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Quantitative analysis of nutrient intake in children under 3 years old. ALSALMA study☆,☆☆

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Abstract
Objective: The objective of the study was to analyse the nutritional patterns of children under three years of age and to compare the results against the recommendations for energy and nutrient intake.
Patients and methods: In this cross-sectional epidemiological study, parents completed a dietary diary on their food intake of their children on 4 non-consecutive days. The percentage of children with mean intakes below the recommendations for each age and nutrient was analysed using the ''Estimated Average Requirement (EAR) cut-point method.''
Results: A total of 186 paediatricians included 1701 children in the study. A total of 95.9% ($n = 1320$) of the children between 7 and 36 months had a protein consumption more than twice that of the Recommended Daily Allowances. The deficiencies observed (% <EAR) in the age groups 13–24 months and 25–36 months, respectively, were: vitamin D in 81.7% and 92.1%; vitamin E in 39.3% and 53.4%; folic acid in 12.5% and 14.8%; calcium in 10.1% and 5.5%; iodine in 27.1% and 31%. It was observed that a higher percentage in the daily intake of proteins ($P = .013$) and of carbohydrates ($P < .0001$), and a lower percentage of total lipids ($P < .0001$), were related to a greater body mass index, regardless of energy intake.

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Conclusions: The study presents a very detailed view of the eating patterns of Spanish children less than three years of age. The encouragement of healthy feeding should be directed towards the correction of the dietary imbalances detected, in order to promote the future health of children.

PALABRAS CLAVE
Nutrición;
Encuesta;
Nutrientes;
Proteínas;
España

Análisis cuantitativo de la ingesta de nutrientes en niños menores de 3 años. Estudio ALSALMA

Resumen
Objetivo: El objetivo del estudio fue analizar el patrón de alimentación de niños menores de 3 años y comparar los resultados con las recomendaciones de consumo energético y de nutrientes.
Pacientes y métodos: En este estudio epidemiológico transversal, los padres completaron un diario dietético sobre el consumo de alimentos de sus hijos, durante 4 días no consecutivos. Se analizó la proporción de niños con ingestas medias inferiores a las recomendaciones para cada edad y nutriente, mediante el método «Estimated Average Requirement (EAR) cut-point method».
Resultados: Participaron 186 pediatras, que incluyeron a 1.701 niños. El 95,9% (n = 1320) de los niños de 7 a 36 meses consumieron proteínas por encima del doble de las Recommended Dietary Allowances. Las deficiencias observadas (% < EAR) en los grupos de edad de 13-24 meses y 25-36 meses, respectivamente, fueron: vitamina D en el 81,7 y el 92,1%; vitamina E en el 39,3 y el 53,4%; ácido fólico en el el 12,5 y el 14,8%; calcio en el 10,1 y el 5,5%; yodo en el 27,1 y el 31%. Se observó que una mayor proporción en el consumo diario de proteínas (p = 0,013) y de hidratos de carbono (p < 0,0001), y una menor proporción de lípidos totales (p < 0,0001), estaban relacionadas con un mayor índice de masa corporal, independientemente del consumo energético.
Conclusiones: El estudio mostró una visión muy detallada de los patrones de alimentación de los niños españoles menores de 3 años. La promoción de una alimentación saludable debería ir dirigida a la corrección de los desequilibrios dietéticos detectados, para favorecer la salud futura de los niños.

Introduction

Nutrition is one of the main determinants of health in humans. An adequate nutrition is essential across the lifespan, but it is of particular importance during childhood, as nutritional deficiencies and imbalances in this period may not only have deleterious effects on children's health, but also impact on their future health as adults. An inadequate nutrition may increase the risk of developing several chronic disorders (cancer, high blood pressure, coronary artery disease and other cardiovascular diseases, cerebrovascular diseases, type 2 diabetes mellitus, obesity, osteoporosis) that are the main causes of morbidity and mortality.[1,2]

If we take action during childhood, we can influence the learning and development of future dietary habits and lifestyle. But the first step is to observe the baseline, to recognise the deviation from the recommended dietary patterns and assess the magnitude of this problem. The ALSALMA study was created to this end, a three-phase project designed to explore the clinical perception of paediatricians and the opinion of parents regarding the main nutritional problems in children.[3] The third phase of the project consisted of an epidemiological study, preceded by a pilot study,[4] the purpose of which was to assess the actual nutrient intake of a representative sample of Spanish children less than 3 years of age. This study is the first of its kind in this age group in Spain, and this article presents the results of the quantitative analysis of nutrient intakes.

Methods

Study design and ethical principles

We designed an observational cross-sectional epidemiological study adhering to the principles applicable to observational studies in Spain and to the Declaration of Helsinki. The study was approved by the Ethics Board of the Hospital Clínic i Provincial de Barcelona (2.013/8.152). All parents signed an informed consent to participate in the study.

Selection criteria

The sample size was calculated on the basis of the energy intake data obtained in the ALSALMA-pilot study,[4] and the minimum size was estimated to be 200 children 0–6 months of age (precision, 24.08; power [β], 81.3%); 200 children 7–12 months of age (precision, 32.57; β, 85.3%); 800 children 13–24 months of age (precision, 22.41; β 86.5%), and 800 children 25–36 months of age (precision, 25.32; β, 87.2%). The sample was stratified by province.[5]

The parents included in the study had to have children that met the following criteria: (a) of any ethnicity or sex; (b) 0–36 months of age; (c) meeting the criteria for a healthy child, with no chronic condition that might affect their dietary intake, and (d) not following a specific diet.

Data collection

We designed a 24-h diet diary for the parents, who were instructed by the paediatricians on how to complete it, writing down the type of food, time of day, and quantities consumed. The diary included the weight of the foods, measured uncooked and unpeeled. The full name of product and brand was recorded for processed child nutrition products. When the volume of breast milk could not be measured, it was estimated according to the child's age: 700–900 mL/day in children younger than 6 months and 600 mL/day in children older than 6 months.[6,7]

The diaries were completed over 4 non-consecutive days during the week and at the weekend. The paediatricians recorded the child's date of birth, sex, birth and current weight and height, weeks of gestation, physical activity level (light, moderate, vigorous), whether the child ate at the day care centre, and intake of vitamin supplements (description and dosage). The anthropometric data of the parents, whether the mother smoked during the pregnancy, and the parents' educational level were also recorded.

Quality control

The information collected in the diaries was reviewed by the paediatricians, who entered the data in the study's website (www.estudioalsalma.es). A centralised quality control of the data was performed by a specially trained coordinating medical team.

Statistical analysis

We analysed the frequencies and percentages for qualitative variables, and the mean ± standard deviation, median, minimum, maximum, and 95% confidence interval for quantitative variables.

We converted each consumed food to its macronutrient and energy contents using the DIAL foods database and other Spanish and international databases, analysing the edible portion.[8–11] We created a new database of more than 460 nutrition datasheets with the composition of child formulas and nutrition products.

We calculated the mean daily intake of energy and of each nutrient based on the data collected in the diaries using repeated-measure split–plot analysis of variance (ANOVA). We studied the energy intake profile or energy distribution by macronutrient for every 100 kcal.

We compared the results of our study with the Dietary Reference Intake (DRI) recommendations of the National Academy of Sciences (2002/2005) and the recommendations of the Comité de Nutrición de la Asociación Española de Pediatría (Committee on Nutrition of the Spanish Association of Paediatrics).[12–14] The calculations for the estimated average requirement (EAR) of energy were made based on weight and sex for children 7–11 months of age, and based on the child's sex for children older than 12 months. We did not calculate the energy EAR for infants younger than 6 months, which can only be evaluated in exclusively breastfed infants.[15] We used the Estimated Average Requirement cut-point method, which is recommended by the Institute of Medicine[16] and was adopted by the EFSA in 2010,[17] to determine the population prevalence of intakes below those recommended.

We used one-factor ANOVA to analyse differences in weight, height and body mass index (BMI) between age groups, using a Bonferroni or Games Howell adjustment to correct for multiple comparisons. Proportions were compared by means of Fisher's exact test or the chi square test.

We conducted the exploratory assessments of the association between nutrient intake and BMI by means of a multiple linear regression analysis that included all the variables recorded for children and their parents. Macronutrients were assessed by the mean intake and by contribution to the total energy intake using different equations. We adjusted the significance levels based on the number of variables included in the equation.

We set the level of significance at .05. The software used in the statistical analysis was SPSS 14.0, C-SIDE (Iowa State University) for the EAR assessment, and WHO Anthro for the anthropometric assessment.[18]

Results

Sample data

There were 186 participating paediatricians that included 1701 children in the study between April 4 and October 14, 2013. The sample reached 85% of the initial sample size estimation (2000 children; power > 80%). The data of 1559 children, who amounted to 91.7% of the patients selected for the study, was valid and could be used in the nutritional analysis.

Demographic and anthropometric data of the children

The sample, which included children from 51 provinces, matched the national distribution and was representative of the Spanish population.[19] Out of all children, 54% were male (n = 919) and 46% female (n = 782), with a mean age of 20 months (95% CI, 19.5–20.5) and a median age of 20 months; 99.9% were Caucasian (n = 1699). The age distribution was: 10.8% (n = 183) 0–6 months; 10.9% (n = 186) 7–12 months; 40.6% (n = 690) 13–24 months; and 37.7% (n = 642) 25–36 months.

Table 1 Mean nutrient intakes and proportion of children younger than 6 months with inadequate intakes below the EARs or above the ULs.

Nutrients per day	DRI				Age 0–6 months, *N* = 172			
	EAR	RDA	AI	UL	Mean intake (95% CI)	Median intake	% <EAR	% >UL
Energy (kcal)	–	–	–	–	611.6 (568.6–654.6)	580.8	–	–
Proteins (g)	–	–	9.1[a]	–	12.3 (10.3–14.3)	10.9	–	–
Carbohydrates (g)	–	–	60	–	71.3 (65.5–77.2)	63.7	–	–
Lipids (g)	–	–	31	–	30.6 (28.3–33)	29.6	–	–
Saturated fats (g)	–	NS	–	–	25.6 (23.5–27.6)	14.7	–	–
Monounsaturated fats (g)	–	NS	–	–	7.7 (6.4–9)	10.1	–	–
Polyunsaturated fats (g)	–	NS	–	–	3.9 (3.6–4.2)	3.9	–	–
Cholesterol (mg)	–	NS	–	–	121.5 (108.9–134)	160.9	–	–
Fibre (g)	–	NS	–	–	9.6 (8.5–10.7)	0.6	–	–
Water (mL)[b]	–	–	700	–	745.7 (698–793.5)	727.1	–	–
Vitamin A (μg)	–	–	400	600	620.7 (566.2–675.3)	568.2	–	41.9
Vitamin C (mg)	–	–	40	–	72.8 (66.6–79.1)	64.4	–	–
Vitamin D (μg)	–	10	–	25	6.1 (5.2–6.9)	1.6	–	2.3
Vitamin E (mg)	–	–	4	–	5.8 (5.3–6.3)	3.3	–	–
Vitamin K (μg)	–	–	2	–	25.7 (19.4–32)	9.5	–	–
Vitamin B1 (mg)	–	–	0.2	–	0.4 (0.3–0.5)	0.2	–	–
Vitamin B2 (mg)	–	–	0.3	–	0.6 (0.5–0.7)	0.4	–	–
Niacin (mg)	–	–	2	–	5.4 (4.4–6.3)	4.3	–	–
Vitamin B6 (mg)	–	–	0.1	–	0.4 (0.3–0.4)	0.2	–	–
Folic acid (μg)	–	–	65	–	89.1 (78–100.2)	76.6	–	–
Vitamin B12 (μg)	–	–	0.4	–	0.9 (0.6–1.1)	0.6	–	–
Pantothenic acid (mg)	–	–	1.7	–	1.1 (1–1.3)	1.4	–	–
Biotin (μg)	–	–	5	–	3.6 (2.3–4.8)	3.9	–	–
Copper (mg)	–	–	0.2	–	0.3 (0.3–0.4)	0.3	–	–
Iodine (μg)	–	–	110	–	61.9 (57.6–66.2)	51.3	–	–
Iron (mg)	–	–	0.27	40	3.5 (2.8–4.1)	1.1	–	0
Magnesium (mg)	–	–	30	–	41.4 (34.7–48.2)	32.7	–	–
Calcium (mg)	–	–	200	1000	350.2 (315.6–384.7)	297.3	–	0.6
Phosphorus (mg)	–	–	100	–	201.5 (163.6–239.3)	157.9	–	–
Sodium (mg)	–	–	120	–	170.7 (99.1–242.2)	130.8	–	–
Potassium (mg)	–	–	400	–	556.6 (483.8–629.3)	461.7	–	–
Selenium (μg)	–	–	15	45	36.9 (27.4–46.5)	22.4	–	0
Zinc (mg)	–	–	2	4	7.2 (6.6–7.9)	1.7	–	39.5

DRI met through diet;[11–13] EAR represents the average daily nutrient intake level estimated to meet the requirement of half the healthy individuals in a particular life stage and sex group; NS, there are no current recommendations for this nutrient in this age group; RDA is the reference value for each nutrient sufficient to meet the requirements of 97–98% of healthy individuals in a particular life stage or sex group; AI is the value estimated to meet the requirements of all healthy individuals in each age group based on observations made in apparently healthy individuals for which it is assumed to be adequate. This value is used as a reference in the absence of an established EAR for a given nutrient and age group; UL represents the highest average daily nutrient intake level that is likely to pose no risk of adverse health effects to almost all individuals in the general population. As intake increases above the UL, the potential risk of adverse effects may increase.

AI: Adequate Intake; DRI: Dietary Reference Intakes; EAR: Estimated Average Requirement; 95% CI: 95% confidence interval for the mean; NS: not specified; RDA: Recommended Dietary Allowances; UL: Tolerable Upper Intake Level; % <EAR: prevalence or proportion of individuals with mean intakes below the EARs in the analysis of inadequate dietary intakes; % >UL: prevalence or proportion of individuals with mean daily intakes of the nutrient above the UL in the analysis of the population at potential risk of suffering adverse effects due to excessive intake of the nutrient.

[a] The calculation of AI in this age group is based on 1.5 g/kg/day.

[b] Drinking water and water contained in foods and beverages.

The mean gestational age was 39 weeks (95% CI, 38.9–39.1; median 39), with no differences between sexes or age groups.

We did not observe any differences in the birth weight, height or BMI between children in the 4 age groups. The current BMI of children was 16.5 kg/m^2 (95% CI, 16.4–16.6). Using the standards of the World Health Organization (WHO Anthro) as a reference, we determined that 6.1% of the children were 2 standard deviations (SDs) above the mean BMI (95% CI, 4.2–8.7%) and 1.5% of the children were 3 SDs above

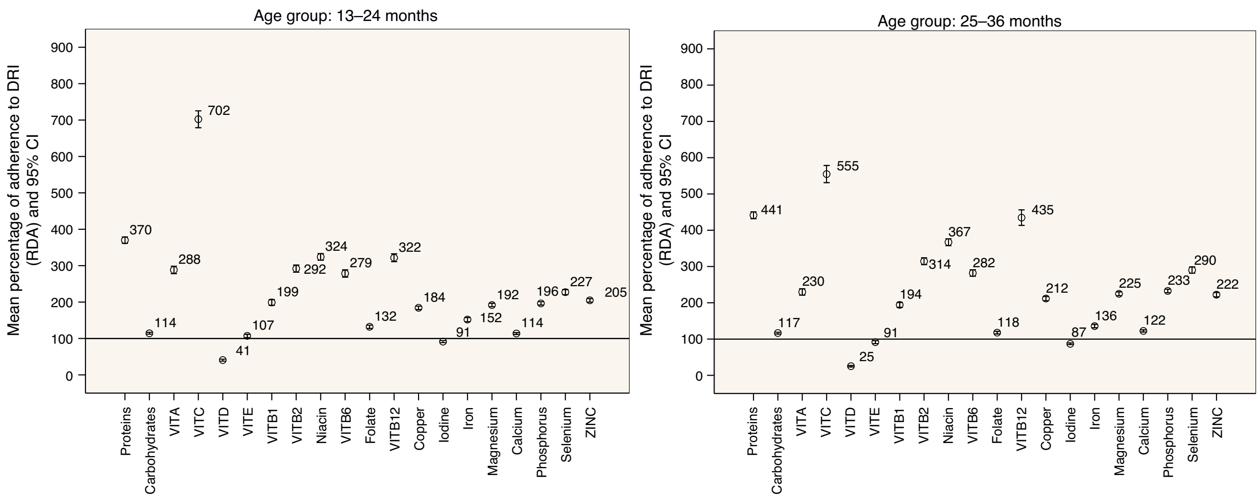

Figure 1 Mean percentage of adherence to DRIs (RDAs) in the daily nutrient intake. An adequate adherence to DRIs (RDA/AI) corresponds to a 100% adherence (horizontal line at 100%). Values below 100% represent energy or nutrient intakes below the recommended values. Values above 100% represent energy or nutrient intakes above the recommended values.

(1.1–2.1%). The physical activity level was light in 15.2% of the children (n = 259), moderate in 53.9% (n = 916) and vigorous in 30.9% (n = 526).

Of all children, 32.9% (n = 559) ate at the day care centre. This proportion increased significantly with the child's age (P < .0001).

Also, 14.6% of the children (n = 248) took vitamin supplements, in greater proportion the younger the children (P < .01). The supplement was vitamin D3 in 74.5% of them (n = 173 children).

Parent data

The mean age was 34.7 years in mothers (95% CI, 34.5–34.9; median 35) and 36.8 years in fathers (95% CI, 36.5–37; median 36). Of all mothers, 7.2% smoked during pregnancy (n = 123). The educational level of mothers and fathers, respectively, was: no studies 0.1%, 0.2%; elementary school 6.8%, 9.2%; secondary education 14.5%, 16.2%; middle vocational education 14.3%, 16.2%; superior vocational education 12.8%, 15.3%, and post-secondary education 51.4%, 42.9%.

Mean daily energy and nutrient intake and comparison with Dietary Reference Intakes (Estimated Average Requirement and Upper limits)

We analysed 76,472 intakes of 1265 different foods. Tables 1–4 summarise the results of the mean daily intake for each macronutrient by age group and the proportion of children with intakes below the EAR or above the upper limit (UL).[11–13]

Percentage of adherence to Recommended Dietary Allowances

Fig. 1 shows the results of the analysis of the mean percentage and the 95% CI for the adherence to RDAs from 13 months of age. At 7–12 months, the mean percentage of adherence to RDAs was 267% (95% CI, 254–279) for protein, 91% (95% CI, 84–98) for iron, and 157% (95% CI, 149–166) for zinc.

The proportion of adherence for energy intake was 135% (95% CI, 130–140) in the 7–12 month group, 123% (95% CI, 121–125) in the 13–24 month group, and 124% (95% CI, 122–126) in the 25–36 month group. Adherence was 125% (95% CI, 123–127) in children 7–36 months of age.

Proportion of children with energy and protein intakes above the Recommended Dietary Allowances

Table 5 shows the proportion of children with energy (EAR) and protein (RDA) intakes 1/3 (133–166%), 2/3 (166–200%) and twice (>200%) above the DRI.

Analysis of the energy distribution

Fig. 2 shows the proportion of energy contributed by each macronutrient per 100 kcal consumed by age and time of day. We observed a significant increase in the proportion of energy contributed by proteins as age increased (P < .05), as well as a significant reduction in the lipid contribution to the energy intake (P < .05). We did not observe any differences in the carbohydrate contribution to the total energy intake between the age groups.

Relationship between body mass index and nutrient intake

We performed a multiple linear regression analysis to study the variables with a potential association to current BMI. The data of 1495 children were valid and could be used in the analysis (r^2 = 0.069). We found that BMI decreased as the child's age increased, an association that was statistically significant (0.024 kg/m^2 per month of age; 95% CI, 0.011–0.037; P < .0001). The BMI was lower in girls than in boys (0.293 kg/m^2; 95% CI, 0.112–0.475; P = .002). The

Table 2 Mean nutrient intakes and proportion of children 7–12 months of age with inadequate intakes below the EARs or above the ULs.

Nutrients per day	DRI				Age 7–12 months, $N = 176$			
	EAR	RDA	AI	UL	Mean intake (95% CI)	Median intake	% <EAR	% >UL
Energy (kcal)	[a]	–	–	–	927.2 (884.3–970.1)	912.4	14.2	–
Proteins (g)	1 g/kg	11	–	–	29.4 (27.4–31.4)	28.4	0.6	–
Carbohydrates (g)	–	–	95	–	129.3 (123.4–135.1)	127.6	–	–
Lipids (g)	–	–	30	–	30.7 (28.4–33)	29.7	–	–
Saturated fats (g)	–	NS	–	–	10.2 (8.1–12.2)	9.5	–	–
Monounsaturated fats (g)	–	NS	–	–	7.8 (6.3–8.9)	6.8	–	–
Polyunsaturated fats (g)	–	NS	–	–	4 (3.7–4.3)	3.9	–	–
Cholesterol (mg)	–	NS	–	–	85.9 (73.4–98.4)	62.4	–	–
Fibre (g)	–	NS	–	–	10.1 (9–11.2)	10.2	–	–
Water (mL)[b]	–	–	800	–	817.2 (769.5–864.8)	817.2	–	–
Vitamin A (μg)	–	–	500	600	1004.7 (950.3–1059.1)	938.5	–	89.6
Vitamin C (mg)	–	–	50	–	117.5 (111.3–123.7)	113.7	–	–
Vitamin D (μg)	–	10	–	38	7.6 (6.8–8.5)	7.4	–	0
Vitamin E (mg)	–	–	5	–	7.4 (6.9–7.9)	7.2	–	–
Vitamin K (μg)	–	–	2.5	–	92.7 (86.4–99)	85.6	–	–
Vitamin B1 (mg)	–	–	0.3	–	1.1 (1–1.2)	0.8	–	–
Vitamin B2 (mg)	–	–	0.4	–	1.1 (1–1.2)	1	–	–
Niacin (mg)	–	–	4	–	13.5 (12.5–14.5)	12	–	–
Vitamin B6 (mg)	–	–	0.3	–	1.2 (1.1–1.2)	1	–	–
Folic acid (μg)	–	–	80	–	182.6 (171.5–193.8)	172.2	–	–
Vitamin B12 (μg)	–	–	0.5	–	1.7 (1.4–1.9)	1.5	–	–
Pantothenic acid (mg)	–	–	1.8	–	1.8 (1.6–2)	1.6	–	–
Biotin (μg)	–	–	6	–	7.6 (6.3–8.9)	6.9	–	–
Copper (mg)	–	–	0.22	–	0.5 (0.5–0.52)	0.5	–	–
Iodine (μg)	–	–	130	–	77.8 (73.5–82.1)	73.9	–	–
Iron (mg)	6.9	11	–	40	10.1 (9.4–10.8)	9	27.7	0
Magnesium (mg)	–	–	75	–	106.4 (99.6–113.2)	101.6	–	–
Calcium (mg)	–	–	260	1500	596.1 (561.7–630.6)	577.8	–	0.6
Phosphorus (mg)	–	–	275	–	533 (495.2–570.7)	500.7	–	–
Sodium (mg)	–	–	370	–	640.7 (569.3–712.1)	617.1	–	–
Potassium (mg)	–	–	700	–	1390.7 (1318.1–1463.3)	1354.4	–	–
Selenium (μg)	–	–	20	60	27 (17.5–36.5)	24.8	–	1.2
Zinc (mg)	2.5	3	–	5	4.7 (4.03–5.4)	4.6	9.2	41

DRI met through diet;[11–13] EAR represents the average daily nutrient intake level estimated to meet the requirement of half the healthy individuals in a particular life stage and sex group; NS, there are no current recommendations for this nutrient in this age group; RDA is the reference value for each nutrient sufficient to meet the requirements of 97–98% of healthy individuals in a particular life stage or sex group; AI is the value estimated to meet the requirements of all healthy individuals in each age group based on observations made in apparently healthy individuals and that is supposed to be adequate. This value is used as a reference in the absence of an established EAR for a given nutrient and age group; UL represents the highest average daily nutrient intake level that is likely to pose no risk of adverse health effects to almost all individuals in the general population. As intake increases above the UL, the potential risk of adverse effects may increase.

AI: Adequate Intake; DRI: Dietary Reference Intakes; EAR: Estimated Average Requirement; 95% CI: 95% confidence interval for the mean; NS: not specified; RDA: Recommended Dietary Allowances; UL: Tolerable Upper Intake Level; % <EAR: prevalence or proportion of individuals with mean intakes below the EARs in the analysis of inadequate dietary intakes; % >UL: prevalence or proportion of individuals with mean daily intakes of the nutrient above the UL in the analysis of the population at potential risk of suffering adverse effects due to excessive intake of the nutrient.

[a] The calculation of the EAR was made based on the age, sex and weight of the child.

[b] Drinking water and water contained in foods and beverages.

children that had higher BMIs at birth also had higher current BMIs (0.222 kg/m^2: 95% CI, 0.159–0.284; P < .0001). Higher levels of physical activity correlated to lower BMIs (0.148 kg/m^2; 95% CI, 0.002–0.295; P = .048). Higher current energy intakes were associated with higher current BMIs, as each additional 100 kcal in energy intake was associated with a 0.5 kg/m^2 increase in IMC (95% CI, 0–1; P = .032). Higher dietary lipid intakes were significantly associated with lower BMIs (0.054 kg/m^2; 95% CI, 0.012–0.97; P = .013).

We observed that higher contributions of protein to the total energy intake were associated to higher BMIs (0.029 kg/m^2; 95% CI, 0.006–0.051; P = .013). Higher

Table 3 Mean nutrient intakes and proportion of children 13–24 months of age with inadequate intakes below the EARs or above the ULs.

Nutrients per day	DRI				Age 13–24 months, $N = 626$			
	EAR	RDA	AI	UL	Mean intake (95% CI)	Median intake	% <EAR	% >UL
Energy (kcal)	[a]				1240.1 (1217.3–1262.9)	1211	20.3	–
Proteins (g)	0.87 g/kg	13	–	–	47.9 (46.9–49)	46.3	0	–
Carbohydrates (g)	100	130	–	–	148.1 (145–151.2)	143	9.5	–
Lipids (g)	–	NS	–	–	48.3 (47.1–49.5)	46	–	–
Saturated fats (g)	–	NS	–	–	17.2 (16.1–18.3)	16.8	–	–
Monounsaturated fats (g)	–	NS	–	–	17.9 (17.2–18.6)	16.8	–	–
Polyunsaturated fats (g)	–	NS	–	–	5.4 (5.3–5.6)	5.2	–	–
Cholesterol (mg)	–	NS	–	–	177.4 (170.8–184.1)	166.9	–	–
Fibre (g)	–	–	19	–	11.2 (10.6–11.8)	10.9	–	–
Water (mL)[b]	–	–	1300	–	936.7 (911.3–962)	924.5	–	–
Vitamin A (μg)	210	300	–	600	856.8 (827.9–885.7)	822.1	1.3	73.8
Vitamin C (mg)	13	15	–	400	105 (101.7––108.3)	103.2	0.3	0
Vitamin D (μg)	10	15	–	63	6.1 (5.6–6.6)	5.2	81.7	0.2
Vitamin E (mg)	5	6	–	200	6.4 (6.1–6.7)	5.9	39.3	0
Vitamin K (μg)	–	–	30	–	88.4 (85–91.7)	81.5	–	–
Vitamin B1 (mg)	0.4	0.5	–	–	0.99 (0.95–1)	0.9	4.3	–
Vitamin B2 (mg)	0.4	0.5	–	–	1.5 (1.4–1.5)	1.4	1.1	–
Niacin (mg)	5	6	–	10	19.4 (18.8–19.9)	18.6	0.6	94.2
Vitamin B6 (mg)	0.4	0.5	–	30	1.4 (1.3–1.4)	1.3	0.6	0
Folic acid (μg)	120	150	–	300	197.3 (191.3–203.2)	185.2	12.5	9.6
Vitamin B12 (μg)	0.7	0.9	–	–	2.9 (2.8–3)	2.8	0.8	–
Pantothenic acid (mg)	–	–	2	–	3.04 (3–3.1)	2.8	–	–
Biotin (μg)	–	–	8	–	15.9 (15.2–16.5)	13.5	–	–
Copper (mg)	0.26	0.34	–	1	0.6 (0.6–0.64)	0.6	2.7	4.8
Iodine (μg)	65	90	–	200	81.9 (79.6–84.1)	79.9	27.1	0.3
Iron (mg)	3	7	–	40	10.6 (10.3–11)	9.7	1.4	0.2
Magnesium (mg)	65	80	–	–	152.9 (149.3–156.5)	151.3	2.1	–
Calcium (mg)	500	700	–	2500	795.1 (776.8–813.4)	784.6	10.1	0
Phosphorus (mg)	380	460	–	3000	900.5 (880.4–920.5)	883	1.8	0
Sodium (mg)	–	–	1000	1500	1148.3 (1110.4–1186.3)	1092	–	17.7
Potassium (mg)	–	–	3000	–	1877.6 (1839–1916.2)	1859	–	–
Selenium (μg)	17	20	–	90	45.3 (40.2–50.4)	42.9	3.2	2.4
Zinc (mg)	2.5	3	–	7	6.1 (5.8–6.5)	6	1.4	28.9

DRI met through diet;[11–13] EAR represents the average daily nutrient intake level estimated to meet the requirement of half the healthy individuals in a particular life stage and sex group; NS, there are no current recommendations for this nutrient in this age group; RDA is the reference value for each nutrient sufficient to meet the requirements of 97–98% of healthy individuals in a particular life stage or sex group; AI is the value estimated to meet the requirements of all healthy individuals in each age group based on observations made in apparently healthy individuals and that is supposed to be adequate. This value is used as a reference in the absence of an established EAR for a given nutrient and age group; UL represents the highest average daily nutrient intake level that is likely to pose no risk of adverse health effects to almost all individuals in the general population. As intake increases above the UL, the potential risk of adverse effects may increase.

AI: Adequate Intake; DRI: Dietary Reference Intakes; EAR: Estimated Average Requirement; 95% CI: 95% confidence interval for the mean; NS: not specified; RDA: Recommended Dietary Allowances; UL: Tolerable Upper Intake Level; % <EAR: prevalence or proportion of individuals with mean intakes below the EARs in the analysis of inadequate dietary intakes; % >UL: prevalence or proportion of individuals with mean daily intakes of the nutrient above the UL in the analysis of the population at potential risk of suffering adverse effects due to excessive intake of the nutrient.

[a] The calculation of the EAR was made based on the age and sex of the child.

[b] Drinking water and water contained in foods and beverages.

contributions of carbohydrates were associated with higher BMIs (0.021 kg/m^2; 95% CI, 0.009–0.033; $P < .0001$). Higher contributions of lipids corresponded to lower BMIs (0.028 kg/m^2; 95% CI, 0.016–0.039; $P < .0001$).

Our analysis of the relationship between BMI and the mean daily micronutrient intake ($r^2 = 0.095$) showed that higher intakes of vitamin D correlated to lower BMIs (4.4 μg, 95% CI, 1.9–10.2, $P = .001$).

Table 4 Mean nutrient intakes and proportion of children 25–36 months of age with inadequate intakes below the EARs or above the ULs.

Nutrients	DRI				Age 25–36 months, $N = 584$			
	EAR	RDA	AI	UL	Mean intake (95% CI)	Median intake	% <EAR	% >UL
Energy (kcal)	[a]				1413 (1389.6–1436.4)	1407.8	19	–
Proteins (g)	0.87 g/kg	13	–	–	57.6 (56.5–58.6)	56.4	0	–
Carbohydrates (g)	100	130	–	–	152.1 (148.9–155.3)	151	8.8	–
Lipids (g)	–	NS	–	–	61.5 (60.3–62.8)	60.4	–	–
Saturated fats (g)	–	NS	–	–	22.9 (21.7–24)	22.5	–	–
Monounsaturated fats (g)	–	NS	–	–	25.7 (25–26.4)	24.4	–	–
Polyunsaturated fats (g)	–	NS	–	–	6.7 (6.5–6.8)	6.4	–	–
Cholesterol (mg)	–	NS	–	–	230 (223.2–236.9)	227.8	–	–
Fibre (g)	–	–	19	–	11 (10.4–11.6)	10.7	–	–
Water (mL)[b]	–	–	1300	–	1006.1 (980.2–1032.1)	929.8	–	–
Vitamin A (μg)	210	300	–	600	692.5 (662.8–722.1)	646.6	1.4	57.6
Vitamin C (mg)	13	15	–	400	83.7 (80.3–87.1)	74.8	0.2	0
Vitamin D (μg)	10	15	–	63	3.8 (3.3–4.3)	2.3	92.1	0
Vitamin E (mg)	5	6	–	200	5.5 (5.2–5.8)	4.8	53.4	0
Vitamin K (μg)	–	–	30	–	72.4 (69–75.8)	64.3	–	–
Vitamin B1 (mg)	0.4	0.5	–	–	0.99 (0.91–1)	0.9	1.6	–
Vitamin B2 (mg)	0.4	0.5	–	–	1.6 (1.5–1.6)	1.5	0.5	–
Niacin (mg)	5	6	–	10	22.1 (21.6–22.7)	21.3	0	97.8
Vitamin B6 (mg)	0.4	0.5	–	30	1.4 (1.4–1.5)	1.3	0.2	0
Folic acid (μg)	120	150	–	300	177.4 (171.3–183.4)	165.1	14.8	4.5
Vitamin B12 (μg)	0.7	0.9	–	–	3.9 (3.8–4)	3.4	0	–
Pantothenic acid (mg)	–	–	2	–	3.8 (3.7–3.9)	3.7	–	–
Biotin (μg)	–	–	8	–	21.4 (20.7–22.1)	21.3	–	–
Copper (mg)	0.26	0.34	–	1	0.7 (0.7–0.74)	0.7	1.4	11
Iodine (μg)	65	90	–	200	78.3 (76–80.7)	74.4	31	0.2
Iron (mg)	3	7	–	40	9.6 (9.2–9.9)	8.6	0.5	0
Magnesium (mg)	65	80	–	–	180.4 (176.7–184.1)	178.2	1.2	–
Calcium (mg)	500	700	–	2500	858.6 (839.8–877.4)	836.6	5.5	0
Phosphorus (mg)	380	460	–	3000	1073.3 (1052.8–1093.9)	1062.6	0.9	0
Sodium (mg)	–	–	1000	1500	1452.4 (1413.5–1491.3)	1353.4	–	38.3
Potassium (mg)	–	–	3000	–	2097.5 (2058–2137.1)	2066.1	–	–
Selenium (μg)	17	20	–	90	58.4 (53.2–63.6)	56.4	0.7	7.1
Zinc (mg)	2.5	3	–	7	6.7 (6.3–7.1)	6.4	0.7	37.1

DRI met through diet;[11–13] EAR represents the average daily nutrient intake level estimated to meet the requirement of half the healthy individuals in a particular life stage and sex group; NS, there are no current recommendations for this nutrient in this age group; RDA is the reference value for each nutrient sufficient to meet the requirements of 97–98% of healthy individuals in a particular life stage or sex group; AI is the value estimated to meet the requirements of all healthy individuals in each age group based on observations made in apparently healthy individuals and that is supposed to be adequate. This value is used as a reference in the absence of an established EAR for a given nutrient and age group; UL represents the highest average daily nutrient intake level that is likely to pose no risk of adverse health effects to almost all individuals in the general population. As intake increases above the UL, the potential risk of adverse effects may increase.

AI: Adequate Intake; DRI: Dietary Reference Intakes; EAR: Estimated Average Requirement; 95% CI: 95% confidence interval for the mean; NS: not specified; RDA: Recommended Dietary Allowances; UL: Tolerable Upper Intake Level; % <EAR: prevalence or proportion of individuals with mean intakes below the EARs in the analysis of inadequate dietary intakes; % >UL: prevalence or proportion of individuals with mean daily intakes of the nutrient above the UL in the analysis of the population at potential risk of suffering adverse effects due to excessive intake of the nutrient.

[a] The calculation of the EAR was made based on the age and sex of the child.

[b] Drinking water and water contained in foods and beverages.

Discussion

The high protein intake in children's diets was the most remarkable finding of our study. Similar results have been found in other European countries (Table 6) for the same age groups.[20] Data from the United States are also similar.[21]

The percentage of children that consumed more than twice the recommended daily amount of protein was 95.9% (Table 5). Although current evidence is insufficient to establish upper limits (ULs) for protein intake, the EFSA estimates than intakes up to twice the recommended value are safe in adults.[20] Protein contributions above 20% of the energy

Table 5 Energy and protein intake: proportion of children with values above 133%, 166% and 200% of the EARs and RDAs.

Age group	Energy (kcal) Proportion above the EAR			Protein (g) Proportion above the RDA		
	>133% < 166% N (%)	>166% < 200 N (%)	>200% N (%)	>133% < 166% N (%)	>166% < 200 N (%)	>200% N (%)
7–12 months	63 (35.8)	19 (10.8)	8 (4.5)	10 (5.8)	19 (11)	142 (82)
13–24 months	152 (24)	39 (6.2)	10 (1.6)	3 (0.5)	15 (2.4)	605 (97.1)
25–36 months	166 (28.4)	31 (5.3)	9 (1.5)	3 (0.5)	5 (0.9)	573 (98.8)
7–36 months	381 (27.5)	89 (6.4)	27 (2)	16 (1.2)	39 (2.8)	1320 (95.9)

EAR: minimum reference value that meets the requirements of 50% of the population for each age group.
RDA: reference value that meets the requirements of 97–98% of healthy individuals for each age group.
EAR: Estimated Average Requirement; RDA: Recommended Dietary Allowances.

intake can seriously impair the water balance in children, so high protein intakes must be avoided, especially in the first year of life.[20] Our study showed that the mean protein intake was 370% of the recommended intake in children 13–24 months of age, and 441% of the recommended intake in children 25–36 months of age (Fig. 1), that is, intakes up to 4 times the recommended values. This increasing trend in protein intake has also been observed in children between 1 and 3 years of age in other European countries, with energy intakes of 131% of the RDA/adequate intake (AI) in Italy,[22] 138% in France,[23] and 284% in the United Kingdom.[24] Yet the contribution of protein did not go over 20% of the energy intake in any age group (Fig. 2A), demonstrating an adequate energy distribution overall, albeit with a tendency to consume more protein as age increases, especially during lunch and supper (Fig. 2B). The high absolute values of the protein intake could be due to an excessive energy intake, as they exceeded recommended values by 135% at 7–12 months, by 123% at 13–24 months and by 124% at 25–36 months. Furthermore, 27.5% of children had energy intakes 1/3 greater than the recommended values (Table 5). We must take into account that the intake recommendations for protein and other nutrients are based on the determination of minimum values below which intakes would be insufficient and could

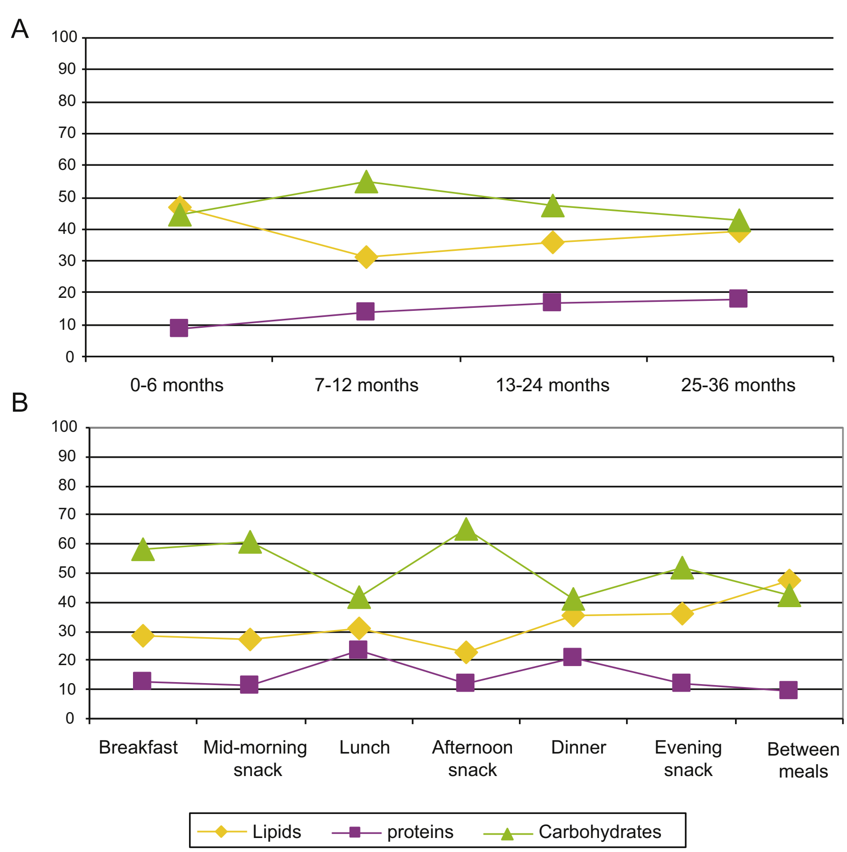

Figure 2 Energy distribution: energy contribution of lipids, proteins, and carbohydrates by age group (A) and time of day (B), per 100 kcal of energy intake.

Table 6 Protein intake in children 1–3 years of age in European countries.

Country	Age	N[a]	Mean protein intake (g/day)[a]	SD[a]
Belgium (Huybrechts and de Henauw, 2007)	2.5–3 years	102/95	62.5/57.7	11.3/11.3
Bulgaria (Abrasheva et al., 1998)	1–3 years	154	39.4	14.8
Denmark (Andersen et al., 1996)	1–3 years	129/149	52/54	NS
Finland (Kyttälä et al., 2010)	1 year	257/198	35/34	11/8
	2 years	112/118	43/44	12/11
	3 years	236/235	49/46	12/44
Greece (Manios, 2006)	12–24 months	100/107	52.2/50.5	10.7/9.6
	25–36 months	274/226	57.8/55.2	11.7/12.6
	37–48 months	488/434	59.8/56.9	12.7/12.6
Netherlands (Ocke et al., 2008)	2–3 years	327/313	44/43	NS
Netherlands (de Boer et al., 2006)	9 months	333	28.8	6.2
	12 months	306	36.5	8.3
	18 months	302	43.1	6.5
United Kingdom (Bates et al., 2011)	1.5–3 years	219	42.6	11.1
Italy (Sette et al., 2010)	0–3 years	52	41.5	18
Norway (Kristiansen and Andersen, 2009)	2 years	829/826	50.8/48.6	14.9/14.9
Poland (Szponar et al., 2003)	1–3 years	70/48	46.4/41.2	21.3/13.4

SD: standard deviation; NS: not specified.
[a] Data for both sexes or for boys/girls.
Taken from the EFSA Panel on Dietetic Products, Nutrition and Allergies (NSA).[20]

lead to nutritional deficiencies. More specifically, the calculation of the recommended protein intake is based on an adequate nitrogen balance.[20] An association between high protein intakes and greater weights in children younger than 2 years has been reported,[25] which increases the risk of future obesity.[26–30] It is believed that protein consumption stimulates the secretion of insulin-like growth factor I, which leads to cellular proliferation, accelerated growth and increased body fat.[30,31] In this regard, our study showed that higher contributions of protein and carbohydrates to the total energy intake were associated with a significantly higher BMI. We observed a rate of overweight and obesity (>2 SD) of 6.1%. The most recent data on 8-year-old children in Spain (ALADINO study) showed an 11.6% prevalence of obesity.[32] This means that the prevalence of obesity doubles between 3 and 8 years of age. This is a crucial period for intervention and to counsel children and parents on what constitutes a balanced diet, as it is the time when children develop their dietary habits.

We observed the most important deficiencies in the vitamin D intake in 81.7% and 92.1% of the children (Tables 3 and 4). The use of vitamin supplements was lower from 12 months of age, so these were actual deficiencies. This finding may be important when it comes to future health in light of the association between vitamin D and risk factors for cardiovascular and metabolic disease.[33,34] Our study also showed an inverse correlation between vitamin D intake and BMI. This finding is consistent with the results of different studies on increased body fat and its association with vitamin D.[35–38]

We observed that 27.1% of children 13–24 months of age and 31% of children 25–36 months of age had iodine intakes below the EAR. Iodine deficiency is considered to be the most frequent and preventable cause of intellectual disability. Although Spain is among the countries with adequate iodine intakes, the percentage of children with an insufficient intake found in our study was surprising.[39] It is possible that the consumption of iodised salt was underreported in the diet diaries, as considering that 17.7% and 38.3% of children had a sodium intake in excess of the ULs (Tables 3 and 4), it is likely that some of the salt consumed was iodised.

To conclude, similar to what occurs in other European countries and the United States, children younger than 3 years in Spain consume an imbalanced diet with an excessive protein intake, which indicates the need for a nutritional intervention in this age group. The paediatricians or doctors that monitor children, scientific associations and government institutions should make dietary recommendations to decrease the protein intake and facilitate the development of healthy dietary habits, which are of utmost importance in this life stage, when they get established. The role of this imbalance in overweight, obesity and low vitamin D levels, which was demonstrated by our study, are the subject of extensive studies at present.

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Conflicts of interest

Begoña Soler was hired by Danone Nutricia Early Life Nutrition, Spain, for the design, quality control, and statistical analysis of the study, and the writing of this paper for publication.

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