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Micronutrient intake and status in Central and Eastern Europe compared with other European countries, results from the EURRECA network

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Abstract

Objective: To compare micronutrient intakes and status in Central and Eastern Europe (CEE) with those in other European countries and with reference values.
Design: Review of the micronutrient intake/status data from open access and grey literature sources from CEE.
Setting: Micronutrients studied were folate, iodine, Fe, vitamin B_{12} and Zn (for intake and status) and Ca, Cu, Se, vitamin C and vitamin D (for intake). Intake data were based on validated dietary assessment methods; mean intakes were compared with average nutrient requirements set by the Nordic countries or the US Institute of Medicine. Nutritional status was assessed using the status biomarkers and cut-off levels recommended primarily by the WHO.
Subjects: For all population groups in CEE, the mean intake and mean/median status levels were compared between countries and regions: CEE, Scandinavia, Western Europe and Mediterranean.
Results: Mean micronutrient intakes of adults in the CEE region were in the same range as those from other European regions, with exception of Ca (lower in CEE). CEE children and adolescents had poorer iodine status, and intakes of Ca, folate and vitamin D were below the reference values.
Conclusions: CEE countries are lacking comparable studies on micronutrient intake/status across all age ranges, especially in children. Available evidence showed no differences in micronutrient intake/status in CEE populations in comparison with other European regions, except for Ca intake in adults and iodine and Fe status in children. The identified knowledge gaps urge further research on micronutrient intake/status of CEE populations to make a basis for evidence-based nutrition policy.

Keywords
Micronutrient
Intake
Status
Central and Eastern Europe

Epidemiological research has shown socio-economic differences in health at all ages throughout Europe[1]. These inequalities in health have been reported to vary between countries and between socio-economic indicators[2,3]. A possible explanation for these inequalities is a less optimal nutritional status in disadvantaged groups. For example, those with lower income suffer from higher rates of obesity, CVD and certain cancers that are linked to nutrition and diet[3,4]. This may be due to the fact that groups with limited economic means consume unhealthy foods that are cheap, energy-dense and nutrient-poor. Socio-economic position, as measured by income for instance, has been found to be one of the most important predictors of diet quality[4].

Since the proportion of (economically) disadvantaged populations is higher in Central and Eastern European

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(CEE) countries[5–9] it is highly relevant to evaluate whether differences in nutritional status may contribute to higher morbidity and mortality in CEE as compared with other European countries.

Assessment of dietary intake and nutritional status for European populations has been an emerging focus for the last two decades. However, current nutritional data are lacking for CEE populations[10,11]. This hinders research on nutritional health, which is needed to underpin nutrition policies for CEE populations with sizeable disadvantaged groups.

To fill the knowledge gap mentioned above, an additional approach is needed to deal with the standard searches conducted in known (open access) literature databases, i.e. the identification of commonly overlooked grey literature sources from CEE countries. So far, available nutritional data in CEE have often only been used for local health policies and have remained largely unexploited because they are either not published in an accessible manner or not available in English[1,12,13].

In the present study, we compare micronutrient intakes and status in CEE with those in other European countries using both open access sources and grey literature sources. A better use of the latter data from CEE and its further exploitation will enable evaluation of the current nutritional situation of CEE populations to enhance regional policy making.

Methods

EURRECA

The present study was carried out within the context of the EURRECA (EURopean micronutrient RECommendations Aligned) Network of Excellence (http://www.eurreca.org). This network aims to advance methodology for setting micronutrient requirements and recommendations, and to identify vulnerable groups regarding micronutrient intake and status[14,15]. To answer our research question, we used the standardized dietary intake/status methodology recommended by EURRECA (more details are below). We focused on the EURRECA top ten micronutrients, prioritized on the basis of the amount of new scientific evidence, their relevance to public health and the variations in current micronutrient recommendations (vitamin B_{12}, folate, Fe, Zn and iodine (intake and status) and vitamin C, vitamin D, Ca, Se and Cu (intake only))[14].

Search methodology

Data on CEE countries were collected from PubMed and grey literature for intake and status, and from the WHO Vitamin and Mineral Nutrition Information System (VMNIS) database (http://www.who.int/vmnis/database/en/) for status. For other European countries, we used available comprehensive reviews, primarily the European Nutrition and Health Report 2009 (ENHR II) for intake[16] and PubMed and WHO VMNIS for status only. Review of the EFSA (European Food Safety Authority) Concise and Comprehensive European Food Consumption Databases did not result in additional data.

We searched for studies on intake and/or status in PubMed published from January 1990 until April 2010 using common medical subject headings (MeSH) and free text search terms: Micronutrients (listed) OR Biomarkers of status (listed) AND General intake/status terms with terms for adequacy, i.e. intake/status (requirement* or recommend* or adequacy or inadequacy or adequate or inadequate or cut point or threshold – in title and abstract) AND Country (CEE and non-CEE countries, listed).

The WHO Global Micronutrient Databases on Iodine Deficiency and Anaemia were used to collate information on iodine and Fe status.

To collect grey literature data on intake and or status from CEE countries, we cooperated with the United Nations University/Standing Committee on Nutrition Network for Capacity Development in Nutrition in Central and Eastern Europe (NCDN CEE)[17]. This network gathers nutritional researchers and public health specialists from all CEE countries, whose representatives were introduced to the purpose of the present study and with the search criteria for collection of grey literature at their NCDN annual meeting in November 2008. They were asked to identify potentially relevant data from their countries, translate the data to English if necessary and send them to us for further screening.

Titles and abstracts from every source were screened, and for potentially relevant papers and reports, full texts were retrieved. Subsequently, we assessed which studies were eligible for our study using the following inclusion criteria.

1. The population studied should be representative for the country and apparently healthy, and data gathered should have had a sample size of at least 100 per gender group[18].
2. The study should include information on mean usual micronutrient intake and apply one of the following dietary intake methods (EURRECA best practice dietary intake methods): a validated FFQ or validated diet history; a food diary/register with at least 7 d; three or more 24 h recalls or registers; or three or fewer 24 h recalls with an adjustment for intra-individual variability[19]. Initially, these criteria were applied to both CEE and non-CEE data; however, keeping this condition for CEE data would have resulted in very few studies for assessment. For this reason, CEE studies on intake that used one or more 24 h recalls (with no adjustments for intra-individual variability) or other dietary assessment methods were included as well. If more than one country-representative study that fulfilled the inclusion criteria were available, the choice of the study to be presented graphically was made by

giving preference to the one that was most recently published.

3. Regarding nutritional status, data gathered should include information on mean or median status using best practice biomarkers defined in the context of EURRECA: Hb, serum/plasma ferritin or serum/plasma transferrin receptor for Fe; erythrocyte (red cell) folate, serum/plasma folate or serum/plasma homocysteine for folate; serum/plasma total B_{12}, serum/plasma methylmalonic acid or serum/plasma holotranscobalamin for vitamin B_{12}; serum/plasma Zn for Zn; and urinary iodine (24 h or spot), serum or dried whole blood spot thyroglobulin or serum thyroid-stimulating hormone for iodine[20–27].

Data analyses

We compared mean intakes and median (or mean) status levels between countries, between regions and with external reference values to evaluate differences between countries and indications for inadequacies. When several studies were available for one country, studies were ranked for their eligibility considering representativeness of the sample for the country, dietary assessment method used and year of the study (most recent were given preference).

To study regional variations in micronutrient intake and/or status, Europe was divided into four geographical regions: (i) CEE (Albania, Bosnia-Herzegovina, Bulgaria, Croatia, Czech Republic, Estonia, Latvia, Lithuania, Hungary, Macedonia, Montenegro, Poland, Romania, Serbia, Slovakia and Slovenia); (ii) Mediterranean (Greece, Italy, Portugal and Spain); (iii) Western Europe (Austria, Belgium, France, Germany, Ireland, The Netherlands, Switzerland and the UK); and (iv) Scandinavia (Denmark, Finland, Iceland, Norway and Sweden).

Regional comparisons were made when data for a specific micronutrient and population group were available for at least three CEE countries. This comparison included the calculation of weighed mean regional intakes and median status levels, plotting of country means (medians) and subsequently the description of: (i) differences in intake and/or status across European regions and (ii) observed mean intake and/or status in CEE countries in contrast to nutritional reference values. Variables considered in the description were differences in dietary assessment method (checked also by differences in mean daily energy consumption) and study population. In cases where data were available for fewer than three CEE countries, data from CEE countries were compared with the data from other European countries published in ENHR II[16] or from single studies, selecting those with the most comparable data (regarding age group, status biomarker, dietary assessment method and year of the study).

To evaluate whether there is an indication for inadequacy in micronutrient intake, the mean usual intake was compared with the ANR (Average Nutrient Requirement; amount of nutrient which is sufficient for 50 % of the apparently healthy population) derived for the Nordic countries (Nordic Nutrition Recommendations, NNR)[28,29], as these are the most recent reference values set for a series of European countries.* If an ANR for a micronutrient was not set by NNR (Ca and vitamin D in adults, all micronutrients in children), the ANR published for the USA/Canada by the US Institute of Medicine was used[22]. Relevant ANR are given in the figure captions. To assess adequacy of levels of status markers, we used guidance on cut-off values from EURRECA experts[30–33]. These cut-off values were based on key references mostly published by the WHO in cooperation with other institutions[20–27]. The specific values used are added to figure captions, table footnotes or text where applicable.

Results

Literature search and data availability

The search on micronutrient intake/status for all age ranges in CEE in the PubMed database resulted in 1949 titles and abstracts, out of which 121 were left after screening for potential relevance. The key reason for exclusion was that studies did not report mean intake or status. For one hundred and thirteen, full manuscripts were obtained and checked for compliance with the inclusion criteria; eight studies were inaccessible. Finally, thirty-eight studies were kept for further analysis, of which the grey literature added nine studies in total and contributed primarily data on micronutrient intake in adults. The WHO VMNIS database provided thirty-four studies on iodine and Fe status. A detailed overview of the study characteristics is given in Table 1.

Comparison of micronutrient intakes

Micronutrient intake data were most abundant for Ca, folate, Fe, vitamin B_{12}, vitamin C and vitamin D in adults. Figures 1 to 6 plot the mean micronutrient intakes (with 95 % confidence intervals) geographically (by country in four regions) and information is given on the dietary assessment method, age range of the study population, number of subjects and mean energy intake for males and females.

Observed mean Ca intake (Fig. 1) among females in CEE countries (pooled estimated mean: 869 mg/d) was in general lower than those in other European countries. The pooled means were 978, 1006 and 881 mg/d for Scandinavian, Western European and Mediterranean countries, respectively. The observed mean intake among

* Although more sophisticated methods are available for assessment of inadequacy such as the EAR (Estimated Average Requirement) cut-point method[27], we only compared mean levels with a reference value, as the more advanced methods use standard deviations. Standard deviations vary considerably by assessment method and request a higher comparability of measurement between countries.

Table 1 Characteristics of studies included in the present review*

Country	Study name	Study year	Population group	No. of subjects; sex	Food intake method or Status measure	Micronutrients included in the study
Albania	Iodine treatment in children with subclinical hypothyroidism due to chronic iodine deficiency decreases thyrotropin and C-peptide concentrations and improves the lipid profile[46]	2009	Children aged 10 ± 2 years	133 M&F	Urinary iodine	Iodine
	Iodine supplementation improves cognition in iodine-deficient school children in Albania: a randomized, controlled, double-blind study[47]	2006	Children aged 10–12 years	303 M&F	Urinary iodine	Iodine
Bosnia	Thyroid volume and urinary iodine excretion in school children in North-Eastern Bosnia[48]	2008	Children aged 7–14 years	513 M&F	Urinary iodine	Iodine
Bulgaria	Evaluation of endemic goiter prevalence in Bulgarian schoolchildren results from national strategies for prevention and control of iodine-deficiency disorders[49]	2007	Boys and girls aged 8–15 years	274 M 209 F	Urinary iodine	Iodine
	†AgeingNutrition[50]	2006	>55 years	186 M 194 F	24hR	Vitamin C
	†National study of urinary iodine excretion – biomarker of Iodine nutrition[51]	2003	Children aged 7–11 years; pregnant women	809 M&F; 355 F	Urinary iodine	Iodine
Croatia	Diet quality in Croatian university students: energy, macronutrient intakes according to gender[52]	2007	Males and females aged 18–30 years	183 M 480 F	FFQ quantified	Ca, Cu, folate, Fe, Se, vitamin B_{12}, vitamin C, Zn
	Dietary habits and folate status in women of childbearing age in Croatia[53]	2006	Females aged 20–30 years	100 F	2×24hR; serum folate	Folate
	Calcium intake, food sources and seasonal variations in Eastern Croatia[54]	2005	Males and females aged 18–55 years	46 M 115 F	FFQ	Ca
	Comparison of dietary habits in the urban and rural Croatian schoolchildren[55]	2004	Children aged 8–16 years	315 (urban) 163 (rural)	FFQ quantified	Ca, folate, Fe, Se, vitamin B_{12}, vitamin C, vitamin D, Zn
	Ultrasound bone measurement in children and adolescents: correlation with nutrition, puberty, anthropometry, and physical activity[56]	2003	Boys and girls aged 7–10 years; boys and girls aged 15–17 years	120 M 122 F; 112 M 147 F	Semi-quantitative FFQ	Ca
Czech Republic	Dietary habits in three Central and Eastern European countries: the HAPIEE study[57]	2009	Males and females aged 45–69 years	3690 M 4223 F	FFQ validated	Ca, folate, Fe, vitamin C
	Health behaviors, nutritional status, and anthropometric parameters of Roma and non-Roma mothers and their infants in the Czech Republic[58]	2009	Lactating women	151 F	Serum folate	Folate
	Iodine in early pregnancy – is there enough?[59]	2008	Pregnant women aged 17–41 years	168 F	Urinary iodine	Iodine
	Actual levels of soy phytoestrogens in children correlate with thyroid laboratory parameters[60]	2006	Boys and girls aged 8–15 years	129 M 139 F	Urinary iodine	Iodine
	Mild hyperhomocysteinaemia is associated with increased aortic stiffness in general population[61]	2006	Males and females aged 25–65 years	126 M 125 F	Homocysteine; serum folate; serum vitamin B_{12}	Folate, vitamin B_{12}

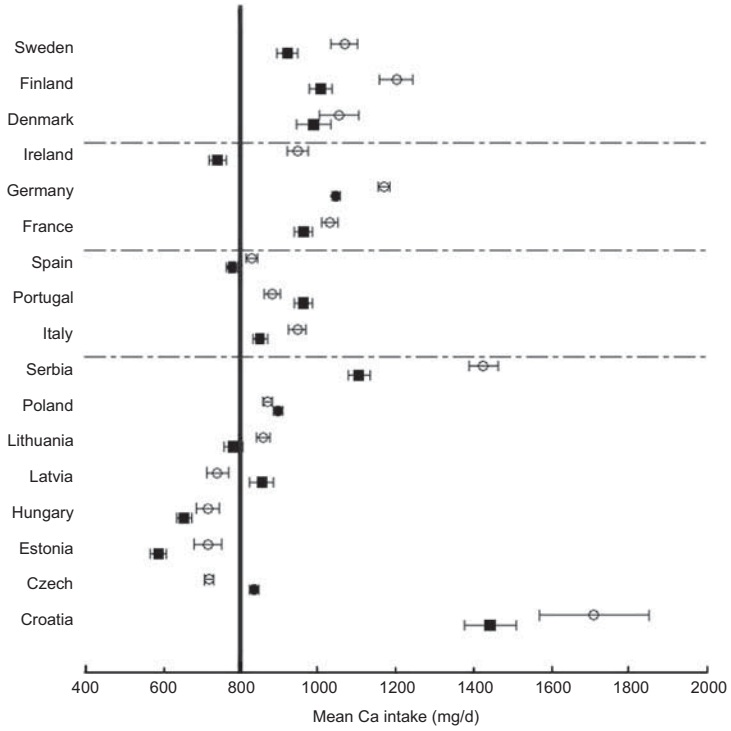
Table 1 *Continued*

Country	Study name	Study year	Population group	No. of subjects; sex	Food intake method or Status measure	Micronutrients included in the study
	Genetic determinants of folate status in Central Bohemia[62]	2005	Males and females aged 18–65 years	250 M 261 F	Serum folate; serum homocysteine; erythrocyte folate; serum vitamin B_{12}	Folate, vitamin B_{12}
	INAA of serum zinc of inhabitants in five regions of the Czech Republic[63]	1999	Boys and girls aged 10 years; males aged 36–49 years; females aged 36–49 years and 50–65 years	90 M 104 F; 118 M; 118 F 106 F	Serum zinc	Zinc
Estonia	The reference limits and cut-off value for serum soluble transferrin receptors for diagnosing iron deficiency in infants[64]	2008	9–12 months	146 M&F	Serum transferrin	Fe
	Prevalence and causes of iron deficiency anemias in infants aged 9 to 12 months in Estonia[65]	2007	9–12 months	171 M&F	Hb; serum transferrin; serum ferritin	Fe
	†AgeingNutrition[50]	2006	>55 years	126 M 190F	24hR	Folate, vitamin B_{12}, vitamin D
	†Nutrition and Lifestyle in the Baltic Republics – Summary Report[66]	1999	Males and females aged 19–64 years	900 M 1115 F	24hR	Ca, vitamin C, Fe, folate
Hungary	Dietary habits of schoolchildren: representative survey in metropolitan elementary schools: Part 2[67]	2007	Boys and girls aged 11–14 years	124 M 111 F	3dDR	Ca, Cu, folate, Fe, vitamin B_{12}, vitamin C, vitamin D, Zn
	†Report on Periconceptional Folic Acid Supplementation for Hungary[68]	2007	Females aged 18–59 years	352 F	3×24hR	Folate
	†AgeingNutrition[50]	2006	>55 years	93 M 159 F	24hR	Vitamin B_{12}, vitamin C
	Dietary survey in Hungary, 2003–2004[69]	2005	Males and females aged 18–60+ years	473 M 706 F	24hR	Ca, Cu, folate, Fe, vitamin B_{12}, vitamin C, vitamin D, Zn
	Prevalence and seasonal variation of hypovitaminosis D and its relationship to bone metabolism in community dwelling postmenopausal Hungarian women[70]	2003	Females aged 41–91 years	319 F	FFQ validated	Ca
	†Nutrition survey of the Hungarian population in a randomized trial between 1992–1994[71]	1996	Males aged 18–34 years and 35–59 years; females aged 18–34 years, 35–54 years and >55 years	338 M 730 M; 343 F 938 F 105 F	24hR; Hb; serum folate; serum Zn	Ca, Cu, folate, Fe, vitamin C, Zn
Latvia	†Nutrition and Lifestyle in the Baltic Republics – Summary Report[66]	1999	Males and females aged 19–64 years	1065 M 1235 F	24hR	Ca, Fe, vitamin C
Lithuania	Prognostic value of reticulocyte haemoglobin content to diagnose iron deficiency in 6–24-month-old children[72]	2008	6–24 months	180 M&F	Hb	Fe

Table 1 *Continued*

Country	Study name	Study year	Population group	No. of subjects; sex	Food intake method or Status measure	Micronutrients included in the study
	†Nutrition and Lifestyle in the Baltic Republics – Summary Report[66]	1999	Males and females aged 20–65 years	2606 M 1132 F	24hR	Ca, Fe, vitamin C
Poland	Iodine excretion with urine and thyrotrophic hormone concentration in normal and complicated pregnancies in the industrial region of iodine deficiency[73]	2006	Pregnant women aged 28·2 ± 6·4 years	104 F	Urinary iodine	Iodine
	†Food consumption of low income groups in Poland and Belgium[74]	2007	Males and females aged 19–59 years	240 M&F	24hR and FFQ	Ca, Cu, Fe, vitamin B_{12}, vitamin C, Zn
	†Wartość energetyczna i odżywcza diety dorosłych mieszkańców Polski. Wyniki programu WOBASZ (unpublished results, obtained by personal correspondence with Dr Elzbieta Sygnowska, 10 November 2010)[75]	2010	Males and females aged 20–74 years	3132 M 3529 F	24hR; homocysteine	Ca, Cu, folate, Fe, vitamin B_{12}, vitamin C, vitamin D, Zn
	Dietary habits in three Central and Eastern European countries: the HAPIEE study[57]	2009	Males and females aged 45–69 years	4815 M 5044 F	FFQ validated	Ca, folate, Fe, vitamin C
	Polish Food Consumption and Anthropometric Survey 2000: comparison between household budget survey and 24-h recall data in a nationally representative sample of Polish households[76]	2005	All age groups (0–96 years)	3716 M&F	24hR	Ca, Cu, Fe, vitamin C, Zn
	Effectiveness of the iodine prophylaxis model adopted in Poland[77]	2008	Boys and girls aged 6–12 years	1450 M 1563 F	Urinary iodine	Iodine
	Increased prevalence of hyperthyroidism as an early and transient side-effect of implementing iodine prophylaxis[78]	2007	Males and females aged >16 years	491 M 933 F	Urinary iodine	Iodine
	Comparative analysis of zinc status, food products' frequency intake and food habits of 11-year-old healthy children[79]	2002	Children aged 11 years	157 M&F	Serum Zn	Zn
Serbia	†National Survey of the Biological Impact of Universal Salt Iodisation in the Population of Serbia 2007[80]	2007	Children aged 6–14 years	1745 M&F	Urinary iodine	Iodine
	†Yugoslav study of atherosclerosis precursors in schoolchildren in Serbia from 1998–2003[36]	2003	Boys and girls aged 15 years; males and females aged 10–15 years, 30–59 years and 60–75 years	1984 M 1859 F; 1225 M 1173 M 147 M 1228 F 1227 F 246 F	HFCS (7 d record); Hb	Ca, Cu, folate, Iodine, Fe, vitamin B_{12}, vitamin C, vitamin D, Zn
Slovakia	Vitamin C protective plasma value[81]	2007	Males and females aged 19–68 years	78 M 109 F	FFQ	Vitamin C
The Republic of Srpska	The Republic of Srpska Iodine Deficiency Survey 2006[82]	2008	Boys and girls aged 7–10 years	599 M 592 F	Urinary iodine	Iodine

M, males; F, females; 24hR, 24 h recall; 3dDR, 3 d diet record; HFCS, household food consumption survey.
*For all studies: supplements are not included in the assessment.
†Grey literature.



Country	Dietary intake method	No. of subjects; sex	Age range (years)	Mean (mg/d)	SD	Energy (kJ/d)	SD
Sweden[16]	EFR	500 M 500 F	19–64	1069 922	395 300	9933 7841	
Finland[16]	24hR	730 M 846 F	19–64	1202 1007	592 450	9265 6804	2960 2028
Denmark[16]	EFR	300 M 300 F	19–64	1055 990	448 389	10 638 8232	2910 2209
Ireland[16]	EFR	650 M 650 F	19–64	949 742	354 299	11 033 7623	3108 2007
Germany[16]	DH	5000 M 5000 F	19–64	1171 1047	558 389	11 041 8131	4112 2511
France[16]	EFR	954 M 800 F	52–68	1032 964	325 339	NA	
Spain[16]	2x24hR	750 M 750 F	19–59	830 778	200 170	8925 7047	
Portugal[16]	FFQ	1200 M 1200 F	19–64	883 963	354 359	9937 8731	2305 2108
Italy[16]	EFR	700 M 700 F	19–64	947 851	309 264	10 336 8433	1906 1604
Serbia[36]	HFCS	1173 M 1227 F	30–60	1426 1105	643 501	11 415 (M&F)	
Poland[56]	FFQ	4815 M 5044 F	45–69	872 899	425 438	9529 8727	2910 2608
Lithuania[66]	24hR	2606 M 1132 F	19–64	858 782	468 420	10 945 8202	4317 3494
Latvia[66]	24hR	1065 M 1235 F	19–64	742 855	456 547	10 848 7522	5023 3355
Hungary[69]	24hR	473 M 706 F	18–60+	717 656	319 276	11 734 9227	
Estonia[66]	24hR	900 M 115 F	19–64	716 589	544 362	9567 6888	4804 3217
Czech Republic[57]	FFQ	3690 M 4223 F	51–65	721 835	362 411	8727 4867	3007 3007
Croatia[62]	FFQ	183 M 480 F	18–30	1711 1444	965 740	15 955 11 982	7534 5720

Fig. 1 Mean (SD) calcium intake in mg/d and mean (SD) energy intake in kJ/d for males (M) and females (F) by country and region (separated at — - —, from top to bottom, into Scandinavia, Western Europe, Mediterranean and Central and Eastern Europe). Dietary intake method: EFR = estimated food record; 24hR = 24 h recall; DH = diet history; HFCS = household food consumption survey. NA = not available. Plot shows mean intakes with 95 % confidence intervals represented by horizontal bars: ○, males; ■, females; ——, Average Nutrient Requirement (800 mg/d for females and males)

females in Estonia, Hungary and Lithuania was below the ANR (source: NNR), which indicates that there is a risk of inadequacy. Similar results were observed for CEE males (pooled estimated mean: 862 mg/d); the pooled mean Ca intakes for Scandinavian, Western European and Mediterranean countries were 1130, 1129 and 885 mg/d, respectively. In CEE, four out of eight countries had a mean intake below the ANR among males, and in three countries among females. Within CEE, relatively high levels of Ca intake were observed for Croatia and Serbia. This can likely be explained by the different age range of the study population in the Croatian study (university students, 18–30 years) and the different dietary assessment method used in the Serbian study (intake data were collected per household and calculated per person using the consumption units). This explanation is supported by the fact that mean energy intakes in these studies are also relatively high. This remark also holds for the levels of intake of other micronutrients from these two studies.

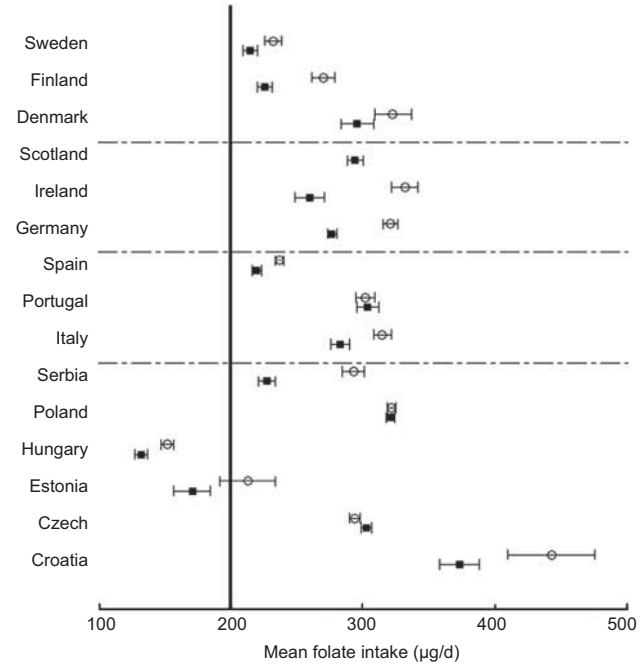
Figure 2 shows the observed mean intakes for folate. In CEE the mean pooled intake (307 μg/d) was slightly higher than in the other regions (Scandinavia: 235 μg/d, Western Europe: 278 μg/d, Mediterranean: 275 μg/d), which was due to the relatively high value for Croatia. In CEE, Hungarian and Estonian females had mean intake below the ANR, indicating a risk of inadequacy. Among CEE males, the estimated mean intake (302 μg/d) was in the same range as those in other regions (Scandinavia: 268 μg/d, Western Europe: 322 μg/d, Mediterranean: 287 μg/d). Hungarian males had folate intake below the ANR.

These results correspond with the previous publication by de Bree *et al.*[34] which indicated that mean dietary folate intake in Europe is in line with recommendations.

The observed mean Fe intakes are shown in Fig. 3. The pooled mean intake among females from CEE (13 mg/d) was similar to those from the other European regions (range: 11–13 mg/d). For all CEE countries the mean intake of females was above the ANR with the exception of Hungary. For males, the mean estimated intake in CEE (16 mg/d) was slightly higher than that in other regions (range: 13–15 mg/d); all countries reported an observed mean intake higher than the average daily requirements.

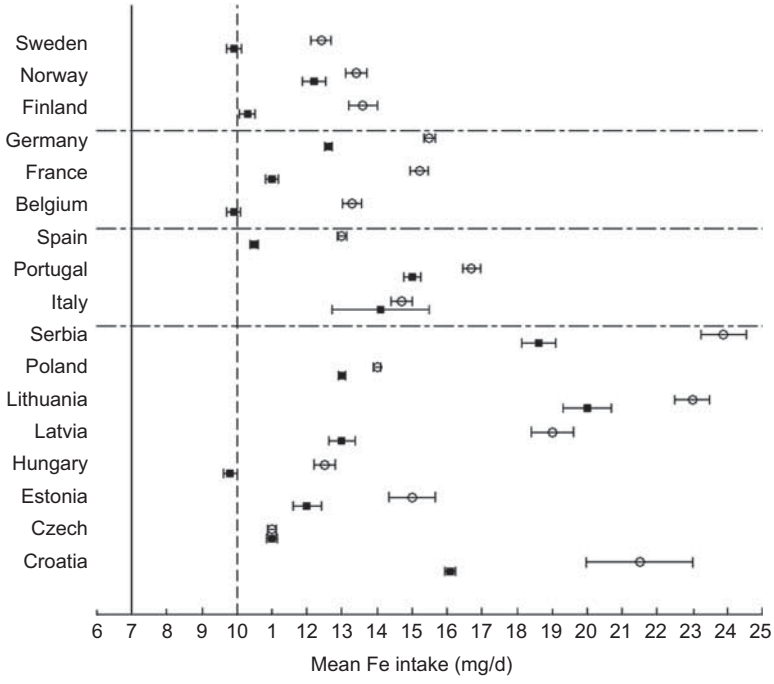
The mean intakes of vitamin B_{12} are shown in Fig. 4. The pooled levels for both females and males in CEE (4 and 7 μg/d, respectively) were similar to the pooled means for Scandinavia and Western Europe, whereas the highest means were observed in the Mediterranean countries (7 μg/d in females, 8 μg/d in males). For both genders in all countries, mean intake values were above the ANR.

The mean observed vitamin C intake (Fig. 5) in CEE females (pooled estimate: 134 mg/d) was similar to that in



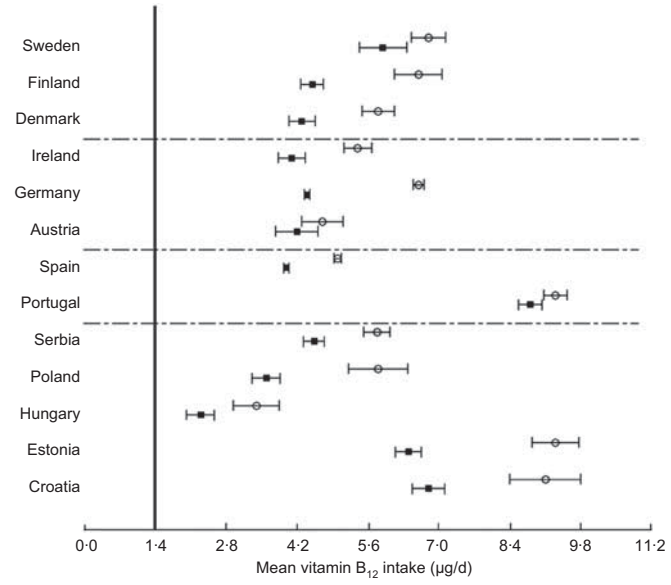
Country	Dietary intake method	No. of subjects; sex	Age range (years)	Mean (μg/d)	SD	Energy (kJ/d)	SD
Sweden[16]	EFR	500 M	19–64	232	73	9933	
		500 F		215	65	7841	
Finland[16]	24hR	730 M	19–64	270	120	9265	2960
		846 F		226	88	6804	2028
Denmark[16]	EFR	300 M	19–64	323	120	10 638	2910
		300 F		296	111	8232	2209
Scotland[16]	FFQ	898 F	45–54	294	89	7925	
Ireland[16]	EFR	650 M	19–64	332	128	11 033	3108
		650 F		260	144	7623	2007
Germany[16]	DH	5000 M	19–64	321	202	11 041	4112
		5000 F		277	124	8131	2511
Spain[16]	2x24hR	750 M	19–59	237	45	8925	
		750 F		220	48	7047	
Portugal[16]	FFQ	1200 M	19–64	302	130	9937	2305
		1200 F		304	144	8731	2108
Italy[16]	EFR	700 M	19–64	315	91	10 336	1906
		700 F		283	100	8433	1604
Serbia[36]	HFCS	1173 M	30–60	293	148	11 415 (M&F)	
		1227 F		228	116		
Poland[56]	FFQ	4815 M	45–69	322	118	9529	2910
		5044 F		321	124	8727	2608
Hungary[69]	24hR	473 M	18–60+	152	53	11 734	
Hungary[68]	3x24hR	352 F	18–59	132	47	9227	
Estonia[50]	24hR	126 M	55–65	213	121	9567	4804
		190 F		171	99	6888	3217
Czech Republic[57]	FFQ	3690 M	51–65	294	115	8727	3007
		4223 F		303	135	4867	3007
Croatia[52]	FFQ	183 M	18–30	443	226	15 955	7534
		480 F		373	168	11 982	5720

Fig. 2 Mean (SD) folate intake in μg/d and mean (SD) energy intake in kJ/d for males (M) and females (F) by country and region (separated at — - —, from top to bottom, into Scandinavia, Western Europe, Mediterranean and Central and Eastern Europe). Dietary intake method: EFR = estimated food record; 24hR = 24 h recall; DH = diet history; HFCS = household food consumption survey. NA = not available. Plot shows mean intakes with 95 % confidence intervals represented by horizontal bars: ○, males; ■, females; ——, Average Nutrient Requirement (200 μg/d for females and males)



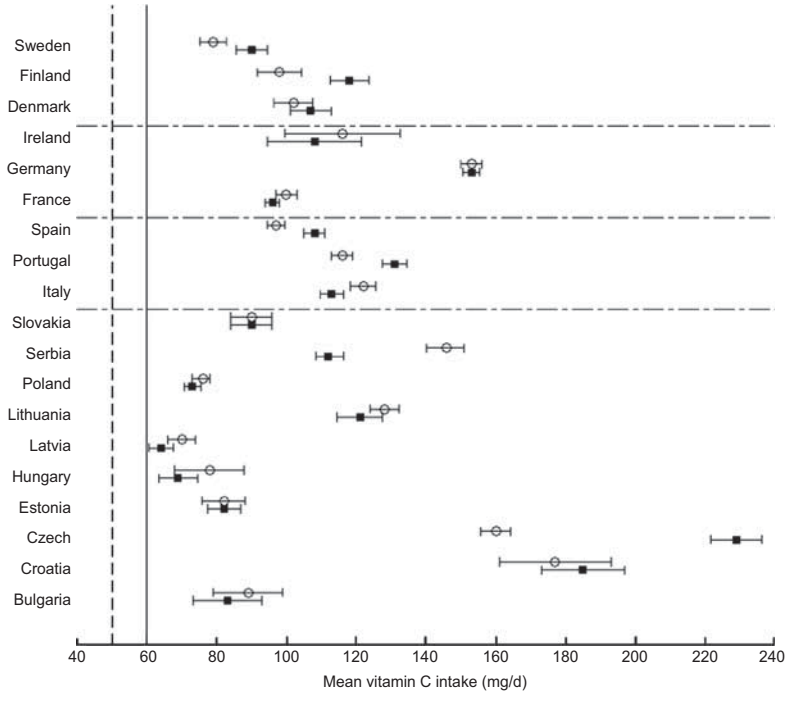
Country	Dietary intake method	No. of subjects; sex	Age range (years)	Mean (mg/d)	SD	Energy (kJ/d)	SD
Sweden[16]	EFR	500 M	19–64	12	3	9933	
		500 F		10	2	7841	
Norway[16]	FFQ	1100 M	16–79	13	5	11142	3914
		1100 F		12	6	1936	645
Finland[16]	24hR	730 M	19–64	14	6	9265	2960
		846 F		10	3	6804	2028
Germany[16]	DH	5000 M	19–64	16	6	11 041	4112
		5000 F		13	4	8131	2511
France[16]	EFR	954 M	52–68	15	4	NA	
		800 F		11	3		
Belgium[16]	24hR	500 M	19–64	13	3	NA	
		500 F		10	2		
Spain[16]	2x24hR	750 M	19–59	13	2	8925	
		750 F		11	2	7047	
Portugal[16]	FFQ	1200 M	19–64	17	5	9937	2305
		1200 F		15	4	8731	2108
Italy[16]	EFR	700 M	19–64	15	4	10 336	1906
		700 F		14	19	8433	1604
Serbia[36]	HFCS	1173 M	30–60	24	11	11 415 (M&F)	
		1227 F		19	9		
Poland[56]	FFQ	4815 M	45–69	14	4	9529	2910
		5044 F		13	4	8727	2608
Lithuania[66]	24hR	2606 M	19–64	23	13	10 945	4317
		1132 F		20	12	8202	3494
Latvia[66]	24hR	1065 M	19–64	19	10	10 848	5023
		1235 F		13	7	7522	3355
Hungary[69]	24hR	473 M	18–60+	13	3	11 734	
		706 F		10	3	9227	
Estonia[66]	24hR	900 M	19–64	15	10	9567	4804
		1115 F		12	7	6888	3217
Czech Republic[57]	FFQ	3690 M	51–65	11	4	8727	3007
		4223 F		11	5	4867	3007
Croatia[52]	FFQ	183 M	18–30	22	10	15 955	7534
		480 F		16	2	11 982	5720

Fig. 3 Mean (SD) iron intake in mg/d and mean (SD) energy intake in kJ/d for males (M) and females (F) by country and region (separated at — - —, from top to bottom, into Scandinavia, Western Europe, Mediterranean and Central and Eastern Europe). Dietary intake method: EFR = estimated food record; 24hR = 24 h recall; DH = diet history; HFCS = household food consumption survey. NA = not available. Plot shows mean intakes with 95 % confidence intervals represented by horizontal bars: ○, males; ■, females; ——, Average Nutrient Requirement (ANR; 7 mg/d for males); – – –, ANR (10 mg/d for females)



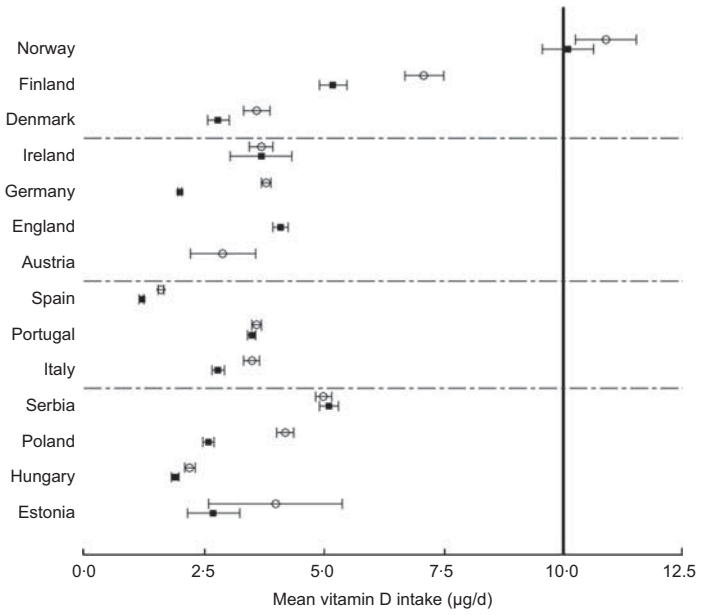
Country	Dietary intake method	No. of subjects; sex	Age range (years)	Mean (mg/d)	SD	Energy (kJ/d)	SD
Sweden[16]	EFR	500 M	19–64	7	4	9933	
		500 F		6	5	7841	
Finland[16]	24hR	730 M	19–64	7	6	9265	2960
		846 F		5	3	6804	2028
Denmark[16]	WFR	400 M	19–64	6	3	10 638	2910
		400 F		4	3	8232	2209
Ireland[16]	EFR	700 M	19–64	5	4	11 033	3108
		700 F		4	4	7623	2007
Germany[16]	DH	5000 M	19–64	7	4	11 041	4112
		5000 F		4	2	8131	2511
Austria[16]	EFR	125 M	>64	5	2	8026	
		125 F		4	2	6921	
Spain[16]	2x24hR	750 M	19–59	5	1	8925	
		750 F		4	1	7047	
Portugal[16]	FFQ	1200 M	19–64	9	4	9937	2305
		1200 F		9	4	8731	2108
Serbia[36]	HFCS	1173 M	30–60	6	4	11 415 (M&F)	
		1227 F		5	4		
Poland[75]	24hR	3132 M	20–74	6	17	10 386	
		3529 F		4	8	7060	
Hungary[50]	24hR	93 M	>65	3	2	10 432	2205
		159 F		2	2	8828	1705
Estonia[50]	24hR	126 M	55–65	9	3	9567	4804
		190 F		6	2	6888	3217
Croatia[52]	FFQ	183 M	18–30	9	5	15 955	7534
		480 F		7	4	11 982	5720

Fig. 4 Mean (SD) vitamin B_{12} intake in μg/d and mean (SD) energy intake in kJ/d for males (M) and females (F) by country and region (separated at — - —, from top to bottom, into Scandinavia, Western Europe, Mediterranean and Central and Eastern Europe). Dietary intake method: EFR = estimated food record; 24hR = 24 h recall; WFR = weighed food record; DH = diet history; HFCS = household food consumption survey. NA = not available. Plot shows mean intakes with 95 % confidence intervals represented by horizontal bars: ○, males; ■, females; ——, Average Nutrient Requirement (1.4 μg/d for females and males)



Country	Dietary intake method	No. of subjects; sex	Age range (years)	Mean (mg/d)	SD	Energy (kJ/d)	SD
Sweden[16]	EFR	500 M	19–64	79	45	9933	
		500 F		90	50	7841	
Finland[16]	24hR	730 M	19–64	98	88	9265	2960
		846 F		118	82	6804	2028
Denmark[16]	WFR	400 M	19–64	102	56	10 638	2910
		400 F		107	61	8232	2209
Ireland[16]	EFR	700 M	19–64	116	223	11 033	3108
		700 F		108	183	7623	2007
Germany[16]	DH	5000 M	19–64	153	106	11 041	4112
		5000 F		153	84	8131	2511
France[16]	EFR	954 M	52–68	100	49	NA	
		1369 F		96	43		
Spain[16]	2x24hR	750 M	19–59	830	200	8925	
		750 F		778	170	7047	
Portugal[16]	FFQ	1200 M	19–64	883	354	9937	2305
		1200 F		963	359	8731	2108
Italy[16]	EFR	700 M	19–64	947	309	10 336	1906
		700 F		851	264	8433	1604
Slovakia[80]	FFQ	68 M	19–68	90		NA	
		109 F		90			
Serbia[36]	HFCS	1173 M	30–60	146	93	11 415 (M&F)	
		1227 F		112	71		
Poland[75]	24hR	3132 M	20–74	76	74	10 386	
		3529 F		73	75	7060	
Lithuania[66]	24hR	2606 M	19–64	128	108	10 945	4317
		1132 F		121	112	8202	3494
Latvia[66]	24hR	1065 M	19–64	70	65	10 848	5023
		1235 F		64	63	7522	3355
Hungary[50]	24hR	93 M	>65	78	49	10 432	2205
		159 F		69	36	8828	1705
Estonia[66]	24hR	900 M	19–64	82	96	9567	4804
		1115 F		82	81	6888	3217
Czech Republic[57]	FFQ	3690 M	51–65	160	135	8727	3007
		4223 F		229	242	4867	3007
Croatia[52]	FFQ	183 M	18–30	177	111	15 955	7534
		480 F		185	132	11 982	5720
Bulgaria[50]	24h R	186 M	60–75	89	70	10 231	4116
		194 F		83	70	8127	2608

Fig. 5 Mean (SD) vitamin C intake in mg/d and mean (SD) energy intake in kJ/d for males (M) and females (F) by country and region (separated at — - —, from top to bottom, into Scandinavia, Western Europe, Mediterranean and Central and Eastern Europe). Dietary intake method: EFR = estimated food record; 24hR = 24 h recall; WFR = weighed food record; DH = diet history; HFCS = household food consumption survey. NA = not available. Plot shows mean intakes with 95 % confidence intervals represented by horizontal bars: ○, males; ■, females; ——, Average Nutrient Requirement (ANR; 60 mg/d for males); – – –, ANR (50 mg/d for females)



Country	Dietary intake method	No. of subjects; sex	Age range (years)	Mean (μg/d)	SD	Energy (kJ/d)	SD
Norway[16]	FFQ	1100 M	16–79	11	11	11 142	3914
		1100 F		10	9	1936	645
Finland[16]	24h	730 M	19–64	7	6	9265	2960
		846 F		5	4	6804	2028
Denmark[16]	WFR	400 M	19–64	4	3	10 638	2910
		400 F		3	2	8232	2209
Ireland[16]	EFR	700 M	19–64	4	3	11 033	3108
		700 F		4	9	7623	2007
Germany[16]	DH	5000 M	19–64	4	4	11 041	4112
		5000 F		2	1	8131	2511
Austria[16]	EFR	170 M	>64	3	5	NA	
England[16]	FFQ	898 F	45–54	4	2	7925	2205
Spain[16]	2x24hR	750 M	19–59	2	1	8925	
		750 F		1	1	7047	
Portugal[16]	FFQ	1200 M	19–64	4	2	9937	2305
		1200 F		4	2	8731	2108
Italy[16]	EFR	700 M	19–64	4	2	10 336	1906
		700 F		3	2	8433	1604
Serbia[36]	HFCS	1173 M	30–60	5	3	11 415 (M&F)	
		1227 F		5	3		
Poland[75]	24hR	3132 M	20–74	4	5	10 386	
		3529 F		3	4	7060	
Hungary[69]	24hR	473 M	18–60+	2	1	11 734	
		706 F		2	1	9227	
Estonia[50]	24hR	126 M	55–65	4	8	9567	4804
		190 F		3	4	6888	3217

Fig. 6 Mean (SD) vitamin D intake in μg/d and mean (SD) energy intake in kJ/d for males (M) and females (F) by country and region (separated at — - —, from top to bottom, into Scandinavia, Western Europe, Mediterranean and Central and Eastern Europe). Dietary intake method: EFR = estimated food record; 24hR = 24 h recall; WFR, weighed food record; DH = diet history; HFCS = household food consumption survey. NA = not available. Plot shows mean intakes with 95 % confidence intervals represented by horizontal bars: ○, males; ■, females; ——, Average Nutrient Requirement (10 μg/d for females and males)

Western European countries (136 mg/d) and higher than in Scandinavia and the Mediterranean (107 and 119 mg/d, respectively). The same held for CEE males: the pooled estimate for CEE was 118 mg/d, for other regions it ranged from 93 to 142 mg/d. Both genders in CEE countries had mean intake above the ANR.

The pooled mean vitamin D intakes for females and males of CEE countries were 3 and 4 μg/d, respectively (Fig. 6). These values were comparable to those of the other regions; pooled estimates for females and males were 7·8 μg/d in Scandinavia, 2·4 μg/d in Western Europe and 3·3 μg/d in Mediterranean countries. The mean intakes in CEE and in other regions were below the ANR with exception of Norway.

Data for the other micronutrients (Cu, iodine, Se and Zn) were limited and available for one or two CEE countries and for some population groups only (see Table 2).

The mean Cu intake in CEE countries was comparable to those in other European countries, 1·2–1·9 mg/d[16], except for Serbia, which reported the highest intake. The mean intakes were above the reference values set for Cu. Iodine intake data were available only for Serbia, and the mean intake was in the range of other regions (108–253 μg/d for males; 101–194 μg/d for females)[16] being above the ANR. Se intake data for CEE adults were available for Croatia, and the mean intake value was above the range observed in the other regions (36–73 μg/d for males; 31–55 μg/d for females)[16]. The mean intakes for both genders were well above the ANR. Data on mean Zn intake were available for three CEE countries, and the values were similar to those for non-CEE countries (7·8–13·6 mg/d for males; 7·8–10·3 mg/d for females)[16]; the average intakes were considerably above the ANR.

Data on micronutrient intakes in CEE children were available from Croatia, Hungary and Serbia. The mean micronutrient intakes in these countries (Table 3) were in range of intakes in children in other European countries[16]: Ca (600–1381 mg/d), Cu (0·8–1·9 mg/d), folate (138–428 μg/d), iodine (94–209 μg/d), Fe (7·7–17·9 mg/d), Se (28–110 μg/d), vitamin C (78–197 mg/d), vitamin D (1·2–4·8 μg/d) and Zn (6·5–14·6 mg/d), except for the intake of vitamin B_{12} in Hungary, which was lower in comparison to other European regions (2·9–11·8 μg/d). In these three CEE countries, mean daily intakes below the ANR were observed for Ca (except in boys in Serbia), folate, vitamin D and for Se in Croatia.

Comparison of micronutrient status

For micronutrient status most CEE data were available for iodine and Fe status in children. Figures 7 and 8 show the median urinary iodine concentrations and the mean (SD) Hb concentrations, respectively, for children in Europe. The data on iodine and Fe status were retrieved mainly from the WHO VMNIS database. Exceptions are the data for The Republic of Srpska and Serbia. CEE countries had lower median urinary iodine levels than other European

Table 2 Mean energy and micronutrient intakes (copper, iodine, selenium and zinc) by Central and Eastern European country in males and females

Nutrient/country	Dietary intake method	No. of subjects; sex	Age range (years)	Mean	SD	Energy (kJ/d)	SD
Cu (mg/d)							
Croatia[52]	FFQ	183 M	18–30	2	1	15 955	7534
		480 F		2	1	11 982	5720
Hungary[69]	24hR	473 M	18–60+	1	1	11 734	
		706 F		1	0·5	9227	
Poland[75]	24hR	3132 M	20–74	1	0·5	10 386	
		3529 F		1	0·4	7060	
Serbia[36]	HFCS	1173 M	30–60	5	7	11 415 (M&F)	
		1227 F		4	5	11 415 (M&F)	
Iodine (μg/d)							
Serbia[36]	HFCS	1173 M	30–60	184	139	11 415 (M&F)	
		1227 F		144	112	11 415 (M&F)	
Se (μg/d)							
Croatia[52]	FFQ	183 M	18–30	215	106	15 955	7534
		480 F		141	65	11 982	5720
Zn (mg/d)							
Croatia[52]	FFQ	183 M	18–30	18	9	15 955	7534
		480 F		13	6	11 982	5720
Hungary[69]	24hR	473 M	18–60+	10	3	11 734	
		706 F		8	2	9227	
Serbia[36]	HFCS	1173 M	30–60	15	9	11 415 (M&F)	
		1227 F		12	8	11 415 (M&F)	

24hR, 24 h recall; HFCS, household food consumption survey.
Reference values: Average Nutrient Requirement (value from Nordic Nutrition Recommendations or US Institute of Medicine) for adults per d: Cu 0·7 mg; iodine 100 μg; Se 30 μg for females, 35 μg for males; Zn 5 mg for females, 6 mg for males.

regions: mild iodine deficiency (median urinary iodine <100 μg/l) in CEE was found in children and adolescents from Estonia, Hungary, Latvia and Lithuania, whereas children in Albania suffered from moderate iodine deficiency (median urinary iodine <50 μg/l). Data from other European countries showed an adequate iodine status (median urinary level >100 μg/l) for all countries, except for Italy and Belgium.

The mean Hb levels in CEE children and adolescents were lower than in other European countries, for which the data were scarce. Mean levels were in general above the cut-off values; only infants in Lithuania were at risk of Fe-deficiency anaemia (Hb <110 g/l), whereas children in Romania had borderline concentration.

CEE data on iodine and Fe status in adults, and on folate, vitamin B_{12} and Zn status for all population groups, were too limited to allow between-region comparisons. An overview of the available status data for CEE populations is presented in Table 4.

Median urinary iodine concentration in CEE adults ranged from 51 to 158 μg/d, similar to those in other European regions (source: WHO VMNIS database for non-CEE countries; not included in the table). In CEE, mild iodine deficiency (median urinary iodine <100 μg/l) was observed in Romanian females. In other regions, both males and females from Italy, France and Germany had mean urinary iodine levels below the cut-off.

Prevalence of iodine deficiency in Europe was recently outlined by Zimmerman and Andersson[35]. For CEE countries (data on school-aged children; if not available, pre-school children, adolescents or adults) iodine deficiency was reported in Albania, Estonia, Hungary, Latvia and Lithuania.

For Fe status, CEE data were available only for Serbia[36] and for females from Macedonia[12]. Reported mean Hb concentrations were in the same range as those in other European countries included in the WHO global database (e.g. Spain, France, Denmark and Finland) and above the cut-off value of 120 or 130 g/l.

Overall, the results on Fe status (Hb levels above the cut-offs) confirm the results on Fe intake for all countries in the present study (except Hungary).

Data on folate status were available for adults in Croatia, Czech Republic and Hungary. Mean serum folate levels in CEE were comparable to those from other European countries (range mean: 16 to 18 nmol/l)[37–39], with the exception of Norwegian adults (7 nmol/l)[40]. The mean serum folate levels in CEE populations and in other regions were above the cut-off values for both genders, except for Roma mothers in Czech Republic. The findings on folate status are in accordance with observed results on folate intake from the present study for all European regions (except Hungary and Estonian females).

For vitamin B_{12} status, only one study from CEE was identified. In the Czech Republic reported mean levels of serum vitamin B_{12} were comparable to those in other European countries, such as Norway[40], and above the reference value (150 pmol/l). These findings are consistent with the vitamin B_{12} intake results from the present study (Fig. 4).

Data on Zn status were available for adults and children in three CEE countries. CEE adults from Czech

Table 3 Energy and micronutrient intakes by Central and Eastern European country in boys and girls – means and SD, dietary intake method, age range and number of subjects (*n*)

	Ca (mg)	SD	Cu (mg)	SD	Folate (μg)	SD	Iodine (μg)	SD	Fe (mg)	SD	Se (μg)	SD	Vitamin B_{12} (μg)	SD	Vitamin C (mg)	SD	Vitamin D (μg)	SD	Zn (mg)	SD	Energy (kJ)	SD
Croatia[55], FFQ, 8–16 years																						
Boys and girls, *n* 315	927	306			162	63			19	7	22	8	5	2	135	68	2	1	12	4	9017	2604
Hungary[67], FFQ, 11–14 years																						
Boys, *n* 124	798	288	1	0·3	151	58			11	3			3	2	99	79	2	1	9	2	10 453	1902
Girls, *n* 111	696	238	1	0·3	140	65			10	3			2	1	94	70	2	1	7	2	9219	1503
Serbia[36], HFCS, 10–15 years																						
Boys, *n* 1225	1123	499	4	7	230	117	147	112	19	9			5	4	114	72	4	3	12	8	11 533	
Girls, *n* 1228	958	428	3	4	196	97	124	94	16	7			4	3	97	60	3	2	10	7	9769	

HFCS, Household food consumption survey.
Reference values: Average Nutrient Requirement (value from US Institute of Medicine) for children per d: Ca 1100 mg; Cu 0·5 mg; folate 250 μg; iodine 73 μg; Fe 6 mg; Se 35 μg; vitamin B_{12} 1·5 μg; vitamin C 39 mg; vitamin D 10 μg; Zn 7 mg.

Republic and Hungary had mean Zn status concentrations (13–17 μmol/l) comparable to those in Western European countries (range mean: 13–14 μmol/l)[41–43] and higher than the reference value. Mean status levels for Polish and Czech children were in the range from 12 to 15 μmol/l (above the cut-offs), and similar to findings from other European countries such as the UK (15 μmol/l)[44].

Discussion

The present study reports the first comprehensive overview of CEE nutritional data using both open access and grey literature sources with a twofold objective: evaluation of intake and status for targeted micronutrients in CEE in comparison to (i) those of other European countries and (ii) the reference values.

From the limited data available, the results of this review show no differences in micronutrient intake and status in CEE populations in comparison to other European regions except for intake of Ca in adults, and iodine and Fe status in children (intake and status levels lower in CEE than in non-CEE countries). Comparisons with the intake/status reference values suggest highest risk of inadequacy in intake of vitamin D in all age ranges, and of Ca, folate and iodine in children.

We collated data using EURRECA's best practice guidance on dietary assessment methods and status biomarkers[30]. In general, CEE studies on micronutrient intake and status for all age ranges were scarce: even after being less strict in inclusion criteria, only a few intake studies could be added to the current comprehensive overview. The largest knowledge gap regarding intake refers to children; whereas data on status were scarce for all population groups, with the exception of Fe and iodine in children. The available studies on micronutrient intake and status studies in CEE countries are diverse with regard to design: they differ in dietary assessment, food composition databases, sampling procedures and age range, and this may confound regional and between-country comparisons. Cooperation with the nutritional network from CEE[17] resulted in obtaining nine studies from grey literature. Even though this was not sufficient to fill an evident knowledge gap in nutritional data from CEE, it added to the existing open sources. However, despite a paucity of data and the variations in methodologies that can influence the true differences in intake[45], some regional variations were observed: it seems that nutritional health in CEE in comparison to other European countries is less favourable but only for certain micronutrients.

Since CEE is less affluent compared with other European regions, it would be interesting to examine the variations in micronutrient intake and status within CEE countries across different socio-economic layers. That would indicate specific subgroups that are most at

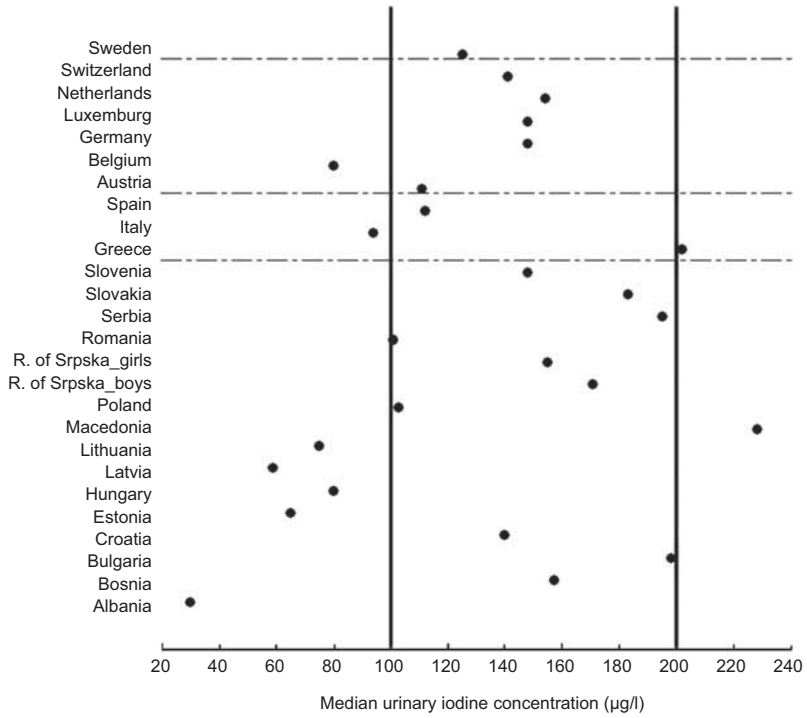


Fig. 7 Median urinary iodine concentration in μg/l per d in children and adolescents by country and region (separated at — - —, from top to bottom, into Scandinavia, Western Europe, Mediterranean and Central and Eastern Europe). ——, Optimal range for median urinary iodine concentration (100–199 μg/l). Source of data: WHO Vitamin and Mineral Nutrition Information System, except for studies from Republic of Srpska[82] and Serbia[80]

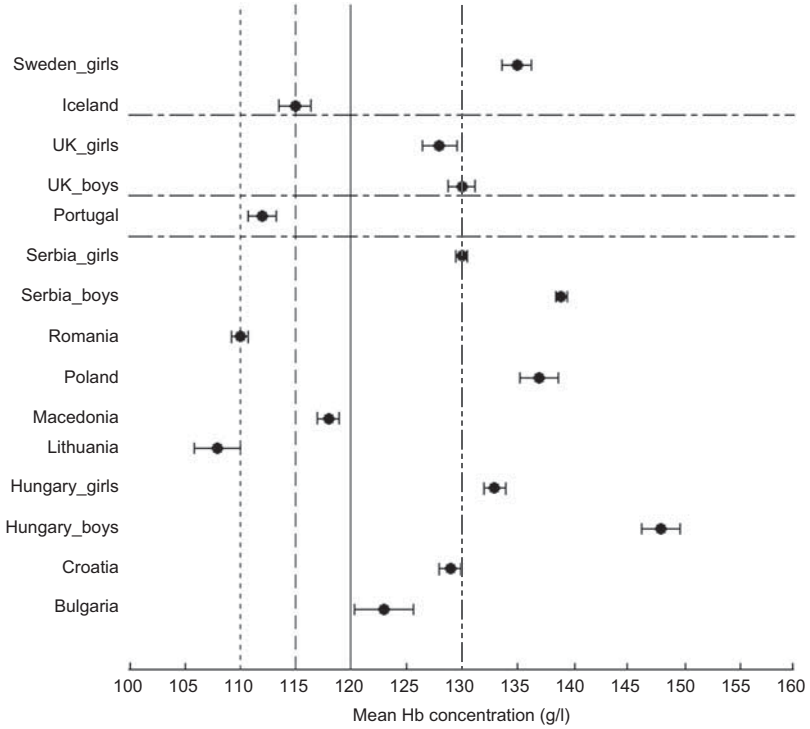


Fig. 8 Mean Hb concentrations (with 95 % confidence intervals represented by horizontal bars) in g/l per d in children and adolescents by country and region (separated at — - —, from top to bottom, into Scandinavia, Western Europe, Mediterranean and Central and Eastern Europe). Age range of the subjects: Bulgaria 2–4 years; Croatia 7–8 years; Hungary 15–19 years; Lithuania 0·5–2 years; Macedonia 0·5–5 years; Poland 10–13 years; Romania 1 year; Serbia 15 years; Portugal 1 year; Iceland 1 year; UK 7–10 years; Sweden 15–16 years. Hb concentration below which anaemia is present: - - -, 110 g/l (children aged 0·5–5 years); – – –, 115 g/l (children aged 5–11 years); ——, 120 g/l (children aged 12–14 years and females aged >15 years); — - - —, 130 g/l (males aged >15 years). Source of data: WHO Vitamin and Mineral Nutrition Information System, except for study from Serbia[36]

Table 4 Micronutrient status by Central and Eastern European country: folate, vitamin B_{12} and zinc in adults and children, iodine and iron in adults – medians or means and SD

Country	No. of subjects; sex	Age range (years)	Mean status marker level (or median where indicated)	SD
Serum folate (mean and SD/median; nmol/l)				
Croatia[53]	100 F	20–30	23	9
Czech Republic (lactation)[58]	227 F	20–35	20 (median) Polish; 7 (median) Roma	
Czech Republic[61]	126 M	25–65	14	0·4
	125 F		14	0·4
Czech Republic[62]	250 M	18–65	14 (median)	
	261 F	18–64	14 (median)	
Hungary[71]	1173 M	>18	20	9
	1386 F		21	10
Urinary iodine (median; μg/l)				
Poland[78]	491 M	>16	121	
	933 F		106	
Romania[WHO database]	1387 F	15–46	51	
Czech Republic[WHO database]	254 M&F	18–66	114	
Bulgaria (pregnancy)[51]	355 F	26 ± 5	165	
Czech Republic (pregnancy)[59]	168 F	17–41	367	
Serbia (pregnancy)[80]	347 F	20–35	158	
Hb (mean and SD; g/l)				
Serbia[36]	544 M	20–21	148	10
	725 F		128	11
Macedonia[WHO database]	1018 F	15–46	134	14
Serum vitamin B_{12} (mean and SD/median; pmol/l)				
Czech Republic[61]	126 M	25–65	239	7
	125 F		239	7
Czech Republic[62]	250 M	18–65	278 (median)	
	261 F		278 (median)	
Serum Zn (mean and SD; μmol/l)				
Czech Republic[63]	118 M	36–49	13	3
	118 F		13	3
Hungary[71]	1173 M	>18	17	3
	1386 F		17	3
Czech Republic[63]	90 boys	10	15	3
	194 girls		14	3
Poland[79]	157 boys and girls	11	12	2

WHO database, WHO Vitamin and Mineral Nutrition Information System; M, males; F, females.
Proposed cut-off values[20–27,30–33]: serum folate 10 nmol/l for adults; urinary iodine 100 μg/l for adults, 150 μg/l for pregnant women; Hb 130 g/l for males, 120 g/l for females, 110 g/l for pregnant women; serum vitamin B_{12} 150 pmol/l for adults; serum Zn 10 μmol/l for children and females, 10·7 μmol/l for males.

risk of poor nutritional health. For future research, we recommend reviewing grey literature, and its accessibility and reliability need further attention. However, to bring a comprehensive conclusion on the nutritional situation in CEE countries much work is required: for developing tailored, sound, evidence-based nutritional policy, the knowledge gaps and establishing nutritional surveys of comparable quality, covering the diversity of population groups, need to be addressed. The inclusion of CEE countries in pan-European nutritional surveys is highly essential to achieve this objective.

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