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Changes in food and nutrient intake of 6- to 17-year-old Germans between the 1980s and 2006

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Abstract

Objective: To compare the food consumption and nutrient intakes of German children and adolescents in the 1980s with present dietary habits.
Design: Two cross-sectional representative surveys, the German National Food Consumption Study (Nationale Verzehrsstudie, NVS) from 1985–8 and the nutrition module 'EsKiMo' of the German Health Interview and Examination Survey for Children and Adolescents (KiGGS) from 2006, were analysed for differences in food and nutrient intakes stratified by age and sex groups.
Setting: Secondary analyses of data from representative observational studies.
Subjects: Children and adolescents aged 6–17 years living in Germany in the 1980s (*n* 2265) and in 2006 (*n* 2506).
Results: Food consumption was characterised by higher amounts of vegetables/pulses, fruits/nuts and beverages and less meat products/sausages, butter, fats/oils, potatoes/potato products and bread/pastries in 2006 than in 1985–8. The overall changes in food intake were reflected in improvements of macronutrient composition, increased water intake and lower energy density of the diet. Intake of most vitamins and minerals increased in relation to energy intake, but the nutrient density of the diet for vitamins B_{12} and D decreased. The most critical nutrients observed in NVS and EsKiMo were folate, vitamin D, vitamin A, vitamin E, Ca and Fe. In addition, dietary fibre intake was relatively low and fatty acid and carbohydrate compositions were not favourable.
Conclusions: Further efforts will be necessary to improve dietary habits among children and adolescents.

Keywords
Nutrition
Food consumption
Energy and nutrient intake
Energy and nutrient density
Change
Children and adolescents

During the past two decades, various and complex economic, technological and social changes have occurred in the living conditions of children and adolescents. Several of these developments are likely to have a significant impact on behavioural changes. From the perspective of prevention and health promotion, health behaviour and its change over the years during childhood and adolescence are of special interest. Besides physical activity and social integration, health behaviour includes also dietary behaviour, which has an essential impact on development and well-being in general, as well as on development of overweight and obesity in children and adolescents. In the long term, nutrition in childhood and adolescence has a potential impact on adult morbidity and mortality[1,2].

Changes which may have affected the dietary habits of children and adolescents are, for example, enlargement of the variety of available foods (e.g. fortified foods, energy-dense fast foods and soft drinks), eating and cooking habits at home, time spent on personal computers, video games and Internet use, commercial advertising and consumer information. For about two decades it could only be assumed that changes observed in other industrial nations were similar for Germany, because the most recent representative German National Food Consumption Study (Nationale Verzehrsstudie, NVS), which included children and adolescents, was conducted from 1985 until 1988. The NVS II conducted in 2006 did not include children and adolescents younger than 14 years[3]. After the NVS study, only data from small local studies could give some impression of how food consumption patterns, energy and nutrient intake had changed over time. The Dortmund Nutritional and Anthropometric Longitudinally Designed (DONALD) study is the only study that has been providing long-term food and nutrient intake data of children and adolescents based on 3 d weighed dietary records in Germany since 1985. However, the sample of this study has not been intended to be representative for Germany[4]. Further food consumption data come from household budget surveys (Einkommens- und Verbrauchsstichprobe, EVS). These studies have obtained

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information from household booklets for expenses on foods and beverages. The approximations of individual information from household data have limited validity, especially for children and adolescents[5]. The nationally representative Eating study as a KiGGS Module (EsKiMo) gives up-to-date insight into the food intake of children and adolescents and provides the opportunity to observe changes which have occurred during the last 20 years.

The current paper presents the findings of NVS and EsKiMo, revealing improvements in dietary habits and nutrient intakes and information for preventive measures.

Subjects and methods

The first German National Food Consumption Study (NVS) was conducted between 1985 and 1988 in the Federal Republic of Germany and West Berlin. It was funded by the Federal Ministry for Research and Technology. Sampling of private households was performed stratified and disproportionately by means of a defined random procedure. All persons living permanently in the selected households were asked to participate. The NVS sample included data from 1066 children aged 6–11 years and 1199 adolescents aged 12–17 years (1111 boys and 1154 girls). The food intake was assessed with 7 d dietary records. Amounts of foods were in general obtained by weighing and, if this was not possible outside the home, portion sizes were estimated using household measurements (e.g. cup, teaspoon). The total participation rate of NVS was 74 %; the participation rate of children and adolescents is not reported[6,7].

In 2006, the dietary behaviour of 6- to 17-year-olds was assessed in a module of the German Health Interview and Examination Survey for Children and Adolescents (KiGGS)[8]. KiGGS was conducted by the Robert Koch Institute with the aim to collect comprehensive and nationwide data on the health status of children and adolescents from May 2003 to May 2006. The sample was drawn with a two-stage clustered and stratified sampling procedure. In the first stage, 167 sample points representative for German communities were selected with regard to community size and federal state. In the second stage, for every age, almost the same number of participants was randomly selected from the population registries. The overall response rate was 67 %. A total of 17 641 children and adolescents aged 0 to 17 years were examined[9]. The Eating study as a KiGGS Module (EsKiMo) was performed by the Robert Koch Institute and the University of Paderborn, funded by the Federal Ministry of Food, Agriculture and Consumer Protection. For EsKiMo, an age-stratified random sub-sample of KiGGS participants was comprehensively asked about their food intake from January to December 2006. Data of 1234 children aged 6–11 years and 1272 adolescents aged 12–17 years were obtained (1248 boys and 1258 girls). The participation rate of EsKiMo was 63 %. As children and adolescents differ in their abilities, willingness to cooperate and personal circumstances, two different tools for data collection were used. Parents of participants younger than 12 years were asked to complete dietary records on three given consecutive days. Participants 12 years of age and older were personally interviewed about their food intake during the last four weeks following a modified diet history method with the use of the DISHES (Dietary Interview Software for Health Examination Studies) software[10]. Portion sizes were identified in EsKiMo using tableware models and a German picture book adapted from the EPIC-SOFT Picture Book[11], packaging size and household measurements, or sometimes by weighing. Furthermore, all participants were asked about their sociodemographic background, leisure-time activities, lunch at school, body weight and height. As an incentive, all participants received €5 per recorded day and €10 per interview[10].

Food composition database

All foods were aggregated as consumed to food groups according to the classification system used in the NVS. Similar groups were summarised (e.g. confectionery/jam/sugar, alcoholic beverages). Food intake data were converted to average daily energy and nutrient intakes using the German Nutrient Database (Bundeslebensmittelschlüssel, BLS; Max Rubner Institut, Karlsruhe, Germany). The BLS essentially covers average nutritional values of approximately 10 000 food codes available on the German market (fresh foods, processed foods and dishes). The nutrient calculation in the NVS dataset was performed with the BLS version II.2[5] and the EsKiMo data with the BLS version II.3, which may be assumed to reflect the food composition at the time of the surveys best. In these two versions of the BLS, branded foods and fortified foods are not included. Therefore, the food compositions of about 1200 foods, mainly sweets, cereals and fast foods, were collected from producer information, Internet queries, labels and information from additional food composition databases from other countries as completion of the EsKiMo nutrient database. Furthermore a database of supplements was appended[10], which was developed for the NVS II[3]. Thus, in EsKiMo nutrient intake includes intakes from fortified foods and dietary supplements. For the calculation of total folate, amounts of folic acid in fortified foods and supplements were multiplied by 1·7 because of the higher bioavailability of synthetic folic acid compared with natural folate[12].

Statistical analyses

All analyses were performed with the SPSS statistical software package version 14·0 (SPSS Inc., Chicago, IL, USA). Descriptive statistics (percentiles 25, 50 and 75) summarise the data. The Mann–Whitney *U* test was used to test differences in the distributions of food and nutrient intakes between the years 1985–8 and 2006, taking

statistical significance as $P < 0{\cdot}05$. The analyses were done separately for children, adolescents, boys and girls.

In EsKiMo, all cases were weighed by a weighting factor which corrects for the disproportionally higher number of participants from the eastern parts of Germany, differences in the age, sex and nationality distribution of the final sample and the general population, and takes the day of the week of the records into account[9,10].

Energy density was calculated by dividing the energy content of the diet by the weight of the diet (kJ/g). Energy density of foods (without beverages) could be calculated exactly only with the data of EsKiMo. For NVS, the sugar content of beverages (except water, tea and coffee) was estimated at 10 % (40 kcal (167 kJ)/100 g). Nutrient densities were calculated as nutrient intake (g, mg or μg) per unit of energy (MJ).

Results

Food consumption

Table 1 and Table 2 show the food intake by main food categories among children and adolescents. There are distinct differences for total reported food intake among adolescents between EsKiMo and NVS, with larger quantities in EsKiMo. A slightly higher food intake in EsKiMo than in NVS can be noticed among 6- to 11-year-old girls, but not among boys. Beverage intake, however, was notably higher in all age and sex groups in 2006 than 20 years ago. Differences between food intake in the 1980s and 2006 exist for all food groups, although they are not significant in all age and sex groups. Both children and adolescents ate less bread/pastries, meat, meat products/sausages (NS among 12–17-year-old boys), eggs (NS among 12–17-year-old boys), butter, potatoes/potato products and tea/coffee in 2006. In contrast, the consumed amounts of pasta/rice/cereals, cheese (NS among 6–11-year-old boys), vegetables/pulses, fruits/nuts, confectionery/jam/sugar, condiments/sauces and non-alcoholic beverages were higher than 20 years ago. Decreased intakes in the group of children but increased intakes among adolescents occurred for fish/fish products (NS among 6–11-year-old boys), milk/dairy products (NS among 12–17-year-old boys), fats/oils (NS among 12–17-year-old girls) and alcoholic beverages.

Energy and nutrient intakes

Table 3 and Table 4 show the energy and nutrient intakes of children and adolescents in 1985–8 and 2006. Notable differences between the two surveys exist with respect to energy and most macro- and micronutrients, which are in tendency similar for children and adolescents. Fat intake decreased significantly (NS among 12–17-year-old boys) due to declines of both saturated and unsaturated fatty acids among children and due to reduction of only unsaturated fatty acids among adolescents. Protein intake decreased among children but increased among adolescents (NS among 12–17-year-old girls). Carbohydrate intake increased in all age and sex groups except 6- to 11-year-old boys due to higher polysaccharide intake and additionally, among adolescents, because of increased mono- and disaccharide intake. Only in adolescents was consumption of dietary fibre significantly higher in 2006 than in 1985–8. The lower fat intake and higher carbohydrate intake resulted in a lower percentage of energy from fat and a higher percentage of

Table 1 Distribution of average daily food intakes among 6- to 11-year-old German boys and girls in 1985–8 and 2006

	6- to 11-year-old boys							6- to 11-year-old girls						
	NVS 1985–8			EsKiMo 2006				NVS 1985–8			EsKiMo 2006			
Food intake (g/d)	P25	P50	P75	P25	P50	P75	*P*	P25	P50	P75	P25	P50	P75	*P*
Total food (except beverages)	871	1077	1281	917	1071	1274	0·913	817	966	1155	869	1019	1179	0·015
Total beverages	373	543	750	700	921	1167	<0·001	354	516	695	633	830	1101	<0·001
Bread/pastries	124	163	212	100	140	188	<0·001	108	148	193	92	129	174	<0·001
Pasta/rice/cereals	23	42	66	57	88	139	<0·001	18	35	54	54	88	124	<0·001
Meat	29	49	73	15	32	55	<0·001	25	44	66	10	27	52	<0·001
Meat products/sausages	31	51	79	16	35	62	<0·001	25	41	66	11	29	55	<0·001
Fish/fish products	0	0	16	0	0	19	0·135	0	0	14	0	0	18	0·008
Eggs	12	22	34	1	10	23	<0·001	11	20	31	0	7	22	<0·001
Milk/dairy products	190	301	455	155	260	388	<0·001	170	278	420	121	224	333	<0·001
Cheese	4	14	29	5	17	39	0·050	4	13	26	5	17	38	<0·001
Butter	4	11	21	0	3	8	<0·001	3	10	19	0	3	8	<0·001
Fats/oils	8	12	20	4	8	13	<0·001	7	11	18	3	7	11	<0·001
Potatoes/potato products	47	73	111	23	49	83	<0·001	45	69	106	22	50	79	<0·001
Vegetables/pulses	48	78	116	51	87	139	0·002	47	74	109	51	96	155	<0·001
Fruits/nuts	43	93	158	57	113	183	0·001	46	93	154	57	125	208	<0·001
Confectionery/jam/sugar	29	49	72	33	61	97	<0·001	25	44	70	32	56	88	<0·001
Condiments/sauces	3	6	11	14	33	80	<0·001	3	6	9	15	32	74	<0·001
Non-alcoholic beverages	320	485	682	683	917	1148	<0·001	289	470	640	627	817	1100	<0·001
Tea/coffee	0	0	56	0	0	0	<0·001	0	0	66	0	0	0	<0·001
Alcoholic beverages	0	0	1	0	0	0	<0·001	0	0	1	0	0	0	<0·001

NVS, German National Food Consumption Study; EsKiMo, Eating study as a KiGGS Module; KiGGS, German Health Interview and Examination Survey for Children and Adolescents; P25, 25th percentile; P50, 50th percentile; P75, 75th percentile.

Table 2 Distribution of average daily food intakes among 12- to 17-year-old German boys and girls in 1985–8 and 2006

	12- to 17-year-old boys							12- to 17-year-old girls						
	NVS 1985–8			EsKiMo 2006				NVS 1985–8			EsKiMo 2006			
Food intake (g/d)	P25	P50	P75	P25	P50	P75	*P*	P25	P50	P75	P25	P50	P75	*P*
Total food (except beverages)	1025	1241	1554	1250	1603	2053	<0·001	821	1019	1231	1029	1373	1697	<0·001
Total beverages	508	730	1107	1382	1919	2617	<0·001	454	643	863	1231	1630	2246	<0·001
Bread/pastries	162	218	297	137	190	268	<0·001	127	172	227	116	154	206	<0·001
Pasta/rice/cereals	24	43	67	93	142	200	<0·001	20	33	54	63	108	165	<0·001
Meat	53	80	109	43	69	106	0·001	43	66	92	24	40	63	<0·001
Meat products/sausages	45	75	114	40	71	114	0·291	29	50	80	20	40	65	<0·001
Fish/fish products	0	0	21	0	7	15	0·002	0	0	17	0	5	13	<0·001
Eggs	14	24	38	13	22	36	0·122	11	21	34	9	16	25	<0·001
Milk/dairy products	161	281	457	168	305	500	0·081	92	199	313	116	235	390	<0·001
Cheese	7	20	40	15	28	48	<0·001	8	18	35	15	29	47	<0·001
Butter	6	16	30	4	10	24	<0·001	3	10	20	3	7	16	<0·001
Fats/oils	11	17	28	12	20	34	<0·001	10	15	22	9	16	25	0·286
Potatoes/potato products	67	99	151	55	93	138	0·002	50	86	126	44	73	114	0·003
Vegetables/pulses	73	104	152	101	169	272	<0·001	62	100	152	109	180	302	<0·001
Fruits/nuts	27	73	139	60	132	231	<0·001	37	93	162	84	161	282	<0·001
Confectionery/jam/sugar	30	53	86	41	66	109	<0·001	22	42	66	33	56	89	<0·001
Condiments/sauces	4	8	13	43	67	110	<0·001	3	6	11	35	56	87	<0·001
Non-alcoholic beverages	350	561	862	1334	1786	2415	<0·001	313	486	705	1149	1554	2130	<0·001
Tea/coffee	0	60	191	0	0	21	<0·001	0	80	180	0	0	43	<0·001
Alcoholic beverages	0	0	29	0	3	101	<0·001	0	0	5	0	2	24	<0·001

NVS, German National Food Consumption Study; EsKiMo, Eating study as a KiGGS Module; KiGGS, German Health Interview and Examination Survey for Children and Adolescents; P25, 25th percentile; P50, 50th percentile; P75, 75th percentile.

energy from carbohydrate in the diet. Protein as a proportion of total energy intake did not change significantly among children, but decreased among adolescents. Total energy intake was lower among children, but higher among adolescents in 2006 than in the previous years. Water intake increased in all age and sex groups. Intake of vitamin D was lower in all age and sex groups, while intake of vitamin E was higher among adolescents, but not among children, in 2006 than in 1985–8. Vitamin A intake fell among children but increased among adolescents, whereas β-carotene intake increased among both children and adolescents. In 2006, the intakes of all water-soluble vitamins apart from vitamin B_{12} were higher compared with the 1980s, although not always significant among children. The intakes of the minerals Ca and Mg increased in all groups; the intakes of K, P, Fe and Zn increased among adolescents but decreased or did not change among children.

In 2006, energy density was significantly lower in all age and sex groups than 20 years ago, but nutrient density of the diet increased for both dietary fibre and most micronutrients (Table 5 and Table 6). The densities of vitamin B_1, vitamin B_2, vitamin B_6, folate, niacin and vitamin C increased whereas the densities of vitamin B_{12} (NS among 6–11-year-old boys) and vitamin D decreased among both children and adolescents. β-Carotene density became higher in all age and sex groups, whereas total vitamin A density increased only among adolescents but decreased among children. Nutrient densities of K, Ca, Mg, P (NS among 12–17-year-old boys) and Fe increased, but density of Zn did not change.

Discussion

Between the years 1985–8 and 2006, food consumption and nutrient intakes of children and adolescents changed considerably. On the one hand, positive changes were, for example, increases of vegetables/pulses, fruits/nuts and non-alcoholic beverage consumption and decreased consumption of meat products/sausages, butter and fats/oils. On the other hand, the decreased consumption of potatoes/potato products and bread/pastries was undesirable. The macronutrient composition of the diet improved, the micronutrient content of the diet in relation to energy intake increased and the energy density became lower. However, some micronutrients were not supplied sufficiently, fibre intake was relatively low, and fatty acid and carbohydrate compositions were unfavourable in both the 1980s and 2006.

Before discussing the implications of the results, some limitations of the analyses have to be considered. Areas and populations differ between the two nationwide surveys NVS (1985–8) and EsKiMo (2006). NVS was conducted before the German reunification and covered only the western part of Germany. EsKiMo, however, was conducted in both the western and the eastern part of Germany. Analyses of the National Health Surveys conducted in 1991 and in 1998 indicated that differences in food intake between adults from eastern and western parts of Germany existed in 1998, although these differences were smaller than those observed one year after the reunification[13]. It might be suspected that the results of the present analyses were affected by including children

Table 3 Distribution of average daily energy and nutrient intakes among 6- to 11-year-old German boys and girls in 1985–8 and 2006

	6- to 11-year-old boys							6- to 11-year-old girls						
	NVS 1985–8			EsKiMo 2006				NVS 1985–8			EsKiMo 2006			
Energy/nutrient intake (/d)	P25	P50	P75	P25	P50	P75	*P*	P25	P50	P75	P25	P50	P75	*P*
Energy (kJ)	7038	8242	9642	6634	7580	8833	<0·001	6399	7508	8838	6091	7010	8013	<0·001
Fat (g)	69	84	103	54	66	80	<0·001	62	77	93	49	60	74	<0·001
Energy from fat (%)	34	37	41	29	32	36	<0·001	34	37	42	29	32	36	<0·001
SFA (g)	28	36	45	22	28	34	<0·001	26	33	41	21	26	31	<0·001
MUFA (g)	25	31	38	18	23	29	<0·001	22	28	34	17	20	25	<0·001
PUFA (g)	9	11	14	7	8	11	<0·001	8	10	13	6	8	10	<0·001
Protein (g)	54	65	78	51	60	70	<0·001	49	58	71	46	56	65	<0·001
Energy from protein (%)	12	13	15	12	13	15	0·213	12	13	15	12	13	15	0·190
Carbohydrate (g)	195	233	277	202	238	275	0·356	175	209	250	184	218	256	0·015
Energy from carbohydrate (%)	44	48	52	49	53	57	<0·001	43	48	52	49	53	58	<0·001
Mono-, disaccharides (g)	94	124	152	94	119	148	0·123	86	111	142	85	108	142	0·337
Polysaccharides (g)	87	106	131	90	112	140	0·003	77	94	117	83	103	125	<0·001
Dietary fibre (g)	14	17	21	14	17	20	0·086	13	16	19	13	16	20	0·143
Alcohol (g)	0	0	0	0	0	0	0·665	0	0	0	0	0	0	0·003
Water (g)	1013	1224	1474	1391	1613	1877	<0·001	933	1140	1384	1258	1527	1833	<0·001
Vitamin A (mg retinol equivalent)	0·7	1·0	1·4	0·5	0·8	1·2	<0·001	0·7	0·9	1·2	0·5	0·7	1·1	<0·001
β-Carotene (mg)	1·1	1·7	2·6	1·1	2·0	3·7	<0·001	1·1	1·7	2·4	1·1	2·1	3·8	<0·001
Vitamin D (μg)	1·4	2·0	2·7	0·9	1·4	2·1	<0·001	1·3	1·8	2·5	0·8	1·3	2·1	<0·001
Vitamin E (mg tocopherol equivalent)	7·7	9·8	12·5	7·5	9·2	12·4	0·105	7·0	9·0	11·5	6·8	8·7	11·9	0·788
Vitamin B_1 (mg)	0·9	1·2	1·4	1·0	1·2	1·6	0·025	0·8	1·0	1·3	0·9	1·1	1·4	0·020
Vitamin B_2 (mg)	1·1	1·4	1·7	1·2	1·5	1·9	0·022	1·1	1·3	1·5	1·0	1·3	1·7	0·064
Vitamin B_6 (mg)	1·1	1·4	1·6	1·2	1·6	2·0	<0·001	1·0	1·3	1·5	1·1	1·4	1·8	<0·001
Folate (μg folate equivalent)	167	203	260	155	204	264	0·120	159	194	247	146	190	259	0·155
Niacin (mg niacin equivalent)	18·0	21·8	25·8	18·1	21·9	26·6	0·744	16·3	19·4	23·5	16·2	19·8	24·2	0·785
Vitamin B_{12} (μg)	3·2	4·2	5·7	2·9	3·9	5·0	<0·001	2·8	3·8	5·0	2·5	3·3	4·4	<0·001
Vitamin C (mg)	60·3	85·5	118·1	64·7	96·0	138·0	0·012	61·3	86·5	116·8	62·7	93·2	139·0	0·029
K (mg)	1981	2394	2826	1918	2299	2696	0·001	1849	2209	2654	1779	2184	2567	0·143
Ca (mg)	572	759	948	703	886	1099	<0·001	538	709	890	629	833	983	<0·001
Mg (mg)	229	273	321	242	284	336	0·008	210	250	303	221	272	326	<0·001
P (mg)	904	1135	1330	891	1052	1262	0·001	858	1016	1208	852	1019	1192	0·507
Fe (mg)	9·2	11·0	12·7	9·1	10·8	12·9	0·645	8·3	9·9	11·8	8·5	9·9	11·8	0·820
Zn (mg)	7·6	9·2	10·8	7·0	8·4	9·8	<0·001	7·0	8·2	9·7	6·5	7·8	9·0	<0·001

NVS, German National Food Consumption Study; EsKiMo, Eating study as a KiGGS Module; KiGGS, German Health Interview and Examination Survey for Children and Adolescents; P25, 25th percentile; P50, 50th percentile; P75, 75th percentile.

Table 4 Distribution of average daily energy and nutrient intakes among 12- to 17-year-old German boys and girls in 1985–8 and 2006

	12- to 17-year-old boys							12- to 17-year-old girls						
	NVS 1985–8			EsKiMo 2006				NVS 1985–8			EsKiMo 2006			
Energy/nutrient intake (/d)	P25	P50	P75	P25	P50	P75	*P*	P25	P50	P75	P25	P50	P75	*P*
Energy (kJ)	8834	10 733	12 810	9759	12 148	15 026	<0·001	6933	8377	9781	7424	9277	11 514	<0·001
Fat (g)	90	112	136	83	112	142	0·606	69	86	106	59	79	103	0·001
Energy from fat (%)	35	39	43	30	34	38	<0·001	35	38	42	28	32	36	<0·001
SFA (g)	38	47	59	34	47	61	0·580	28	36	45	25	34	45	0·090
MUFA (g)	33	41	52	29	39	51	0·009	25	32	39	20	27	36	<0·001
PUFA (g)	11	15	19	11	15	20	0·460	10	12	16	8	11	15	0·023
Protein (g)	75	89	108	75	95	125	<0·001	58	71	83	55	70	86	0·847
Energy from protein (%)	13	14	16	12	14	15	<0·001	13	14	16	12	13	14	<0·001
Carbohydrate (g)	229	283	346	279	371	455	<0·001	174	219	267	227	289	358	<0·001
Energy from carbohydrate (%)	41	45	49	46	51	55	<0·001	41	45	49	49	53	57	<0·001
Mono-, disaccharides (g)	103	141	181	130	188	254	<0·001	75	106	140	110	156	202	<0·001
Polysaccharides (g)	110	137	172	135	168	212	<0·001	88	108	131	101	130	163	<0·001
Dietary fibre (g)	16	21	26	20	27	35	<0·001	14	18	22	18	24	31	<0·001
Alcohol (g)	0	0	1	0	1	5	<0·001	0	0	1	0	1	2	<0·001
Water (g)	1227	1525	1899	2280	2917	3719	<0·001	1039	1275	1525	2027	2531	3264	<0·001
Vitamin A (mg retinol equivalent)	0·8	1·1	1·6	1·0	1·4	2·0	<0·001	0·7	1·0	1·4	1·0	1·3	1·9	<0·001
β-Carotene (mg)	1·3	1·9	2·9	2·2	3·8	6·4	<0·001	1·1	1·8	2·8	2·6	4·2	6·8	<0·001
Vitamin D (μg)	1·7	2·5	3·7	1·5	2·2	3·3	<0·001	1·4	2·1	3·0	1·2	1·7	2·5	<0·001
Vitamin E (mg tocopherol equivalent)	9·2	12·5	16·1	11·9	16·2	23·7	<0·001	8·2	10·1	13·7	10·2	13·7	20·2	<0·001
Vitamin B_1 (mg)	1·2	1·6	1·9	1·5	2·0	2·9	<0·001	1·0	1·2	1·5	1·1	1·4	2·1	<0·001
Vitamin B_2 (mg)	1·3	1·7	2·2	1·6	2·2	3·2	<0·001	1·1	1·4	1·7	1·3	1·8	2·6	<0·001
Vitamin B_6 (mg)	1·4	1·8	2·1	1·9	2·5	3·8	<0·001	1·2	1·4	1·7	1·4	1·9	2·8	<0·001
Folate (μg folate equivalent)	205	260	342	242	320	466	<0·001	180	224	294	204	286	416	<0·001
Niacin (mg niacin equivalent)	25·0	30·2	35·8	28·8	38·3	53·1	<0·001	19·7	24·1	28·6	21·0	27·2	38·5	<0·001
Vitamin B_{12} (μg)	4·3	5·9	7·7	4·5	6·2	8·8	0·006	3·6	4·7	6·3	2·9	4·3	6·1	<0·001
Vitamin C (mg)	64·6	94·1	134·7	101·3	168·7	279·6	<0·001	58·9	85·7	125·4	110·9	175·5	257·4	<0·001
K (mg)	2386	2897	3541	2807	3692	4693	<0·001	1931	2380	2894	2418	3087	3944	<0·001
Ca (mg)	616	857	1166	1043	1385	1803	<0·001	511	674	870	932	1204	1506	<0·001
Mg (mg)	273	333	411	392	508	652	<0·001	225	270	328	339	425	528	<0·001
P (mg)	1150	1393	1711	1280	1624	2112	<0·001	906	1111	1317	1004	1246	1609	<0·001
Fe (mg)	11·4	13·8	16·7	13·5	17·7	22·7	<0·001	9·5	11·4	13·9	11·4	14·1	18·1	<0·001
Zn (mg)	10·0	12·1	14·4	10·8	13·9	17·8	<0·001	7·9	9·8	11·5	8·5	10·6	13·3	<0·001

NVS, German National Food Consumption Study; EsKiMo, Eating study as a KiGGS Module; KiGGS, German Health Interview and Examination Survey for Children and Adolescents; P25, 25th percentile; P50, 50th percentile; P75, 75th percentile.

Table 5 Distribution of average daily nutrient density of the diet among 6- to 11-year-old German boys and girls in 1985–8 and 2006

	6- to 11-year-old boys							6- to 11-year-old girls						
	NVS 1985–8			EsKiMo 2006				NVS 1985–8			EsKiMo 2006			
Energy/nutrient density	P25	P50	P75	P25	P50	P75	*P*	P25	P50	P75	P25	P50	P75	*P*
Energy (kJ/g)	4·54	5·10	5·62	3·31	3·80	4·26	<0·001	4·47	4·99	5·60	3·18	3·78	4·21	<0·001
Dietary fibre (g/MJ)	1·80	2·03	2·34	1·85	2·15	2·57	<0·001	1·83	2·10	2·39	2·02	2·28	2·85	<0·001
Vitamin A (mg retinol equivalent/MJ)	0·09	0·11	0·16	0·07	0·10	0·16	0·003	0·09	0·11	0·15	0·08	0·11	0·15	0·001
β-Carotene (mg/MJ)	0·13	0·21	0·30	0·16	0·26	0·49	<0·001	0·15	0·21	0·31	0·17	0·29	0·54	<0·001
Vitamin D (μg/MJ)	0·18	0·24	0·31	0·13	0·19	0·27	<0·001	0·18	0·24	0·31	0·12	0·18	0·28	<0·001
Vitamin E (mg tocopherol equivalent/MJ)	0·96	1·19	1·43	1·02	1·24	1·54	0·002	0·98	1·17	1·41	1·03	1·26	1·61	<0·001
Vitamin B_1 (mg/MJ)	0·12	0·14	0·16	0·13	0·16	0·20	<0·001	0·12	0·14	0·16	0·13	0·16	0·19	<0·001
Vitamin B_2 (mg/MJ)	0·15	0·17	0·20	0·16	0·19	0·25	<0·001	0·15	0·17	0·20	0·16	0·19	0·23	<0·001
Vitamin B_6 (mg/MJ)	0·14	0·16	0·19	0·17	0·21	0·25	<0·001	0·15	0·17	0·19	0·17	0·20	0·25	<0·001
Folate (μg folate equivalent/MJ)	20·5	24·1	29·4	20·8	26·4	34·2	<0·001	21·7	25·3	31·4	22·3	27·2	35·2	0·001
Niacin (mg niacin equivalent/MJ)	2·32	2·58	2·93	2·49	2·91	3·33	<0·001	2·31	2·59	2·94	2·43	2·80	3·23	<0·001
Vitamin B_{12} (μg/MJ)	0·40	0·51	0·66	0·39	0·50	0·64	0·162	0·39	0·50	0·64	0·37	0·47	0·60	0·002
Vitamin C (mg/MJ)	7·4	10·3	13·5	8·5	12·3	17·5	<0·001	8·3	11·5	15·2	9·0	13·5	19·4	<0·001
K (mg/MJ)	256·4	285·2	320·2	267·8	298·6	340·0	<0·001	262·1	297·9	336·9	266·1	308·9	359·9	<0·001
Ca (mg/MJ)	73·8	90·5	107·5	96·7	115·7	136·8	<0·001	75·5	93·0	111·5	96·7	115·1	138·7	<0·001
Mg (mg/MJ)	29·0	32·4	36·1	31·9	36·5	43·1	<0·001	30·0	33·0	37·5	33·5	39·0	44·2	<0·001
P (mg/MJ)	122·4	135·7	148·4	125·1	139·3	158·0	<0·001	121·3	136·1	150·2	127·3	143·6	161·9	<0·001
Fe (mg/MJ)	1·17	1·31	1·45	1·23	1·41	1·61	<0·001	1·18	1·30	1·48	1·27	1·41	1·62	<0·001
Zn (mg/MJ)	0·97	1·08	1·20	0·98	1·10	1·22	0·101	0·97	1·08	1·22	0·98	1·10	1·24	0·070

NVS, German National Food Consumption Study; EsKiMo, Eating study as a KiGGS Module; KiGGS, German Health Interview and Examination Survey for Children and Adolescents; P25, 25th percentile; P50, 50th percentile; P75, 75th percentile.

Table 6 Distribution of average daily nutrient density of the diet among 12- to 17-year-old German boys and girls in 1985–8 and 2006

	12- to 17-year-old boys							12- to 17-year-old girls						
	NVS 1985–8			EsKiMo 2006				NVS 1985–8			EsKiMo 2006			
Energy/nutrient density	P25	P50	P75	P25	P50	P75	*P*	P25	P50	P75	P25	P50	P75	*P*
Energy (kJ/g)	4·66	5·19	5·80	2·88	3·44	4·07	<0·001	4·34	4·99	5·59	2·43	3·06	3·70	<0·001
Dietary fibre (g/MJ)	1·66	1·95	2·27	1·78	2·17	2·69	<0·001	1·86	2·15	2·53	2·09	2·56	3·15	<0·001
Vitamin A (mg retinol equivalent/MJ)	0·08	0·10	0·14	0·09	0·12	0·16	<0·001	0·09	0·12	0·17	0·11	0·14	0·19	<0·001
β-Carotene (mg/MJ)	0·12	0·17	0·26	0·19	0·31	0·50	<0·001	0·14	0·21	0·32	0·29	0·46	0·69	<0·001
Vitamin D (μg/MJ)	0·17	0·23	0·32	0·13	0·18	0·24	<0·001	0·18	0·24	0·35	0·13	0·18	0·24	<0·001
Vitamin E (mg tocopherol equivalent/MJ)	0·94	1·15	1·41	1·05	1·32	1·73	<0·001	1·03	1·25	1·53	1·19	1·48	1·91	<0·001
Vitamin B_1 (mg/MJ)	0·13	0·15	0·17	0·13	0·17	0·22	<0·001	0·13	0·15	0·17	0·13	0·15	0·20	<0·001
Vitamin B_2 (mg/MJ)	0·14	0·16	0·19	0·14	0·18	0·25	<0·001	0·14	0·16	0·19	0·15	0·19	0·24	<0·001
Vitamin B_6 (mg/MJ)	0·15	0·17	0·19	0·17	0·20	0·28	<0·001	0·15	0·17	0·20	0·17	0·20	0·27	<0·001
Folate (μg folate equivalent/MJ)	20·2	23·6	29·7	20·4	26·4	35·7	<0·001	22·6	26·9	33·4	24·0	30·4	40·0	<0·001
Niacin (mg niacin equivalent/MJ)	2·51	2·78	3·17	2·66	3·09	3·77	<0·001	2·58	2·88	3·33	2·53	2·95	3·57	0·039
Vitamin B_{12} (μg/MJ)	0·42	0·54	0·69	0·42	0·52	0·65	0·031	0·43	0·56	0·75	0·36	0·46	0·61	<0·001
Vitamin C (mg/MJ)	6·4	8·6	12·0	9·0	14·2	20·8	<0·001	7·6	10·7	14·9	12·8	18·7	26·9	<0·001
K (mg/MJ)	240·6	274·7	305·7	258·5	300·6	349·9	<0·001	256·2	286·6	324·9	287·4	341·4	399·8	<0·001
Ca (mg/MJ)	63·4	79·4	101·4	91·9	113·3	142·5	<0·001	64·8	81·3	102·5	104·3	129·1	160·5	<0·001
Mg (mg/MJ)	28·0	31·3	35·1	33·8	41·0	50·0	<0·001	29·1	32·8	36·7	37·7	45·9	55·1	<0·001
P (mg/MJ)	116·5	129·9	147·4	116·8	134·4	149·8	0·079	119·3	132·6	150·1	121·8	138·4	155·3	0·001
Fe (mg/MJ)	1·15	1·29	1·43	1·25	1·44	1·62	<0·001	1·23	1·38	1·55	1·36	1·55	1·77	<0·001
Zn (mg/MJ)	1·02	1·12	1·27	1·02	1·14	1·29	0·194	1·03	1·16	1·31	1·02	1·16	1·31	0·797

NVS, German National Food Consumption Study; EsKiMo, Eating study as a KiGGS Module; KiGGS, German Health Interview and Examination Survey for Children and Adolescents; P25, 25th percentile; P50, 50th percentile; P75, 75th percentile.

and adolescents from the newly formed German states. However, including only children from the western parts of Germany in the analyses (implies both same area and similar survey technique) resulted in analogous findings. The only differences were that the increases in cheese intake and nutrient density of Zn became significant among boys.

Another difference between the two surveys, which should be taken into account, is the selection criteria. The NVS sample consists of households with German citizenship householders, but in the EsKiMo study, a representative sample including migrants with both German and non-German nationality was aspired. In both surveys, sufficient German language skills were necessary.

An additional point is that several methods for collecting data on food consumption are available. Crucial to the particular decision for a method are theoretical and practical considerations. General aims are to maximise motivation and participation among the sample and to minimise burden and errors of data collection with the given resources. Beyond doubt, conditions among the population on the one hand and scientific and technical resources on the other hand have changed a lot during the past two decades. Hence, it is perspicuous that NVS and EsKiMo used different methods for data collection. An advantage, but also a limitation of EsKiMo is the fact that the special needs of children and adolescents were met. The estimated 3 d record, which was conducted by the children and their parents in EsKiMo, was methodologically comparatively similar to the weighed 7 d record of the NVS. Although dietary records are often regarded as the gold standard[14], they may interfere with eating habits and are prone to under-reporting, especially in obese subjects and adolescents[15]. In contrast, assessing the food intake of adolescents with the DISHES software might be associated with difficulties in remembering and misreporting. DISHES has been validated for adults aged 19–59 years, but not yet for adolescents[16]. A high ratio of compliance in EsKiMo was observed including few discarded reports and interviews because of doubtful validity and relatively low number of low energy reporters. Low energy reporters were not excluded because that would reduce the representativeness of the total samples. Cut-offs for the identification of high energy reporters were not applied. A separate validation survey for this age group was not performed either in NVS or in EsKiMo. In addition, different periods of data collection (7 d *v.* 3 d and 4 weeks) should also be considered when interpreting the results, especially for seldom consumed foods like fish.

The data sets of NVS and EsKiMo were based upon different versions of the German Nutrient Database. Principally, it is difficult to differentiate between real changes in nutrient intake because of altered dietary behaviour and nutrient contents of food and feigned changes because of different databases when regarding changes over time. Within the GISELA Study, a study with German senior citizens, the effects of the BLS versions II.2 and II.3 on energy and nutrient calculation were analysed. The results indicated that nearly all variables differed marginally but significantly between the two databases. For example, calculated energy intake with BLS II.3 was about 1 % lower than when calculated with BLS II.2. Small positive deviations were calculated for carbohydrate and protein intakes (about +1 % difference), whereas the deviation was negative for fat intake (about −6 % difference). The amounts of most micronutrients were slightly different when calculated with the more recent version, except vitamin D, which differed notably by about −19 % among women and −36 % among men[17]. Thus, the changes in macro- and micronutrient intake observed herein can be attributed only to a very small extent to the different nutrient database versions. The decrease of vitamin D intake, however, might be to some extent artificial.

Food consumption

Although it is necessary to discuss the data with some caution, they provide basic and relevant information.

The comparison of food consumption among children and adolescents in Germany in 1985–8 and 2006 revealed significant changes. During the past two decades, total food intake increased and food selection altered. The amounts consumed of pasta/rice/cereals, cheese, vegetables/pulses, fruits/nuts, confectionery/jam/sugar, condiments/sauces and non-alcoholic beverages increased significantly. Consumption of bread/pastries, meat, meat products/sausages, eggs, butter, potatoes/potato products and tea/coffee decreased in contrast. Intakes of both fats/oils and milk/dairy products decreased significantly among children, but fats/oils increased among adolescent boys and milk/dairy products increased among adolescent girls. Despite mainly improved food selection, more plant foods but less animal, high-fat and high-sugar foods should be consumed to meet the German recommendations for food intake[18]. In addition, beverage selection should be optimised, because energy-supplying juices and sugar-sweetened drinks (soft drinks) accounted for about half the beverages (data not shown). Because of the clear associations of soft drink consumption and nutrition and health outcomes, especially overweight and obesity[19–21], consumption of these beverages should be replaced by energy-free beverages. The main results are to some extent in accordance with findings of studies from Germany and other European countries and the USA, despite different periods and methods of data collection and evaluation (food classification, age groups). The German DONALD study found significant positive trends for beverage consumption in all age and sex groups, bread/cereals among 9- to 13-year-old boys and 4- to 8-year-old girls, and negative trends for both meat/fish/eggs and fats/oils among 4- to 18-year-old boys and

4- to 13-year-old girls and for fruits/vegetables among 4- to 8-year-old boys and 9- to 13-year-old girls, between 1985 and 2000. The consumption of milk/milk products, potatoes/pasta/rice and candy/cakes did not change significantly[22]. In addition, fortified foods became more important for child nutrition[23]. The Bogalusa Heart Study revealed lower consumption of breads/grains, mixed meats, eggs, fats/oils, vegetables/soups, desserts and candy, but higher consumption of cheese, fruits/juices, beverages, snacks, condiments and poultry, among 10-year-olds in 1992–4 compared with 1973–4. The consumption of seafood, beef, pork and milk did not change[24]. Other studies from the USA indicated an increase of beverage intake among 2- to 18-year-olds[25] and among 11- to 18-year-olds an increase of vegetable consumption and a decline of milk consumption[26]. The Nationwide Nutritional Survey of Food Behaviour of the Italian population (INN-CA) conducted in 1980–4 and 1994–6 observed increasing amounts of cakes/biscuits/pastries, ham/salami and savoury snacks among Italian children (1- to 9-year-olds) and adolescents (10- to 17-year-olds)[27].

Energy and nutrient intakes

The overall changes of food intake were reflected in improvements of nutrient intakes. In 2006 most D-A-CH reference values[28] were met better than in the 1980s. First, water intake increased in all age and sex groups; thus the median water intake of children nearly reached the dietary recommendations and adolescents met the recommendations for water intake. The recommended intake of carbohydrates (>50 % energy) was not met in median in any group in the 1980s, but reached the median in all age and sex groups in 2006. Although the intake of polysaccharides increased, mono- and disaccharides accounted still for half of total carbohydrate intake. In contrast, the intake of dietary fibre was also relatively low (2·4 g/MJ recommended). Therefore, the intake of complex carbohydrates and dietary fibre needs increasing further. The recommended fat intake (30–35 % energy for 6- to 14-year-olds, <30 % energy for ≥15-year-olds) was exceeded by far in all groups in the 1980s. In 2006, median fat intake was higher than recommended only among 15- to 17-year-olds (data not shown). Even though the intake of SFA fell in all groups, in comparison to the D-A-CH reference value (saturated:unsaturated fatty acids = 1:2) their proportion was still rather high in 2006. Further improvement of the fatty acid composition is necessary. Median protein intake was much higher than the recommendations in all groups (between 17 g/d and 60 g/d depending on age and sex recommended), thus nearly all children and adolescents ingested more protein than adequate. Other studies indicate similar changes of macronutrient intake. Trend analyses with data of the DONALD study came to the result that overall fat intake, SFA and MUFA intakes of the subjects decreased, whereas carbohydrate intake increased between 1985 and 2000[22]. As evaluations of the Bogalusa Heart Study indicate, trends in total fat, SFA and MUFA and percentage of energy from fat were negative among 10-year-old children between 1984–5 and 1992–4. Total carbohydrate intake and percentage of energy from carbohydrates remained similar[24]. Results of the Continuing Survey of Food Intake by Individuals (CSFII) showed a decline in percentage of energy from fat and protein which was compensated by an increase in carbohydrate intake among 11- to 18-year-olds[26]. In Northumbrian 11- to 12-year-olds, the percentage of energy from fat also decreased between 1980 and 2000, alongside an increase in percentage of energy from starch, but not from sugars[29,30].

The present results indicate that energy intake was lower among children, but higher among adolescents in 2006 compared with 1985–8. On the one hand, this may be due to misreporting as discussed before. On the other hand, the observation may be explained by changed physical activity and body height and weight. Comparable studies support the finding that energy intake develops differently among children and adolescents. Among boys of the DONALD study energy intake decreased slightly, albeit significant only in the group of 14- to 18-year-olds. Among girls energy intake had a negative trend for 4- to 8-year-olds and a positive trend for 9- to 18-year-olds, however not significant[22]. In the third National Health and Nutrition Examination Survey in the USA (NHANES III, 1988–94) energy intake of 6- to 11-year-old children remained stable, but increased for adolescents aged 12–19 years since NHANES II (1976–80)[31]. The CSFII conducted in 1989–91 and 1994–6 among 11- to 18-year-olds came to the result that energy intake increased[26]. In contrast, energy intakes of 11- to 12-year-old boys and girls fell in Northumberland, England, between 1980 and 2000[29].

Besides absolute energy intake, energy density is of special interest because there is convincing evidence that energy-dense foods promote the development of overweight and obesity[19,32]. Consuming nutrient-dense foods instead of energy-rich but nutrient-poor foods helps to improve the nutrient:energy ratio[33]. From this point of view, it is favourable that energy density decreased but the nutrient density of diets increased. However, in both surveys, the energy density of food (without beverages) was relatively high compared with the cut-off point of 125 kcal (523 kJ)/100 g food of the second World Cancer Research Fund report[31]. In the 1980s, median energy density of food was about 170 kcal (711 kJ)/100 g food among children, 185 kcal (774 kJ)/100 g food among adolescent boys and 179 kcal (749 kJ)/100 g food among adolescent girls. In 2006, median energy density of food in these groups was about 150 kcal (627 kJ)/100 g food, 161 kcal (673 kJ)/100 g food and 144 kcal (603 kJ)/100 g food, respectively. Even the 25th percentiles of energy density were above the cut-off point in all age and sex groups in NVS and EsKiMo (data not shown).

In addition, the evaluation of the NVS and EsKiMo data revealed higher absolute intakes and higher densities of most vitamins and minerals in 2006 than in 1985–8. This is mainly due to changes in food intake and consumption of fortified foods. Among children of the DONALD study the intake of water-soluble vitamins and minerals from fortified foods increased significantly since the 1980s[23]. In addition, the changes may be explained to a small extent by supplement intake. In EsKiMo, the inclusion of supplements slightly increased the median intakes and densities of some micronutrients (e.g. vitamins E and C, Ca, Mg) among adolescents, but not among children (data not shown). The D-A-CH recommendations for nutrient densities of vitamin B_6, vitamin B_{12} and Zn were met in all age and sex groups in NVS and EsKiMo. In contrast, folate and vitamin D densities were too low compared with the recommendations in all age and sex groups in both surveys. Among girls, the densities of Fe and Ca were lower than recommended in both surveys. The recommendations for the intakes of vitamin D and folate were not met in any age and sex group in the two surveys. In addition, the intakes of vitamin E, Ca and vitamin A (only EsKiMo) were lower than recommended during childhood. Thus, the most critical nutrients observed in NVS and EsKiMo were folate, vitamin D, vitamin A, vitamin E, Ca and Fe. In the DONALD study, vitamin C density increased linearly and nutrient density of vitamin A remained constant between 1986 and 2001. Vitamin E intake increased from 1986 to 1993 and decreased afterwards[34]. In the US CSFII, Fe intake was higher in 1994–6 than in 1989–91, while vitamin A and C, folate, Ca and fibre remained the same[26]. In Northumberland, vitamin A and C and Fe intake increased, while Ca intake decreased, among 11- to 12-year-olds between 1980 and 1990[35].

Conclusion

Food and nutrient intakes of German children and adolescents changed significantly during the past 20 years. Macronutrient composition and micronutrient intake improved. However, the intake of polysaccharides and dietary fibre should be enhanced and mono- and disaccharide intake should be reduced in future. In addition, the intake of folate, vitamins D, A and E, Ca and Fe have to increase to meet the recommendations. The general trend of higher micronutrient content of the diet in relation to energy intake and lower energy density should proceed. To improve the energy and nutrient density of the diet, the intake of nutritious foods with high water content should be promoted. Further efforts will be necessary to allow well-balanced diets with more plant foods and energy-free beverages, but less animal, high-fat and high-sugar foods for all children and adolescents and to stabilise enduring favourable dietary habits. The results are of interest for all involved in health policy and responsible for nutrition campaigns.

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