the intake of polysaccharides in both genders with higher mean intake values in EPIC-Heidelberg. Since the energy-providing nutrients affect each other when controlled for energy intake [28], a lower contribution of fat to the total energy intake as found in EPIC-Heidelberg is consistent with a higher contribution of carbohydrate and/or protein intake. A significantly lower mean intake in EPIC-Heidelberg was also found for monosaccharides, disaccharides (sucrose), and oligosaccharides in women.

The perception of the role of added sugars on health has substantially changed from the past. While unfavorable health effects have long been linked to a high intake of added sugars, this view has been revised in the last 10 years. Except for dental caries, added sugar consumption was declared not to be causal in the development of other chronic diseases [45]. However, the discussion is still ongoing [9, 46]. Sucrose is quantitatively the most important disaccharide added to foodstuffs. For West Germany, the proportion of added sucrose was estimated to be 75–85% of the total sucrose intake; sucrose contributed 80–90% to the total disaccharide intake [47]. In the present investigation, the observed difference in disaccharide intake between women of both cohorts was due to differences in sucrose intake. On average, the difference between women from EPIC-Potsdam and EPIC-Heidelberg amounted to 1.2% of energy intake (4.5 g/day). Mean sucrose intake in both cohorts exceeded the reported average found in the German National Food Consumption Survey [47].

The recommendation of a high consumption of food rich in polysaccharides (starch) – and concomitantly rich in dietary fiber – is mainly based on the reported negative effects of an otherwise high contribution of (saturated) fat to the total energy intake which has been shown to be associated with the risk of chronic diseases, in particular cardiovascular disease [8]. However, it is becoming clearer that – together with a different composition of dietary fat – the composition of dietary carbohydrates is also relevant for the development of chronic diseases, such as obesity and insulin resistance [9]. The food composition table used in the present study provide a series of subgroups for carbohydrates (table 2), but information on the glycemic index is lacking.

As pointed out in the literature [13, 15], the presently used definition of dietary fiber is confusing and not suitable for valid evaluation of the role of non-digestible food components in (colorectal) cancer etiology and other chronic diseases. Most of the dietary fiber in Western diets is in the form of plant cell walls, but these vary in their composition and presumably in their health effects. For example, plant cell walls containing suberin or lignin may be most protective in carcinogenesis [48]. Therefore, epidemiological research on the role of dietary fiber in disease etiology should be based on the most refined description of dietary fiber intake further stratified by food source. In this context there is clearly a need for more detailed information on dietary fiber components in food composition tables.

In the present analysis, dietary fiber intake data revealed no differences between cohorts; this is also true for the different kinds of dietary fiber available in the food composition tables (table 4). However, when analyzing the contribution of different food groups to the dietary fiber intake, distinct differences between EPIC-Heidelberg and EPIC-Potsdam were observed. In the Heidelberg cohort, more dietary fiber is provided by cereals and cereal products, while the Potsdam cohort consumed more dietary fiber originating from the food groups fruits and potatoes. These differences in the fiber intake results reflect the differences observed at the food group intake level [18]. No information can be given on the intake of resistant starch.

In conclusion, the present results demonstrate differences in the quantity and quality of dietary fat intake between the EPIC cohorts in Potsdam and Heidelberg. The reported dietary fatty acid intake could be largely verified by means of plasma PL fatty acid composition data. Most interestingly, a lower n–6/n–3 PUFA ratio in EPIC Potsdam was observed. Differences between both German EPIC centers were also apparent for the dietary intake of carbohydrate subgroups, while in the case of dietary fiber differences were only visible after further subgrouping by food groups (e.g. cereals). In light of the differing physiologic effects of various types of carbohydrates and dietary fiber, there is a need for the inclusion of further food characteristics in food composition tables, such as the glycemic index or resistant starch, or the detailed description of the dietary fiber intake by food sources.

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