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ORIGINAL CONTRIBUTION

Annika Reinert
Sabine Rohrmann
Nikolaus Becker
Jakob Linseisen

Lifestyle and diet in people using dietary supplements

A German cohort study

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A. Reinert · S. Rohrmann · N. Becker
Priv.-Doz. Dr. J. Linseisen (✉)
German Cancer Research Centre
Division of Cancer Epidemiology
Im Neuenheimer Feld 280
69120 Heidelberg, Germany
Tel.: +49-6221/42-2363
Fax: +49-6221/42-2203
E-Mail: j.linseisen@dkfz.de

Summary *Background* The use of dietary supplements is often associated with a healthy lifestyle. Due to high variation in supplementation practice by country, these associations will be investigated in a large German cohort study. *Aim of the study* To describe the prevalence of dietary supplement use in the EPIC-Heidelberg cohort and to illuminate differences in health-relevant characteristics between regular users and non-users. *Methods* At cohort recruitment, 13,615 women aged 35–65 and 11,929 men aged 40–65 were asked for regular dietary supplementation over the past year. *Results* Regular use of any supplement was reported by 47% of the women and 41% of the men, vitamin or mineral supplements were taken by 40% and 33%, respectively. The use of vitamin and/or mineral supplements was significantly associated with higher age, being non- or ex-smoker, lower BMI, higher physical leisure time activity, and higher educational level. After adjustment for these factors, we observed positive associations between supplement use and the consumption of milk, milk products, and fish as well as the intake of vitamin C and β-carotene. In contrast, the supplement use was related to lower meat and meat product consumption, saturated fat intake, and $n6/n3$-fatty acid ratio in the diet, both in women and men. Except for Hemoccult® testing in women, no association with participation in cancer screening was observed. *Conclusions* The high prevalence of supplement use in EPIC-Heidelberg was associated with several presumably healthier lifestyle and diet characteristics. This needs to be considered in further evaluations of the risk of chronic diseases.

Key words nutrient supplements – vitamins – diet – lifestyle – epidemiology

Introduction

It has been estimated for Germany that dietary modifications might lead to a decrease in cancer mortality by 4–11% and an even higher impact of diet has been estimated for cancer incidence [3]. However, the results of many investigations suggest that dietary patterns rather than individual nutrients might account for such effects, taking into account the possibility of diverse interactions between food components [19, 24]. Thus, whether the use of dietary supplements such as vitamins, minerals, fibers, and protein, but also food extracts like yeast or garlic products could have an effect on the risk of chronic diseases is still a matter of debate [2, 6, 17, 25, 31, 35]. In contrast, for subgroups of the population, a high

intake of specific supplements might even be harmful [1, 30, 32, 40]. However, the use of dietary supplements has increased for years and 383 million Euros were spent on vitamin and mineral supplements in Germany in 2004 [15].

It is the aim of this investigation to describe the consumption of different dietary supplements in the EPIC-Heidelberg cohort, and to further characterize the consumers by lifestyle and dietary behaviours.

Subjects and methods

Subjects

During June 1994 and October 1998, 13,615 women aged 35–65 and 11,929 men aged 40–65 were recruited in the EPIC-Heidelberg (Germany) cohort [11, 36]. The target population was the general population from Heidelberg and surrounding communities. The participation rate was 38.3%. A detailed comparison between the cohort and the survey population is provided elsewhere [10]. The study was approved by the local ethical committee and all participants gave their informed consent prior to the study participation. All study participants were included in the present evaluation.

Data collection

All participants completed a validated semiquantative food frequency questionnaire (FFQ) with 148 food items, which covered dietary habits during the past year [9, 12–14]. Recorded food items were divided into 22 main food groups, and nutrient intake was calculated by means of the German food composition data base BLS version II.1 (BgVV, Berlin, Germany). Questions on regular dietary supplement use, which was defined as 'for at least 4 weeks during the past year', were included in the FFQ. The participants were asked for their use of vitamins, minerals, protein products, yeast products, garlic, and fibre supplements.

By means of a lifestyle questionnaire and a computer-assisted face-to-face interview . smoking habits, physical activity, education, employment, health status as well as family and reproductive life was assessed. Weight, height, and waist circumference were measured following standardised procedures [21]. Participation in cancer screening programs was assessed during the first follow-up between 1998 and 2000.

Statistical analysis

Associations with supplement use were examined for education (≤9 years of schooling and no vocational training; 10 years of schooling and/or vocational or technical training; 13 years of schooling and/or graduated from university [38]), physical activity (average number of hours per week spent on leisure time activities in the last year), occupational activity (mainly sitting; mainly standing or walking; physically exhausting; heavy physical work), smoking status (non-smokers, ex-smokers, current smokers), marital status (living with their spouse/partner versus living without), body mass index (BMI) (<25 kg/m^2, ≥25–<30 kg/m^2, ≥30 kg/m^2), and participation in cancer screening measures (Hemoccult® test, palpation of the rectum, digital rectal examination (DRE), PAP smear test, mammography, palpation of the breast).

All analyses were stratified by sex. Associations between socio-demographic, lifestyle, and dietary factors and supplement use were examined using unconditional logistic regression models. Supplement use was modelled as a dichotomous variable (user/non-user of vitamin and/or mineral supplements). Dietary variables were analysed by quintiles of intake separately for each gender. Quintiles were defined based on the intake of non-supplement users. Models on the association of supplementation and food group or nutrient intake were adjusted for age, education, physical activity and smoking. To test for trend, each food variable was included as an interval-scaled variable in the regression model. For all analyses, SAS version 6.12 (SAS Institute Inc. Cary NC, USA) was used.

Results

Regular use of any of the listed dietary supplements was reported by 47.1% of female and 41.3% of male participants (Table 1). The majority of supplement users took vitamins, followed by minerals. Overall, 40.1% of women and 33.5% of men used vitamin and/or mineral nutrient supplements. Supplementation prevalence was significantly higher in women than in men, especially for the use of minerals. Likewise, there was a significant tendency towards a more frequent use of nutrient supplements (all kinds, vitamins and/or minerals, minerals) with older age (Table 1).

Regular use of only one type of supplement was reported by 33.2% of women and 29.5% of men, two different supplements were taken by 10.3% of women and 8.6% of men, 3.6% of women and 3.2% of men consumed three or more supplements. The most common combination in women was vitamins with minerals, which was consumed by 5.2% (men 3.3%), while men preferred vitamins with fibres 3.7% (women 3.9%).

Table 1 Regular use of nutrient supplements in the EPIC-Heidelberg cohort at recruitment, by gender and age groups

	Men				Women			
	40–44 years (n = 2,353)	45–54 years (n = 4,744)	55–65 years (n = 4,832)	Total (n = 11,929)	35–44 years (n = 4,924)	45–54 years (n = 4,494)	55–65 years (n = 4,197)	Total (n = 13,615)
	Prevalence (%)							
Any supplement	37.1	41.3	43.4	41.3[a,c]	43.1	48.4	50.4	47.1[c]
Vitamins or minerals	28.9	32.9	36.3	33.5[a,c]	36.1	41.3	43.7	40.1[c]
Vitamins	22.5	22.3	23.1	22.7[b]	23.4	23.7	24.3	23.8
Minerals	8.7	13.8	17.1	14.1[a,c]	16.3	23.5	25.6	21.5[c]
Fibre	8.8	10.5	9.2	9.6	9.1	9.6	10.3	9.7
Garlic	6.8	6.7	6.7	6.7	6	6.5	6	6.1
Yeast	2.1	3	2.9	2.8	2.9	3.3	2.7	3
Protein	0.6	0.8	1	0.9	0.9	0.7	0.8	0.8

[a,b] Statistically significant differences in prevalence to the opposite sex [[a] $p \leq 0.001$; [b] $p \leq 0.05$ (χ^2-test)]
[c] Trend to higher prevalence at older age ($p \leq 0.001$) (logistic regression)

Because vitamin and mineral supplements were the most frequently used types of dietary supplements in this cohort, our analyses on the associations of lifestyle and diet with supplement use refer to these two groups only.

Demographic and lifestyle factors

Women, older, more physically active as well as better educated subjects were more likely to use vitamin and mineral supplements (Table 2). In women, quitting of smoking is associated with a supplement use. The likelihood of supplement use is increased in women living without spouse or partner. Obese women took vitamins and/or mineral less often than women with normal BMI (Table 2). In addition, women, but not men, who had had a Hemoccult® test, were more likely to use supplements compared with subjects who had no test (Table 2).

Dietary factors

Neither total energy nor total fat intake was related to the use of vitamin or mineral supplements (Table 3). However, supplementation is associated with a lower intake of saturated fat and a higher intake of n-3 fatty acids, the latter resulting in a lower $n6/n3$-fatty acid ratio In addition, a high intake of the antioxidants vitamin C, vitamin E, and β-carotene was positively, although not always statistically significantly, associated with the use of vitamin or mineral supplements in men and women (Table 3).

A high intake of milk, milk products, fish, and cereals was positively associated with the use of vitamin or mineral supplements (Table 4). Men and women in the highest quintiles of meat, meat products, or animal fat intake were less likely to use supplements than subjects in the lowest quintiles of the respective food groups. In women, we found an inverse relation of cake, bread, and vegetable consumption with the use of supplements (Table 4). No statistically significant associations were seen between intake of fruits and fruit juices and the use of supplements.

Discussion

In Germany, supplement use was shown to contribute up to 50% of the total intake of selected vitamins or minerals [4, 43]. It was the aim of this investigation to describe nutrient supplementation and to identify supplement-use related behaviour that might influence the risk of cancer and chronic diseases.

Our analysis conducted in the EPIC-Heidelberg cohort (1994–1998) is comparable to a previous investigation in the EPIC-Potsdam cohort (1995–1996), which relies on the same study design and, thus, shows good methodological comparability [22]. Regular dietary supplement use in EPIC-Heidelberg was reported by 47% of female and 41% of male participants and use of vitamin and/or mineral nutrient supplements by 40% of women and 33% of men. In EPIC-Potsdam, these numbers were distinctly lower, although relying on the same definition of regular supplement use. There, only 33% of women and 26% of men used supplements, vitamins and/or minerals were consumed by 25% of women and 18% of men. Participants in Heidelberg used more often fibres (16%) than those in Potsdam (10%), who, instead, more often used garlic supplements (22%) than subjects in the Heidelberg cohort (11%). We can only speculate about the reasons for these differences, but they may include factors such as differences in income, education, availability of different types of supplements, or dietary habits between Potsdam and Heidelberg.

Table 2 Association of vitamin and mineral supplementation with socio-demographic and lifestyle factors in the EPIC-Heidelberg cohort at recruitment

	Odds ratios (95% CI)		Sample size	
	Men	Women	Men	Women
Sex				
	1.00 (ref.)	1.43 (1.36–1.52)	11908	13597
p for trend		≤0.001		
Age group (years)				
35–44	1.00 (ref.)	1.00 (ref.)	2344	4918
45–54	1.23 (1.10–1.37)	1.29 (1.19–1.41)	4738	4488
55–65	1.49(1.34–1.67)	1.52 (1.39–1.67)	4826	4188
p for trend	≤0.001	≤0.001		
Body mass index (kg/m^2)				
<25	1.00 (ref.)	1.00 (ref.)	3915	7130
25–<30	0.97 (0.89–1.06)	0.98 (0.90–1.06)	5872	4328
≥30	0.95 (0.85–1.06)	0.90 (0.81–1.00)	2121	2136
p for trend	0.33	0.07		
Educational level				
Low	1.00 (ref.)	1.00 (ref.)	305	1343
Middle	1.17 (0.90–1.51)	1.21 (1.07–1.37)	6657	7809
High	1.36 (1.04–1.77)	1.27 (1.11–1.45)	4946	4442
p for trend	≤0.001	0.003		
Physical activity at work				
Mainly sitting	1.00 (ref.)	1.00 (ref.)	7013	6840
Standing/walking	0.98 (0.89–1.07)	0.96 (0.89–1.03)	3523	6059
Physically exhausting	0.94 (0.82–1.08)	0.99 (0.84–1.16)	1183	666
Heavy physical work	0.84 (0.61–1.17)	1.60 (0.77–3.34)	189	29
p for trend	0.25	0.55		
Physical activity during leisure time (h/week)				
None	1.00 (ref.)	1.00 (ref.)	5420	5751
≤1	1.04 (0.91–1.198)	1.09 (0.98–1.20)	1306	2236
>1–≤2	1.19 (1.06–1.34)	1.18 (1.07–1.30)	1777	2317
>2–≤4	1.03 (0.92–1.16)	1.20 (1.09–1.33)	1877	2148
>4	1.37 (1.22–1.55)	1.63 (1.44–1.86)	1528	1142
p for trend	≤0.001	≤0.001		
Smoking				
Non-smoker	1.00 (ref.)	1.00 (ref.)	3569	6554
Ex-smoker	1.01 (0.92–1.11)	1.14 (1.05–1.24)	4817	3809
Smoker	0.96 (0.87–1.06)	1.09 (0.99–1.19)	3522	3231
p for trend	0.47	0.02		
Marital status				
Living with spouse/partner	1.00 (ref.)	1.00 (ref.)	10680	11009
Living without spouse/partner	1.03 (0.91–1.17)	1.11 (1.02–1.21)	1228	2585
p for trend	0.63	0.02		
Palpation of the colon[a]				
No	1.00 (ref.)	1.00 (ref.)	387	1010
Yes	1.16 (0.93–1.45)	1.00 (0.88–1.15)	6784	6259
Hemoccult® test[a]				
No	1.00 (ref.)	1.00 (ref.)	502	1172
Yes	0.87 (0.72–1.05)	1.19 (1.04–1.35)	5878	6489
DRE[a]				
No	1.00 (ref.)	–	3996	–
Yes	1.06 (0.95–1.19)	–	1934	–
Palpation of the breast[a]				
No	–	1.00 (ref.)	–	200
Yes	–	1.01 (0.76–1.34)	–	11888
Mammography[a]				
No	–	1.00 (ref.)	–	4964
Yes	–	1.03 (0.95–1.12)	–	6144
PAP[a]				
No	–	1.00 (ref.)	–	445
Yes	–	1.13 (0.93–1.38)	–	11471

[a] Assessed during first follow-up conducted 1998–2000 (“Have you ever had a ... ?”)

Table 3 Association of dietary fatty acid and antioxidant intake with vitamin and mineral supplementation in the EPIC-Heidelberg cohort at recruitment[a]

			Quintiles of intake					
			I	II	III	IV	V	*p*-trend
SFA[b] [% of total energy]	Men	Median	10.1	12.4	14.4	15.5	18.0	0.003
		OR[c]	1.00	0.93	0.87	0.87	0.85	
		95% CI	(ref.)	0.83–1.05	0.77–0.98	0.77–0–98	0.75–0.95	
	Women	Median	11.3	13.5	15.0	16.5	18.9	≤0.001
		OR	1.00	0.98	0.94	0.84	0.86	
		95% CI	(ref.)	0.88–1.09	0.84–1.05	0.75–0.93	0.77–0.96	
MUFA[b] [% of total energy]	Men	Median	9.1	10.9	12.0	13.2	14.9	0.11
		OR	1.00	0.99	0.91	0.84	0.97	
		95% CI	(ref.)	0.88–1.11	0.80–1.02	0.74–0.95	0.86–1.09	
	Women	Median	9.6	11.2	12.3	13.4	15.1	0.01
		OR	1.00	0.84	0.89	0.88	0.84	
		95% CI	(ref.)	0.75–0.93	0.79–0.99	0.79–0.98	0.75–0.93	
n-6 PUFA[b] [% of total energy]	Men	Median	3.3	4.0	4.6	5.3	6.7	0.62
		OR	1.00	0.98	1.04	0.97	0.97	
		95% CI	(ref.)	0.87–1.11	0.92–1.17	0.86–1.10	0.86–1.09	
	Women	Median	3.5	4.2	4.8	5.6	7.0	0.22
		OR	1.00	0.94	0.99	0.95	0.92	
		95% CI	(ref.)	0.84–1.05	0.89–1.10	0.85–1.06	0.83–1.03	
n-3 PUFA[b] [% of total energy]	Men	Median	0.50	0.59	0.66	0.74	0.87	0.09
		OR	1.00	1.07	1.02	1.12	1.1	
		95% CI	(ref.)	0.94–1.21	0.89–1.15	0.99–1.27	0.97–1.24	
	Women	Median	0.56	0.65	0.70	0.76	0.89	0.002
		OR	1.00	1.02	0.99	1.02	1.19	
		95% CI	(ref.)	0.92–1.14	0.89–1.12	0.92–1.14	1.08–1.33	
n−6/*n*−3 ratio	Men	Median	5.2	6.2	7.0	8.0	9.2	0.008
		OR	1.00	0.98	0.99	0.89	0.86	
		95% CI	(ref.)	0.87–1.11	0.88–1.12	0.78–1.03	0.76–0.98	
	Women	Median	5.2	6.2	6.9	7.7	9.3	≤0.001
		OR	1.00	0.89	0.92	0.87	0.79	
		95% CI	(ref.)	0.81–0.99	0.82–1.02	0.78–0.97	0.71–0.88	
Vitamin C [mg/d]	Men	Median	46.9	65.6	81.3	102.1	145.5	0.004
		OR	1.00	1.05	1.11	1.12	1.18	
		95% CI	(ref.)	0.93–1.19	0.98–1.26	0.99–1.27	1.04–1.33	
	Women	Median	52.3	71.3	88.8	111.5	155.7	0.002
		OR	1.00	1.04	1.09	1.04	1.21	
		95% CI	(ref.)	0.93–1.16	0.97–1.22	0.93–1.16	1.08–1.35	
Vitamin E [mg/d]	Men	Median	6.6	8.7	10.5	12.9	18.3	0.06
		OR	1.00	1.00	1.06	1.08	1.09	
		95% CI	(ref.)	0.89–1.13	0.94–1.19	0.96–1.22	0.97–1.24	
	Women	Median	6.1	7.9	9.6	11.8	16.5	0.046
		OR	1.00	0.89	0.98	1.02	1.06	
		95% CI	(ref.)	0.80–1.00	0.88–1.09	0.91–1.14	0.96–1.19	
β-Carotene [mg/d]	Men	Median	1.1	1.5	1.9	2.6	4.3	≤0.001
		OR	1.00	1.03	1.07	1.16	1.22	
		95% CI	(ref.)	0.91–1.16	0.95–1.21	1.02–1.31	1.08–1.37	
	Women	Median	1.2	1.7	2.2	2.9	4.9	≤0.001
		OR	1.00	1.05	1.08	1.09	1.26	
		95% CI	(ref.)	0.94–1.17	0.96–1.20	0.97–1.22	1.13–1.39	

[a] The probability of being a supplement user is modelled
[b] SFA, saturated fatty acids, MUFA, monounsaturated fatty acids, PUFA, polyunsaturated fatty acids
[c] OR, odds ratio; CI, confidence interval, adjusted for age, cigarette smoking, physical activity, and education

The definition of regular supplement use and the observed time period has a distinct impact on the results. Thus, it is not surprising that in the present study, covering a period of 1 year and defining regular supplement use as 'at least 4 weeks during the past year', the prevalence of supplement use in the EPIC-Heidelberg cohort was higher than in other German studies. In the MONICA-Augsburg project, which examined supplement use within the last 7 days, the prevalence of vitamin and/or mineral supplement use was 25% in women and 18% in men [37]. In the German Nutrition Survey, the prevalence of vitamin and/or mineral supplement use, defined as regular use at least once a week during the last 12 months, was 22% in women and 18% in men [29]. Evaluation of a comparable variable in EPIC-Heidel-

Table 4 Association of selected food group consumption with vitamin and mineral supplementation in the EPIC-Heidelberg cohort at recruitment[a]

			Quintiles of intake					*p*-trend
			I	II	III	IV	V	
Vegetables [g/d] [vegetables of all kind]	Men	Median	53	83	107	135	192	0.25
		OR[b]	1.00	0.95	1.02	0.97	1.07	
		95% CI	(ref.)	0.84–1.08	0.90–1.15	0.85–1.09	0.95–1.21	
	Women	Median	66	95	120	151	217	0.002
		OR	1.00	0.85	0.88	0.84	0.93	
		95% CI	(ref.)	0.76–0.94	0.79–0.99	0.75–0.94	0.84–1.04	
Potatoes [g/d] [boiled potatoes, potato products of all kind]	Men	Median	43	73	94	118	163	0.33
		OR	1.00	1.01	0.92	0.9	0.99	
		95% CI	(ref.)	0.89–1.13	0.81–1.04	0.79–1.02	0.87–1.11	
	Women	Median	32	56	74	95	130	0.04
		OR	1.00	0.79	0.88	0.81	0.87	
		95% CI	(ref.)	0.71–0.89	0.79–0.98	0.73–0.91	0.78–0.97	
Fruit [g/d] [fruit of all kind, nuts and seeds]	Men	Median	29	59	90	110	200	0.13
		OR	1.00	0.96	1.06	1.06	1.06	
		95% CI	(ref.)	0.85–1.09	0.94–1.19	0.94–1.20	0.94–1.19	
	Women	Median	42	82	100	156	244	0.31
		OR	1.00	1.03	1.04	0.99	1.09	
		95% CI	(ref.)	0.92–1.15	0.94–1.17	0.89–1.11	0.97–1.21	
Fruit juices [ml/d] [fruit juices of all kind]	Men	Median	3	25	68	145	334	0.32
		OR	1.00	1.11	1.05	1.04	1.11	
		95% CI	(ref.)	0.99–1.26	0.92–1.18	0.92–1.18	0.98–1.26	
	Women	Median	4	27	70	151	330	0.19
		OR	1.00	1.02	1.04	1.11	1.04	
		95% CI	(ref.)	0.91–1.14	0.93–1.16	0.99–1.24	0.93–1.16	
Cakes [g/d] [cakes of all kind: fancy cakes, flans, pies, tarts]	Men	Median	11	29	50	79	148	0.28
		OR	1.00	0.97	0.96	0.96	0.93	
		95% CI	(ref.)	0.86–1.09	0.86–1.09	0.86–1.09	0.82–1.05	
	Women	Median	12	28	45	69	121	0.003
		OR	1.00	0.90	0.84	0.84	0.86	
		95% CI	(ref.)	0.80–1.00	0.75–0.93	0.75–0.94	0.77–0.96	
Cereals [g/d] [breakfast cereals, flakes]	Men	Median	0.1	0.5	0.9	3	30	0.06
		OR	1.00	0.93	1.03	1.01	1.09	
		95% CI	(ref.)	0.83–1.06	0.91–1.17	0.90–1.14	0.97–1.24	
	Women	Median	0.2	0.9	4	6	24	0.0009
		OR	1.00	1.01	1.09	1.08	1.20	
		95% CI	(ref.)	0.91–1.13	0.98–1.22	0.97–1.21	1.07–1.34	
Bread [g/d] [all varieties of bread and bread rolls, croissant]	Men	Median	50	97	144	186	254	0.07
		OR	1.00	0.97	0.96	0.88	0.93	
		95% CI	(ref.)	0.86–1.09	0.85–1.08	0.78–0.99	0.82–1.04	
	Women	Median	47	92	107	151	204	0.27
		OR	1.00	0.88	1.00	0.98	0.88	
		95% CI	(ref.)	0.79–0.98	0.90–1.12	0.88–1.089	0.79–0.99	
Milk [ml/d] [all fat levels, milk mix drinks]	Men	Median	0	3	12	53	214	0.06
		OR	1.00	0.95	0.96	1.01	1.13	
		95% CI	(ref.)	0.83–1.09	0.85–1.07	0.90–1.12	1.01–1.25	
	Women	Median	0	3	12	53	150	0.004
		OR	1.00	0.96	1.01	1.04	1.16	
		95% CI	(ref.)	0.85–1.08	0.91–1.12	0.94–1.16	1.05–1.28	
Milk products [g/d] [yoghurt, curd, soured milk, cream, pudding]	Men	Median	10	30	63	110	198	0.005
		OR	1.00	1.03	0.99	1.02	1.21	
		95% CI	(ref.)	0.91–1.17	0.88–1.13	0.90–1.16	1.07–1.36	
	Women	Median	18	47	82	139	226	≤0.001
		OR	1.00	1.02	1.18	1.08	1.22	
		95% CI	(ref.)	0.91–1.15	1.06–1.32	0.96–1.21	1.09–1.36	
Cheese [g/d] [cottage cheese, soft and firm cheese]	Men	Median	5	12	20	34	40	0.22
		OR	1.00	1.19	1.19	1.2	1.09	
		95% CI	(ref.)	1.06–1.35	1.05–1.35	1.06–1.36	0.97–1.24	
	Women	Median	6	14	23	34	40	0.24
		OR	1.00	1.01	1.04	1.05	1.06	
		95% CI	(ref.)	0.91–1.13	0.93–1.16	0.94–1.17	0.95–1.18	

(Continued)

Table 4 Continued

			Quintiles of intake					*p*-trend
			I	II	III	IV	V	
Meat [g/d] [fresh meat of all kind, including minced meat]	Men	Median	20	44	62	88	139	0.001
		OR	1.00	0.92	0.88	0.84	0.82	
		95% CI	(ref.)	0.82–1.04	0.78–0.99	0.75–0.95	0.73–0.93	
	Women	Median	12	27	41	55	91	0.07
		OR	1.00	0.98	0.93	0.91	0.93	
		95% CI	(ref.)	0.88–1.09	0.83–1.03	0.82–1.02	0.83–1.04	
Meat products [g/d] [cold cuts and sausages of all kind]	Men	Median	14	32	48	66	110	0.16
		OR	1.00	0.88	0.87	0.93	0.89	
		95% CI	(ref.)	0.78–0.99	0.77–0.98	0.82–1.04	0.79–1.00	
	Women	Median	5	18	30	45	69	≤0.001
		OR	1.00	0.98	0.91	0.84	0.87	
		95% CI	(ref.)	0.88–1.09	0.81–1.01	0.75–0.94	0.78–0.97	
Fish [g/d] [natural and breaded, canned, fumigated]	Men	Median	3	10	19	29	44	0.07
		OR	1.00	1.17	1.07	1.08	1.18	
		95% CI	(ref.)	1.04–1.32	0.95–1.19	0.95–1.22	1.05–1.34	
	Women	Median	2.5	8	15	18	34	≤0.001
		OR	1.00	1.19	1.16	1.32	1.39	
		95% CI	(ref.)	1.07–1.32	1.03–1.31	1.18–1.46	1.25–1.55	
Animal fats [g/d] [butter and other animal fats]	Men	Median	0.0	2	7	18	30	0.03
		OR	1.00	1.03	0.93	0.93	0.9	
		95% CI	(ref.)	0.92–1.15	0.83–1.04	0.82–1.05	0.79–1.03	
	Women	Median	0.0	3	10	12	22	0.11
		OR	1.00	1.04	0.88	1.01	0.91	
		CI 95%	(ref.)	0.93–1.15	0.79–0.99	0.90–1.12	0.81–1.03	
Vegetable fats and oils [g/d] [margarine and vegetable oils]	Men	Median	2	5	7	12	24	0.65
		OR	1.00	1	1.01	1.01	1.03	
		95% CI	(ref.)	0.89–1.13	0.89–1.14	0.89–1.13	0.91–1.16	
	Women	Median	3	5	7	10	20	0.048
		OR	1.00	1.04	1.15	1.16	1.08	
		95% CI	(ref.)	0.93–1.17	1.03–1.28	1.04–1.29	0.97–1.20	

[a] The probability of being a supplement user is modelled
[b] OR, odds ratio; CI, confidence interval; adjusted for age, cigarette smoking, physical activity, and education

berg ('regular use of supplement during the last week') revealed similar results for short-term nutrient supplementation (data not shown).

As reported in other studies [8, 16, 22, 23, 26–29, 34–29, 37–29, 41, 42], vitamin and mineral supplement use in the EPIC-Heidelberg cohort was significantly higher in women than in men, significantly more frequent in older subjects and in subjects with a higher education. Participants of the present study are better educated than a representative selection of German citizens of the same age [39] and better educated subjects are usually more health conscious. Regular engagement in leisure time physical activity is more common in supplement users than in non-users, an association that is confirmed by several European studies [22, 29, 33, 37]. The impact of leisure time physical activity on health is important and has to be kept in mind when comparing relative risks for different diseases among dietary supplement users and non-users [7, 44]. As in other studies [8, 18, 20, 26–29, 34–29, 41], supplement use was less common among current or heavy smokers and in obese subjects. Women who had had a Hemoccult® test were more likely to be users of vitamin and mineral supplements in our study. Similar associations have previously been reported in the French EPIC cohort [41] and two US studies [18, 34]. All these associations confirm the assumption that dietary supplements users tend to have a healthier lifestyle and a better awareness of health risks than non-users.

Higher consumption of milk, milk products, and fish was generally associated with a higher likelihood of using vitamin and mineral supplements, whereas high meat and meat product consumption was inversely associated. Other studies reported similar associations between food choices and use of supplements [5, 26, 28, 41]. However, in contrast to other reports [16, 20, 22, 26, 28, 34], the positive association between fruit or fruit juice consumption and the use of supplements in our cohort did not reach statistical significance. In female participants an even inverse association between vegetable consumption and supplement use was observed. Interestingly, supplement use did not differ by vegetable (men and women) or

fruit (men only) consumption in the German Nutrition Survey either [5]. The associations between nutrient intake and use of vitamin and mineral supplements in our study reflect the differences in food choices. The inverse associations with saturated fat intake and *n*6/*n*3-fatty acid ratio can be seen as a consequence of the lower consumption of meat, meat products and animal fats and a higher consumption of fish and vegetable oils. In addition, a higher vitamin C supply in supplement users may result from the increased consumption of fruit and fruit juices. Similar results have been described in a French study [41] and US studies [20, 26, 28]. The higher likelihood of having a higher β-carotene intake in supplement users can only be explained by a preference for β-carotene-rich vegetables. A high intake of β-carotene, vitamin C (in men), and vitamin E in participants using supplements was also observed in the EPIC-Potsdam cohort. However, they did not find differences in fatty acid intake between supplement users and non-users [22].

In conclusion, data of our study indicate that the use of vitamin and mineral supplements in EPIC-Heidelberg is related to a more health conscious behaviour and can be regarded as one marker of a health conscious lifestyle. Studies on the protective effect of nutrients (including supplementation) on cancer and chronic disease risk should always be aware of this source of confounding.

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References

1. Albanes D, Heinonen O, Taylor P, et al. (1996) Alpha-tocopherol and beta-carotene supplements and lung cancer incidence in the alpha-tocopherol, beta-carotene cancer prevention study: effects of base-line characteristics and study compliance. J Natl Cancer Inst 88:1560–1570
2. Bairati I, Meyer F, Gelinas M, et al. (2005) A randomized trial of antioxidant vitamins to prevent second primary cancers in head and neck cancer patients. J Natl Cancer Inst 97:481–488
3. Becker N (2001) Epidemiologic aspects of cancer prevention in Germany. J Cancer Res Clin Oncol 127:9–19
4. Beitz R, Mensink GB, Fischer B, Thamm M (2002) Vitamins–dietary intake and intake from dietary supplements in Germany. Eur J Clin Nutr 56:539–545
5. Beitz R, Mensink GBM, Hintzpeter B, Fischer B, Erbersdobler HF (2004) Do users of dietary supplements differ from nonusers in their food consumption? Eur J Epidemiol 19:335–341
6. Bjelakovic G, Nikolova D, Simonetti RG, Gluud C (2004) Antioxidant supplements for prevention of gastrointestinal cancers: a systematic review and meta-analysis. Lancet 364:1219–1228
7. Blair SN, Kohl HW, Gordon NF, Paffenbarger RS (1992) How much physical activity is good for health? Annu Rev Public Health 13:99–126
8. Block G, Cox C, Madans J, Schreiber GB, Licitra L, Melia N (1988) Vitamin supplement use, by demographic characteristics. Am J Epidemiol 127:297–309
9. Boeing H, Bohlscheid-Thomas S, Voss S, Schneeweiss S, Wahrendorf J (1997) The relative validity of vitamin intakes derived from a food frequency questionnaire compared to 24-hour recalls and biological measurements: results from the EPIC pilot study in Germany. European prospective investigation into cancer and nutrition. Int J Epidemiol 26(Suppl 1):S82–90
10. Boeing H, Korfmann A, Bergmann MM (1999) Recruitment procedures of EPIC-Germany. European investigation into cancer and nutrition. Ann Nutr Metab 43:205–215
11. Boeing H, Wahrendorf J, Becker N (1999) EPIC-Germany–a source for studies into diet and risk of chronic diseases. European investigation into cancer and nutrition. Ann Nutr Metab 43:195–204
12. Bohlscheid-Thomas S, Hoting I, Boeing H, Wahrendorf J (1997) Reproducibility and relative validity of energy and macronutrient intake of a food frequency questionnaire developed for the German part of the EPIC project. European prospective investigation into cancer and nutrition. Int J Epidemiol 26(Suppl 1):S71–81
13. Bohlscheid-Thomas S, Hoting I, Boeing H, Wahrendorf J (1997) Reproducibility and relative validity of food group intake in a food frequency questionnaire developed for the German part of the EPIC project. European prospective investigation into cancer and nutrition. Int J Epidemiol 26(Suppl 1):S59–70
14. Brandstetter BR, Korfmann A, Kroke A, Becker N, Schulze MB, Boeing H (1999) Dietary habits in the German EPIC cohorts: food group intake estimated with the food frequency questionnaire. European investigation into cancer and nutrition. Ann Nutr Metab 43:246–257
15. Bundesfachverband der Arzneimittel-Hersteller e.V (2005) Der Arzneimittelmarkt in Deutschland in Zahlen 2004. Bundesfachverband der Arzneimittel-Hersteller e.V. Wissenschafts- und Wirtschaftsdienst, Bonn
16. Frank E, Bendich A, Denniston M (2000) Use of vitamin-mineral supplements by female physicians in the United States. Am J Clin Nutr 72:969–975
17. Giovannucci E, Stampfer MJ, Colditz GA, et al. (1998) Multivitamin use, folate, and colon cancer in women in the nurses' health study. Ann Intern Med 129:517–524
18. Hoggatt KJ, Bernstein L, Reynolds P, et al. (2002) Correlates of vitamin supplement use in the United States: data from the California teachers study cohort. Cancer Causes Control 13:735–740
19. Joint WHO/FAO Expert Consultation on Diet Nutrition and the Prevention of Chronic Diseases (2002) Diet, nutrition and the prevention of chronic diseases: report of a joint WHO/FAO expert consultation. World Health Organization, Geneva
20. Kirk SF, Cade JE, Barrett JH, Conner M (1999) Diet and lifestyle characteristics associated with dietary supplement use in women. Public Health Nutr 2:69–73

21. Klipstein-Grobusch K, Georg T, Boeing H (1997) Interviewer variability in anthropometric measurements and estimates of body composition. Int J Epidemiol 26(Suppl 1):S174–180
22. Klipstein-Grobusch K, Kroke A, Voss S, Boeing H (1998) Influence of lifestyle on the use of supplements in the Brandenburg nutrition and cancer study. Z Ernahrungswiss 37:38–46
23. Knudsen VK, Rasmussen LB, Haraldsdottir J, et al. (2002) Use of dietary supplements in Denmark is associated with health and former smoking. Public Health Nutr 5:463–468
24. Lampe JW (1999) Health effects of vegetables and fruit: assessing mechanisms of action in human experimental studies. Am J Clin Nutr 70:475S–490S
25. Lucock M, Yates Z (2005) Folic acid - vitamin and panacea or genetic time bomb? Nat Rev Genet 6:235–240
26. Lyle BJ, Mares-Perlman JA, Klein BE, Klein R, Greger JL (1998) Supplement users differ from nonusers in demographic, lifestyle, dietary and health characteristics. J Nutr 128:2355–2362
27. Marques-Vidal P, Arveiler D, Evans A, et al. (2000) Characteristics of male vitamin supplement users aged 50–59 years in France and Northern Ireland: the PRIME study. Prospective epidemiological study of myocardial infarction. Int J Vitam Nutr Res 70:102–109
28. McNaughton SA, Mishra GD, Paul AA, Prynne CJ, Wadsworth MEJ (2005) Supplement use is associated with health status and health-related behaviors in the 1946 British birth cohort. J Nutr 135:1782–1789
29. Mensink GB, Strobel A (1999) Intake of dietary supplements and nutritional behavior]. Gesundheitswesen 61(Spec No):S132–137
30. Miller ER III, Pastor-Barriuso R, Dalal D, Riemersma RA, Appel LJ, Guallar E (2004) Meta-analysis: high-dosage vitamin e supplementation may increase all-cause mortality. Ann Intern Med 142:37–46
31. Nissen SB, Tjonneland A, Stripp C, et al. (2003) Intake of vitamins A, C, and E from diet and supplements and breast cancer in postmenopausal women. Cancer Causes Control 14:695–704
32. Omenn G, Goodman G, Thornquist M, et al. (1996) Risk factors for lung cancer and for intervention effects in CARET, the beta-carotene and retinol efficacy trial. J Natl Cancer Inst 88:1550–1559
33. Paffenbarger RS Jr, Hyde RT, Wing AL, Lee IM, Jung DL, Kampert JB (1993) The association of changes in physical-activity level and other lifestyle characteristics with mortality among men. N Engl J Med 328:538–545
34. Patterson R, Neuhouser M, White E, Hunt J, Kristal A (1998) Cancer-related behavior of vitamin supplement users. Cancer Epidemiol Biomarkers Prev 7:79–81
35. Patterson RE, White E, Kristal AR, Neuhouser ML, Potter JD (1997) Vitamin supplements and cancer risk: the epidemiologic evidence. Cancer Causes Control 8:786–802
36. Riboli E, Kaaks R (1997) The EPIC project: rationale and study design. European prospective investigation into cancer and nutrition. Int J Epidemiol 26(Suppl 1):S6–14
37. Schellhorn B, Doring A, Stieber J (1998) Use of vitamins and minerals all food supplements from the MONICA cross-sectional study of 1994/95 from the Augsburg study region. Z Ernahrungswiss 37:198–206
38. Schlehofer B, Heuer C, Blettner M, Niehoff D, Wahrendorf J (1995) Occupation, smoking and demographic factors, and renal cell carcinoma in Germany. Int J Epidemiol 24:51–57
39. Statistisches Bundesamt (2000) Bildung im Zahlenspiegel 2000. Statistisches Bundesamt, Wiesbaden
40. Touvier M, Kesse E, Clavel-Chapelon F, Boutron-Ruault M-C (2005) Dual association of {beta}-carotene with risk of tobacco-related cancers in a cohort of French women. J Natl Cancer Inst 97:1338–1344
41. Touvier M, Kesse E, Volatier JL, Clavel-Chapelon F, Boutron-Ruault MC (2006) Dietary and cancer-related behaviors of vitamin/mineral dietary supplement users in a large cohort of French women. Eur J Nutr 45:205–214
42. Wallström P, Elmstahl B, Hanson BS, Östergren PO, Johansson U, Janzon L (1996) Demographic and psychosocial characteristics of middle-aged women and men who use dietary supplements. Results from the Malmö diet and cancer study. Eur J Public Health 6:188–195
43. Winkler G, Doring A, Fischer B (1998) Supplements as a source of micronutrient intake in middle-aged men in southern Germany: results of the MONICA dietary survey 1994/95. Z Ernahrungswiss 37:315–318
44. Wolters M, Hahn A (2001) [Nährstoffsupplemente aus Sicht des Konsumenten]. Ernährungs-Umschau 48:136–141