Received: 3 March 2022 | Revised: 20 December 2022 | Accepted: 3 January 2023

DOI: 10.1111/nbu.12603

ORIGINAL RESEARCH

Nutrition Bulletin

Prevalence of nutritional inadequacy in children aged 12–36 months: EPACI Portugal 2012

Margarida Nazareth[1] | **Elisabete Pinto**[1,2] | **Milton Severo**[3,4] | **Pedro Graça**[3,5] | **Carla Lopes**[3,6] | **Carla Rêgo**[1,7,8,9]

[1]Universidade Católica Portuguesa, CBQF – Centro de Biotecnologia e Química Fina- Laboratório Associado, Escola Superior de Biotecnologia, Porto, Portugal

[2]EPIUnit – Institute of Public Health, University of Porto, Porto, Portugal

[3]EPIUnit/ ITR – Laboratory for Integrative and Translational Research in Population Health – Institute of Public Health, University of Porto, Porto, Portugal

[4]ICBAS – School of Medicine and Biomedical Sciences, University of Porto, Porto, Portugal

[5]Faculty of Nutrition and Food Sciences, University of Porto, Porto, Portugal

[6]Department of Public Health and Forensic Sciences and Medical Education, Faculty of Medicine, University of Porto, Porto, Portugal

[7]Child and Adolescent Centre, CUF Hospital Porto, Porto, Portugal

[8]Center for Health Technology and Services Research (CINTESIS), Porto, Portugal

[9]Faculty of Medicine, University of Porto, Porto, Portugal

Correspondence
Margarida Nazareth, Universidade Católica Portuguesa, CBQF – Centro de Biotecnologia e Química Fina – Laboratório Associado, Escola Superior de Biotecnologia, Rua Diogo Botelho 1327, 4169-005 Porto, Portugal.
Email: mnazareth@ucp.pt

Funding information
EPACI Portugal 2012 was funded by Nutricia Early Life Nutrition; Fundação para a Ciência e a Tecnologia, Grant/Award Number: PhD Grant SFRH/BD/89293/2012 and project UIDB/Multi/50016/2020

Abstract

Adequate nutritional intake in the first years of life is crucial for future health. The purpose of this study is to assess the adequacy of nutritional intake in Portuguese toddlers. The *EPACI Portugal 2012* is a cross-sectional study of a representative sample of toddlers (n = 2230), aged between 12 and 36 months. Data on diets were collected by trained interviewers. The current analysis included 853 children with full data from 3-day food diaries completed by parents/caregivers. Intakes of energy, macro- and micronutrients were estimated through Statistical Program to Assess Dietary Exposure (SPADE). Nutritional adequacy was evaluated using Dietary Reference Values established by the European Food Safety Authority. A large proportion of children exceeded the recommended energy intake. The median daily protein intake was 4.7 g/kg/day, five times more than that recommended. About 9% and 90% of the children consumed a lower proportion of energy than the lower limit of the Reference Intake range for carbohydrates and fat, respectively. Around a third consumed less fibre and magnesium and 100% less vitamin D than the recommended Adequate Intake (AI). Almost a third consumed less vitamin A than the recommended Average Requirement (AR) and 86% of the children showed excessive sodium consumption. Portuguese toddlers consumed a low proportion of energy from fat, had energy and protein intakes above the recommendations and excessive intakes of sodium, and inadequate intakes of vitamin A. Every child consumed less than the recommended AI for vitamin D.

KEYWORDS
dietary recommendations, food sources, nutrients, nutritional inadequacy, Portuguese toddlers

INTRODUCTION

Childhood obesity is currently a major public health problem (Karnik & Kanekar, 2012) and its prevalence in Portugal is high from the first years of life (Nazareth et al., 2021; Spinelli et al., 2019; Vilela et al., 2019). Childhood nutrition determines children's growth and development, and also plays an important role in the origin of obesity and some non-communicable diseases (Mello et al., 2016). Evidence supports that early feeding patterns are determinants of children's future health and in the prevention of obesity and associated co-morbidities (Brands et al., 2014; Koletzko et al., 2012). Moreover, rapid weight gain in the first months of life increases the risk of being overweight and obesity throughout life (Druet et al., 2012; Monteiro & Victora, 2005; Ong & Loos, 2006; Stettler et al., 2002, 2003).

The period between the end of the first year of life and pre-school age (12–36 months) is called toddlerhood. During this period, there is a transition to the family diet, making it an opportunity to review the family's diet and establish adequate eating habits. It is known that interventions at early ages are more effective in the long term, allowing easier maintenance of the learned behaviours throughout life (Araújo et al., 2011).

The first years of life are a period of rapid growth and development, requiring the satisfaction of high energy and nutritional quality needs, which emphasises the concern about the quality of children's diets (EFSA, 2017; Nazareth et al., 2016). Nutritional adequacy is defined as being the intake of essential nutrients sufficient to meet the nutritional recommendations and promote optimal health (Castro-Quezada et al., 2014).

There are some studies on the nutritional intake, including toddlers, carried out in European countries, such as Spain (Dalmau et al., 2015), England (Syrad et al., 2016), Ireland (Walton et al., 2017), Belgium (Huysentruyt et al., 2016), Germany (Alexy et al., 1999), Switzerland (Brunner et al., 2018), Italy (Zuccotti et al., 2020), Greece (Manios et al., 2008; Roma-Giannikou et al., 1997) or Finland (Kyttälä et al., 2010). In Portugal, data from the Generation 21 birth cohort (G21) (Lopes et al., 2014), at 4 years of age are available on the prevalence of nutritional inadequacy and main food sources for different nutrients. Likewise, data from the Portuguese National Food and Physical Activity Survey (IAN-AF) (Lopes et al., 2015) are available, but these do not allow nutritional inadequacy to be characterised and the main food sources in these ages identified. In Portugal, there are no representative studies measuring the nutritional inadequacy of diets specifically concerning toddlerhood.

Knowledge of nutritional status at early ages, particularly regarding nutritional inadequacy and the foods that contribute most to each nutrient intake, may help to establish food policies and guide the setting out of dietary recommendations for parents, caregivers and educators (Fox et al., 2004).

The purpose of this study is to assess the nutritional intake and respective adequacy of diets of a representative group of Portuguese toddlers and to identify the main food sources for specific nutrients in this group.

METHODS AND MATERIALS

Study design

This study was based on *EPACI Portugal 2012* (*Study of the Childhood Feeding Patterns and Growth*), which was a cross-sectional study to characterise dietary intake and nutritional status of Portuguese toddlers (ages between 12 and 36 months).

Sample selection

The study aimed to recruit a representative sample of about 1% of Portuguese children aged 12–36 months living in mainland Portugal. The number of children to be evaluated in each NUTS II region was calculated (NUTS II is the Nomenclature of Statistical Territorial Units, which divides mainland Portugal in five regions). At that time, considering that about 100 000 births per year occur in Portugal, a sample of 2500 (2000 plus 25% for refusals) was defined. The sample was stratified by NUTS II, maintaining the proportions of births in each region, and children were recruited from 128 health units, also randomly selected.

After the identification of the selected health units, a contact with the director of each health unit was made, to invite participation in the study, to request the list of children aged 12–36 months and to schedule the evaluation day. Twenty-five children were randomly selected in each health care unit, their caregivers were contacted and interviews were scheduled. The evaluations took place between May 2012 and July 2013.

All the proceedings of the study were carefully explained by phone, and once again to the caregiver who accompanied each child in the beginning of the face-to-face interview. The participation was formalised through the signature of informed consent. This study was approved by the Portuguese Data Protection Authority and by the Ethic Committee of the Catholic University of Portugal (Ethics Screening Report 02/12) and by all the Ethics Committees of the five Portuguese Health Regional Administrations.

Data collection

Data were collected by trained interviewers. A structured study protocol was applied in face-to-face,

Nutrition Bulletin

computer-assisted interviews, which included data on socio-economic characteristics of the household, parental nutritional status, children's health, dietary intake and supplementation during the first years of life. Furthermore, data on nutritional status were collected from the individual child health bulletin (a document in which the children's health data, including anthropometrics evaluation over time, is recorded and which is given to all children's caregivers in Portugal), and children's anthropometric measurements were taken during the appointment. At the end of the interview, a 3-day food diary was delivered to be filled out by the parents or another main caregiver. The procedure for completing of the diary and subsequently returning by postage-paid envelope (delivered at the time) was explained by the interviewers at the interview.

A Procedures Manual was created, tested and exhaustively presented to all interviewers to minimise errors in the collection of data.

Dietary intake assessment

The 3-day food diary, including information on 2 weekdays and 1 weekend day, was filled in by the caregivers, who were instructed to read the written instructions and to record the intake of all foods and beverages during these days, including detailed information about each item, the quantity consumed and the place and time of consumption, as well as all ingredients, cooking methods, recipes details (like type of fat used) in prepared dishes. Parents were encouraged to share the booklet with other caregivers of the children (for example, schools or nannies), to complete the information.

The codification of the food diaries was performed by a team of trained nutritionists and the food conversion into nutrients was carried out subsequently using the software Food Processor® SQL (ESHA Research). This software is based on Food Composition Table of the United States of America Department of Agriculture. Furthermore, the database has been adapted by researchers from the Institute of Public Health and Faculty of Medicine of the University of Porto with the inclusion of nutritional information of typical Portuguese foods and recipes.

The prevalence of nutritional inadequacy was obtained by the comparison of the children's estimated intake of energy, macro- and micronutrients, obtained from food diaries, and the Dietary Reference Values established by the European Food Safety Authority (EFSA) for children in this age interval (12–36 months) (EFSA, 2017). For clarification, the different terminologies and respective definitions used were summarised in Table 1. The Reference Intake ranges for macronutrients (RI) and Average Requirements (AR) were used as the cut-offs or, alternatively, the Adequate Intake (AI) when the AR was not established (EFSA, 2010b). The AR was adjusted for intra-individual variability. The RI range was used for carbohydrates and total fat, and all children, whose intakes were outside the range (above the upper limit or below the lower limit), were considered to have inadequate or excessive intakes (EFSA, 2010b). For micronutrients, the percentage of intakes below the AR or AI cut-offs were used to estimate the prevalence of inadequate intakes with intakes below the cut-off revealing a likely inadequacy (EFSA, 2010b). However, intakes below the AI are not necessarily inadequate. For sodium, the tolerable upper intake level (UL) issued by Institute of Medicine was used as cut-off (EFSA, 2019; IOM, 2011) and intakes above this cut-off are considered to be excessive.

The 10 main food sources for energy, macronutrients (protein, total fat, total carbohydrates, sugar and fibre) and micronutrients (calcium, vitamin C, vitamin B1, folate, potassium, sodium and iron) were obtained. To evaluate the main food sources, 13 groups were established. The name of each food group and the food items included in it are described in detail in the Table S1.

TABLE 1 Terminologies and definitions of Dietary Reference Values (DRVs)[a] and Dietary Reference Intakes (DRIs)[b] used

Terminology	Definitions
Reference Intake ranges for macronutrients (RI)[a]	Corresponds to the intake range for macronutrients, expressed as % of the energy intake
Average Requirement (AR)[a]	Corresponds to the level of (nutrient) intake that is adequate for half of the people in a population group, given a normal distribution of requirement
Population Reference Intake (PRI)[a]	Corresponds to the level of (nutrient) intake that is adequate for virtually all people in a population group
Adequate Intake (AI)[a]	Corresponds to the value estimated when a Population Reference Intake cannot be established because an average requirement cannot be determined
Tolerable Upper Intake Level (UL)[b]	Corresponds to the highest average daily nutrient intake level likely to pose no risk of adverse health effects to almost all individuals in a particular life stage and gender group

[a]DRVs from EFSA (EFSA, 2010b).

[b]The Tolerable Upper Intake Level (UL) used in the case of sodium was based on DRIs issued by Institute of Medicine (Food and Nutrition Board, 2003).

Statistical analysis

Median intake and percentiles 25 and 75 (P25; P75) of energy (in kcal per day), macronutrients (in %, grams or grams per kg, per day), and micronutrients (in mg or mcg per day) and nutritional inadequacy prevalence of macro- and micronutrients were estimated by gender and age. Prevalence estimates were weighted according to the complex sampling design, considering stratification by Portuguese geographical regions (NUTS II) and cluster effect for the selected Primary Health Care Unit. The Statistical Program to Assess Dietary Exposure (SPADE) software (Dekkers et al., 2014) was used to estimate usual intakes of energy, macro- and micronutrients, adjusting for intra-individual day-to-day variability, to estimate the prevalence of nutrients' inadequacy, and using survey weights, to assure nationally representative estimates. Statistical analysis was performed using the R package nlme and the Statistical Package for the Social Sciences SPSS® version 27 for Windows®.

RESULTS

A total of 2230 children (n = 1049; 47% female) aged between 12 and 36 months were evaluated in *EPACI Portugal 2012*, 1107 (49.6%) aged between 12 and 23 months and 1123 (50.4%) aged between 24 and 36 months.

Only 931 mothers/caregivers filled in and returned food diaries and, from these, 853 presented 3-day complete dietary information (participation proportion - 38%). Only these were included in the present analysis, corresponding to 475 (55.7%) males. Approximately half (n = 427; 51.1%) were aged between 12 and 23 months and (n = 426; 49.9%) between 24 and 36 months.

These children (n = 853) were compared with the rest of the sample (n = 1377) from the analysis regarding characteristics such as parental age, education, body mass index (BMI) and child's gender, age, exclusive breastfeeding at 4 months and BMI. Significant differences were found concerning gender (p = 0.042), maternal age (p < 0.001), paternal age (p = 0.004), maternal education (p < 0.001) and paternal education (p < 0.001) (Table 2). The sub-sample included in the analysis, therefore, has a higher proportion of boys and the parents were older and better-educated than the rest of the sample.

The median daily energy intake was 1221 kcal (percentile 25: 1078; percentile 75: 1381), being 1149 kcal (P25; P75: 1021–1291) in the second year of life (12–23 months) and 1297 kcal (P 25; P 75: 1155–1455) in the third year of life (24–36 months) (Table 3). These median intakes and even the 25th percentiles were higher than the mean recommendations at 12 and 24 months of age, which means that a large proportion of the children had a consumption above the energy recommendations for their age. The food groups that most contributed to energy intake were dairy products (25.4%) and cereal and cereal products, potatoes and other tubers group (23.5%) (Table S2). When analysing individual foods, the main energy sources were milk (10.7%), vegetable soup (8.8%) and fresh fruit (7%) (Table 4).

TABLE 2 Demographic characteristics of the sample with the three-day complete diaries compared to the rest of the sample

	Sample (n = 1377)	Sample with 3-day complete diaries (n = 853)	p
Child's gender n (%)	Girls: 671 (48.7) Boys: 706 (51.3)	Girls: 378 (44.3) Boys: 475 (55.7)	**0.042**
Maternal education n (%)	9 schooling years: 581 (43.0) 12 schooling years: 399 (29.5) Higher education: 371 (27.5)	9 schooling years: 291 (34.3) 12 schooling years: 246 (29.0) Higher education: 311 (36.7)	**<0.001**
Paternal education n (%)	9 schooling years: 713 (54.6) 12 schooling years: 365 (27.9) Higher education: 229 (17.5)	9 schooling years: 394 (47.5) 12 schooling years: 241 (29.0) Higher education: 195 (23.5)	**<0.001**
Maternal age [P50; (P25; P75)]	n = 1368 32.3 (13; 53)	n = 848 33.2 (14; 48)	**<0.001**
Paternal age [P50; (P25; P75)]	n = 1298 34.9 (19; 62)	n = 832 35.7 (13: 68)	**0.004**
Pre-pregnancy BMI [P50; (P25; P75)]	n = 1298 24.0 (15.1; 53.4)	n = 836 24.0 (14.7; 42.1)	0.753
Child BMI [P50; (P25; P75)]	n = 1291 0.52 (– 4.37;3.82)	n = 812 0.45 (−4,15; 4.15)	0.335
Exclusive Breastfeeding at 4 months n (%)	Yes: 786 (62.7) No: 468 (37.3)	Yes: 499 (64.2) No: 278 (35.2)	0.484

Note: The values in bold correspond to statistically significant values.
Abbreviation: BMI, body mass index.

Nutrition Bulletin

TABLE 3 Median intakes of energy and macronutrients and respective prevalence of inadequacy, by age (months)

	DRV [(1)]	Total median (P25-P75)	PI %	Age 12–23 months median (P25-P75)	PI %	Age 24–36 months median (P25-P75)	PI %
Energy (Kcal/day)	Mean 870[a] [(2)]	1221 (1078; 1381)	—	1149 (1021; 1291)	—	1297 (1155; 1455)	—
Boys	Mean 903[a] [(3)]	1246 (1100; 1412)	—	1177 (1045; 1326)	—	1318 (1171; 1484)	—
Girls	Mean 829[a] [(4)]	1190 (1055; 1336)	—	1115 (995; 1244)	—	1270 (1140; 1411)	—
Protein (g/kg/d)	Mean 0.87[a] [(5)]	4.7 (4.1; 5.4)	—	4.8 (4.2; 5.5)	—	4.5 (3.9; 5.2)	—
Carbohydrates (% of energy)	45–60[b]	50.3 (47.7; 52.9)	9.2	50.4 (47.8; 53.0)	8.8	50.2 (47.6; 52.8)	9.5
Fibre (g)	10[c]	10.9 (9.2; 12.8)	36[d]	10.7 (9.0; 12.5)	39.3[d]	11.2 (9.4; 13.0)	32.8[d]
Total sugar (% of energy)		22.7 (20.3; 25.2)	—	23.7 (21.3; 26.1)	—	21.7 (19.4; 24.0)	—
Total fat (% of energy)	35–40[b]	30.8 (28.8; 32.9)	90.9	30.9 (28.9; 33.0)	90.9	30.8 (28.8; 32.9)	91

Note: (1) Recommendations from European Food Safety Authority.
Note: (2) Mean of average requirement at 1 and 2 years old (745; 987).
Note: (3) Mean of average requirement at 1 and 2 years old (777; 1028).
Note: (4) Mean of average requirement at 1 and 2 years old (712; 946).
Note: (5) Mean of average requirement at 1 and 2 years old (0.95 and 0.79).
Abbreviations: DRV, dietary reference value; PI, prevalence of inadequacy.
[a]Average requirement.
[b]Reference intake.
[c]Adequate intake.
[d]In the case of AI's, these % correspond to % of children who are below the AI value.

The median daily protein intake was 4.7 g/kg/day (Table 3), more than five times the mean average requirement, which is 0.87 g/kg/day for this age group (EFSA, 2012). The dairy products group contributed 35.4% of protein intake, with the main food source being milk (15.1%) (Table S2). About 9% of the children consumed a lower proportion of energy as carbohydrates than recommended lower limit (45–60% of total energy [TE]) and about 90% consumed a lower proportion of energy as fat than the recommended lower limit (35%–40% of TE) (Table 3). The major contributors to carbohydrate intake were fresh fruit (14.6%) and vegetable soup (8.3%) and the main contributors for fat intake were also vegetable soup (13.4%) and milk (8.9%) (Table 4). Concerning fibre intake, the median intake was slightly higher than the recommended value (10.9 g vs. 10 g) and 36% of the toddlers had an intake below the AI (10 g), with this proportion, being higher in the second year than in the third year of life (39.3% vs. 32.8%) (Table 3). About 50% of fibre intake was supplied by fresh fruit (31.4%) and vegetable soup (14.6%) (Table 4). An analysis by gender was also carried out and differences were found in the prevalence of children that consumed less fibre than the recommended AI (30.9% in male vs. 42.9% in female). The median total sugar intake, considering all mono- and disaccharides, was 22.7% of TE. (Table 3). The main food sources for this nutrient were fresh fruit (20.1%), milk (15.4%) and yogurt (13.9%) (Table 4).

The median intake of vitamin C (58.3 mg) was almost four times higher than the recommendation (15 mg). The median intake of folate was almost double the recommendation (Table 5). The main food groups contributing to folate intake are cereal and cereal products and potatoes and other tubers (36.1%) (Table S3) and the main food sources were breakfast cereals (12.7%) and vegetables (11.4%) (Table 6). Regarding vitamin A, the prevalence of inadequacy between 12 and 23 months was almost twice as high as between 24 and 36 months (35.7% vs. 19.3%) (Table 5). For calcium, the median intake was much higher than the AR for calcium, as was the median intake of phosphorus above the AI for phosphorus (Table 5). The median intake of vitamin B_{12} was almost double the AI but 30% of the children consumed less magnesium than the recommended AI (Table 5). Concerning iron, the prevalence of nutritional inadequacy in the second year of life was higher than in the third year (15.3% vs. 9.3%) and the main food sources were infant cereals (25%) and breakfast cereals (14.7%) (Table 6). Regarding sodium, most children were above the UL, and the prevalence of excessive intakes in the third year of life was higher than in the second year (95.6% vs. 79.5%) (Table 5). The main contributor to sodium intake was vegetable soup, providing more than 40% (Table 6). When analysing

TABLE 4 The 10 main food sources of energy and macronutrients (%) in Portuguese toddlers (12–36 months)

Food source	% Energy	Food Source	% Protein	Food source	% Total fat	Food source	% Carbohydrates	Food source	% Sugar	Food source	% Fibre
Milk	10.7	Milk	15.1	Vegetable soup	13.4	Fresh Fruit	14.6	Fresh Fruit	20.1	Fresh Fruit	31.4
Vegetable soup	8.8	Poultry	12.3	Milk	8.9	Vegetable soup	8.3	Milk	15.4	Vegetable soup	14.6
Fresh Fruit	7	Yogurt	12.3	Beef and veal	6.9	Infant Cereals	7.8	Yogurt	13.9	Vegetables	10.1
Yogurt	6.8	Fish	11.4	Poultry	6.8	Bread, crispbread, rusks	7.3	Infant Cereals	7.8	Potatoes and other tubers	6.6
Infant Cereals	6.1	Beef and veal	9	Growing-up Milk	6	Milk	7.3	Sweet biscuits	7.1	Bread, crispbread, rusks	6.3
Bread, crispbread, rusks	4.9	Infant Cereals	4.4	Rice	4.6	Yogurt	6.6	Growing-up Milk	4.7	Sweet biscuits	4.7
Poultry	4.7	Growing-up Milk	4.4	Yogurt	4.1	Sweet biscuits	5.5	Processed Fruits	4.3	Processed Fruits	4.5
Rice	4.3	Bread, crispbread, rusks	3.4	Infant Cereals	4	Potatoes and other tubers	5.4	Breakfast Cereals	3.3	Infant Cereals	4
Beef and veal	4.2	Pork meat	3.4	Fish	3.9	Rice	5.1	Vegetable soup	2.2	Cakes, pastries and croissants	2.6
Fish	3.8	Cheeses	1.8	Pork meat	3.3	Breakfast Cereals	4.3	Breast Milk	1.9	Pasta	1.7

TABLE 5 Median intake of micronutrients and respective prevalence of inadequacy, by age (months)

	DRV (1)	Total median (P25-P75)	PI %	Age [12–23 months] median (P25-P75)	PI %	Age [24–36 months] median (P25-P75)	PI %
Vitamin A (mcg/d)	205[a]	271.2 (197.7; 360.9)	27.4	242.8 (176.7; 323.6)	35.7	301.2 (224.3; 393.8)	19.3
Vitamin B_1 (mg/d)	0.30[a] M; 0.28[a] F	0.7 (0.6; 0.9)	0.1	0.7 (0.6; 0.8)	0.2	0.8 (0.7; 1.0)	0
Vitamin B_2 (mg/d)	0.5	1.4 (1.1; 1.8)	0.4	1.3 (1.0; 1.6)	0.7	1.6 (1.3; 1.9)	0.1
Vitamin B_6 (mg/d)	0.5[a]	1.1 (0.9; 1.3)	0.4	1.0 (0.8; 1.2)	0.6	1.2 (1.0; 1.4)	0.1
Folate (mcg/d)	90[a]	158.2 (131.6; 190.0)	1.9	147.0 (123.2; 175.4)	3.1	169.9 (142.4; 202.7)	0.8
Vitamin B_{12} (mcg/d)	1.5[b]	2.9 (2.2; 3.7)	5.5[c]	2.6 (2.0; 3.3)	8[c]	3.1 (2.4; 4.0)	3[c]
Vitamin C (mg/d)	15[a]	58.3 (46.7; 72.0)	0	59.5 (47.7; 73.4)	0	57.1 (45.7; 70.6)	0
Vitamin D (mcg/d)	15[b]	2.1 (1.2; 3.3)	100[c]	2.3 (1.4; 3.6)	100[c]	1.9 (1.1; 3.0)	100[c]
Calcium (mg/d)	390[a]	970.3 (836.0; 1118.3)	0	942.9 (812.3; 1086.8)	0	997.6 (861.9; 1146.9)	0
Iron (mg/d)	5	7.8 (6.0; 10.1)	12.3	7.3 (5.7; 9.5)	15.3	8.2 (6.4; 10.6)	9.3
Magnesium (mg/d)	170[b]	187.1 (166.0; 209.2)	29.3[c]	179.0 (159.0; 200.0)	38.2[c]	195.1 (174.3; 216.9)	20.6[c]
Phosphorus (mg/d)	250[b]	961.1 (833.9; 194.5)	0[c]	906.9 (787.4; 1032.0)	0[c]	1015.4 (890.9; 1145.4)	0[c]
Potassium (mg/d)	800[b]	2246.5 (1993.1; 2513.7)	0[c]	2156.3 (1914.5; 2411.0)	0[c]	2336.8 (2085.8; 2600.8)	0[c]
Sodium (g/d)	1.5[d] (4)	1.9 (1.6; 2.1)	85.6	1.8 (1.6; 2.0)	79.5	2.0 (1.7; 2.2)	91.6

Note: (1) Recommendations from European Food Safety Authority.
Note: (2) Cut-off from Food and Nutrition Board of the Institute of Medicine.
Abbreviations: DRV, dietary reference value; F, female; M, male; PI, prevalence of inadequacy.
[a]Average requirement.
[b]Adequate intake.
[c]In the case of AI's, these % correspond to % of children who are below the AI value.
[d]Tolerable upper intake level.

nutritional intake by gender, girls presented a lower intake of vitamin B12 (lower than AI: 8.5% in girls and 3.6% in boys) and magnesium (lower than AI: 35.0% in girls and 25% in boys).

DISCUSSION

A large proportion of Portuguese toddlers had an excessive consumption of energy and sodium, high intakes of protein and a poor intake of vitamin A. They also consumed a low proportion of energy from fat due to the high proportion of energy from protein. About one-third of the sample consumed less than the recommended AI for fibre and magnesium and 100% had intakes less than the AI for vitamin D. For the other macro- and micronutrients, the intake was similar to the recommendations or presented negligible proportions of inadequacy.

These toddlers presented a high energy intake, as observed in other studies (Devaney et al., 2004; Huysentruyt et al., 2016; Manios et al., 2008). Besides resting energy expenditure, the recommendations for energy account for the energy needed for physical activity (at these ages, considered a low active lifestyle) and an additional 1% of energy expenditure for growth (EFSA, 2013). Excessive daily intakes of energy result in a positive energy balance that can predispose to obesity and ultimately, cardiovascular diseases (Weber et al., 2014) (FAO/WHO, 2003) (Smethers et al., 2019). Previous analyses of this sample, published by our group, found that at 24 months, 7.5% of toddlers were overweight or obese with a BMI z-score greater than 2 and 26.5% were at risk of overweight or obese with a

TABLE 6 The 10 main food sources of micronutrients (%) in Portuguese toddlers (12–36 months)

Food source	% Calcium	Food source	% Vitamin C	Food source	% Vitamin B1	Food source	% Folate	Food source	% Potassium	Food source	% Sodium	Food source	% Iron
Milk	32	Fresh Fruit	28.1	Breakfast Cereals	14	Breakfast Cereals	12.7	Milk	20.1	Vegetable Soup	42.1	Infant Cereals	25
Yogurt	24.2	Vegetables	18.5	Yogurt	8.8	Vegetables	11.4	Yogurt	13.2	Salt	8.6	Breakfast Cereals	14.7
Growing-up Milk	8.6	Vegetable Soup	11.8	Pork meat	7.1	Bread, crispbread, rusks	10.8	Fresh Fruit	11.7	Milk	6.1	Vegetable Soup	10.6
Infant Cereals	8.11	Infant Cereals	8.8	Fresh Fruit	7	Fresh Fruit	8.9	Vegetable Soup	10.7	Stocks	5.1	Bread, crispbread, rusks	5.5
Breakfast Cereals	3	Potatoes and other tubers	5.3	Infant Cereals	6.8	Yogurt	8.4	Potatoes and other tubers	7	Yogurt	4.7	Beef and veal	4.7
Cheeses	2.9	Breakfast Cereals	4.8	Potatoes and other tubers	6.2	Vegetable Soup	7.4	Fish	4.9	Bread, crispbread, rusks	4.6	Poultry	4.4
Vegetable Soup	2.6	Processed Fruits	4.6	Growing-up Milk	6	Pasta	4.3	Growing-up Milk	4.8	Fish	3.3	Milk	2.9
Vegetables	2.3	Natural Fruit and Vegetable juices	3.8	Bread, crispbread, rusks	5.7	Infant Cereals	3.8	Vegetables	4.8	Canned meat and meat products	2.9	Sweet biscuits	2.1
Milk beverages	1.7	Formula Milk	1.8	Vegetables	5.5	Fish	3.6	Beef and veal	3	Sweet biscuits	2.3	Rice	1.9
Fresh Fruit	1.4	Breast Milk	1.7	Pasta	4.9	Cakes, pastries and croissants	3.1	Poultry	2.6	Cheeses	2	Fish	1.9

Nutrition Bulletin

BMI z-score greater than 1 and less than 2 (Nazareth et al., 2021).

The food group that most contributed to energy intake was dairy products, which contributed more than 25%, with milk being the major food contributor (10.7%). Other studies carried out in the United States also found that milk was the largest contributor to energy intakes from 12 to 24 months, with even higher contributions of more than 20% of energy intake (Fox et al., 2006; Grimes et al., 2015). Data from the G21 for Portuguese children at 4 years of age (Lopes et al., 2014), showed that dairy products contributed 21.3% of the energy intake, with milk also being the major contributor, representing 13.9%.

The average protein intake was 4.7 g/kg/day, corresponding to more than five times the average recommended intake (0.87 g/kg/day) by EFSA (EFSA, 2012). This result is in accordance with other studies, where the intake of protein was three or four times higher than the respective recommendations (Brunner et al., 2018; Michaelsen & Greer, 2014; Walton et al., 2017). These results are also in line with other two Portuguese studies, the G21 (4.2 g/kg/day) for children at age of 4 (Lopes et al., 2014) and the *IAN-AF*, where the authors found that 83.2% of the children below 10 years had an intake above 2 g/kg/day (Lopes et al., 2015). The *EPACI* results showed high protein intakes from a young age and corroborate, once again, the observations of protein intakes above recommendations that have been described in several European countries (Agostoni et al., 2005; Hörnell et al., 2013). The literature supports that an excessive intake of protein at earlier ages was associated with a greater risk of overweight and obesity in long term (Günther et al., 2007; Michaelsen & Greer, 2014; Weber et al., 2014), and it can be explained by the "Early Protein Hypothesis" (Koletzko et al., 2013; Michaelsen, 2000; Rolland-Cachera et al., 1995).

The main food source for protein intake was milk (15.1%). Milk was a central food in the Portuguese toddler's diet, although the European Society for Paediatric Gastroenterology Hepatology and Nutrition (ESPGHAN) recommendations (ESPGHAN, 2017a) establish that from the age of complementary feeding (between 17 and 26 weeks), milk should no longer be the main food. Between the first and the third year of life, the daily consumption of dairy products should not exceed 400–500 ml (Benelam et al., 2015). In fact, milk continues to appear as a main food at this age, as parents always find it to be a complete food. It is a food that is familiar for children, who will therefore not reject it, providing an easy and convenient source of calories, and nutrients. The small decrease in average protein intake from the second year (4.8 g/kg/day) to the third year (4.5 g/kg/day) can be explained by the decrease in milk consumption with increasing age.

EPACI results described a high prevalence of inadequate fat intakes, where 90% of children consumed a lower proportion of energy as fat as that recommended (35%–40%). However, added fat is often underestimated, which can lead to an overestimation of inadequacy. It should also be noted that even though fat intakes as a proportion of energy are below the recommendations, the children had a high energy intake so that the absolute fat intake could meet or even exceed their needs. Nonetheless, we can find other references to the low intake of fat at these ages, in the literature. Walton et al. (Walton et al., 2017) found that 87% of children had a fat intake below recommendations, and the present results are also in line with previous results in the Portuguese population (Lopes et al., 2015; Vilela et al., 2019). The main food sources for fat were vegetable soup (13.4%), milk (8.9%), beef and veal (6.9%) and poultry (6.8%). As mentioned, milk continues to be a preponderant food in Portuguese toddlers' diets, and that at this age, the most consumed type of milk is semi-skimmed milk. This may explain why milk was not the main supplier of fat and contributes to the nutritional inadequacy of vitamin A since whole milk is also a good source of vitamin A, but semi-skimmed is not. Total fat was previously associated with cardiovascular disease (CVD), which probably led to changes in eating habits that included a reduction in its consumption (in all ages). This may explain the low intakes found in our study since there are no recommendations in Portugal, as there are in other countries such as the United Kingdom, not to give semi-skimmed milk as a main drink to children under 2 years. However, in the first years of life, fat plays a fundamental role in the maturing of cell membranes, especially in the central nervous system and in the retina (EFSA, 2010a). For this reason, it is not recommended to reduce fat intake until the age of 3 years, even in cases where the child presents dyslipidaemia or family risk for this disease. It is therefore important to also consider intakes of the different fatty acids (EFSA, 2010a).

Our results showed that 36% of the toddlers consumed less than the recommended AI for fibre, a pattern which has already been found in other studies. In fact, another Portuguese study concerning children aged between 7 and 9 years, found a prevalence of fibre inadequacy of about 90% (Valente et al., 2010), although a different recommendation was used. The main food sources for fibre were fresh fruit (31.4%), vegetable soup (14.6%) and vegetables (10.1%). The intake recommendations of five child-size portions of vegetables and fruit per day (Benelam et al., 2015; HSC Public Health Agency Belfast, 2018) must be achieved, so it is important to pay attention to this issue, always including vegetables in main meals (lunch and dinner) and including fruits in meals and snacks.

European children's sugar intake exceeds the recommendations (ESPGHAN, 2017b). The literature established that an excessive intake of sugar is related to dental caries (ESPGHAN, 2017b; Moynihan, 2016) and higher risk of overweight/obesity (ESPGHAN, 2017b). In the *EPACI* data, the median intake of total sugar was almost 25% of TE, and this percentage may be higher, since sugar consumption is often under-reported. However, the intake of free sugars was not possible to ascertain, and therefore it is not possible to determine the inadequacy prevalence. In fact, the three main food sources of sugar (fresh fruit, milk and yogurt) have naturally present sugars, which are not included in the definition of free sugars. As such, it can be postulated that the total sugar consumption was high, but an evaluation regarding only the free sugars would be more comprehensive. The EFSA recommendations were still not available in respect of sugar, but the World Health Organisation (WHO) Guidelines can be used (WHO, 2015). WHO guidelines for children and adults establish a cut-off of 10% of energy intake of free sugars, or even 5%. On the other hand, ESPGHAN (ESPGHAN, 2017b) advocate that the consumption of free sugars should be, at most, 5% of the TE intake for children of these ages.

A Portuguese study (Marinho et al., 2020) that analysed the different types of sugars found that almost 30% of children under 5 years consumed free sugars below 5% and almost 70% below 10%. The same study (Marinho et al., 2020) found that yogurts (16.1%) and infant cereals (14.2%) were the main food sources of free sugar in children under 5 years, and the main food sources of total sugars were milk (15.9%) and fruits (15.7%), which is in line with our results that are related to the total sugar.

In toddlerhood, rapid growth occurs, which is accompanied by an increase in nutritional requirements (Allen & Myers, 2006; Riley et al., 2018). At this stage, children acquire motor skills and become increasingly independent and able to feed themselves (Allen & Myers, 2006). Caregivers must provide a diversified diet, since a monotonous one could lead to nutritional deficits (Allen & Myers, 2006). Micronutrients play an important role in this life stage, characterised by rapid growth and development, with the needs per kg of weight being the highest in life and much higher than for adults (Weaver et al., 2008). This reinforces the importance of a varied and balanced diet (Benelam et al., 2015). A healthy diet during toddlerhood is also crucial to establish appropriate dietary habits in the future (Saavedra et al., 2013).

EPACI data revealed a low prevalence of nutritional inadequacy for many micronutrients, such as vitamins B_1, B_2, B_6, C, folate, calcium, but a prevalence of inadequacy for iron (12.3%), and vitamin A (27.4%). It also showed excessive intakes of sodium (85.6%). Similar results were found in previous national studies (Lopes et al., 2014; Valente et al., 2010) and in international studies in this age group (Brunner et al., 2018; Dalmau et al., 2015; Syrad et al., 2016).

Our results emphasise that food is a small contributor to vitamin D adequacy in this age group, as the total sample (100%) had an intake below the recommended AI. Since the main source of vitamin D is sun exposure, in cases where an adequate sun exposure is not guaranteed and/or recommended, supplementation should be considered. Apart from the recommendation for its universal supplementation during the first year of life, with a dosage of 400 IU/day (ESPGHAN, 2013; Wagner & Greer, 2008), supplementation should also be considered at any age, in at-risk groups, and especially during the fall and winter months (Holick et al., 2011; Saggese et al., 2018). Furthermore, unprotected sun exposure is not recommended until at least 2 years of age and this highlights the recommendation for universal supplementation in vitamin D up to that age, in line with the current recommendations from some nutrition committees (ESPGHAN, 2013).

More than a quarter of children were likely to have inadequate vitamin A intakes. Vitamin A can be found in the fat of dairy products, as well as in foods such as liver, eggs, yellow-orange vegetables and fruits and dark green vegetables (Mahan & Escott-Stump, 2000). An explanation for the high vitamin A inadequacy prevalence can be related to the low consumption of eggs and the reduced fat content of some dairy products, despite a heavy consumption of dairy products at these ages. As such, the use of reduced fat dairy products is probably not the best option at these ages.

About one-third of the toddlers (29.3%) consumed less than the recommended AI for magnesium. However, the median intake of magnesium was higher than the recommended AI and, therefore, the probability of inadequacy is low. These results are in line with the results found in other studies in different Portuguese populations (Dalmau et al., 2015; Lopes et al., 2014; Valente et al., 2010), some of which were conducted in older children (4 and 7–9 years old). The main food sources of magnesium are dried fruit, seeds, whole grains and dark green leafy vegetables, foods which are less frequently consumed by younger children, which may explain our results.

Our data also showed an excessive intake of sodium (especially considering the likely under-reporting of sodium) in children aged 12 months onwards. Sodium addition is proscribed during first year of life (ESPGHAN, 2017a) and sodium needs can be easily supplied by the salt naturally present in foods consumed by toddlers, so salt should not be added to food. The main food sources for sodium consumption were homemade vegetable soup (42.1%) and salt added to other dishes, mainly cooked at home (8.6%). Thus, since at this age children are supposed to be included in the family diet, it is important to reduce the amount

Nutrition Bulletin

of salt added (including in the vegetable soup) in the preparation of food for the whole family. There is an association between early consumption of excess sodium and the risk of hypertension, with the prevalence of hypertension in the Portuguese adult population being almost 40% (Rodrigues et al., 2019).

Many studies reveal a high prevalence of nutritional inadequacy for iron in young children (Brunner et al., 2018; Syrad et al., 2016), and a prevalence of nutritional iron inadequacy of 12.3% was found in this study. Inadequate iron intakes at this age could be explained by the high consumption of dairy products, which take the place of iron-rich foods, such as meat, and which also reduce the bioavailability of the iron (ESPGHAN, 2014). This is particularly relevant since the high growth velocity observed at this age results in a depletion of iron reserves around the sixth month of life, increasing the risk of iron deficiency and/or anaemia (EFSA, 2015). Iron plays an essential role in growth and health and its insufficiency in early ages may have implications on cognitive function and development (Walton et al., 2017). It is important that iron-rich and iron-fortified foods are always included in the diet, especially at these ages (Eussen et al., 2015), and particular attention must be paid to the amount of milk consumed.

In our study, the main contributors to the energy intakes were dairy products and vegetable soup, dairy products also being the main contributors to protein intakes. Although vegetable soup intake was relevant, we found that the total vegetable consumption was below the Portuguese dietary recommendations (Rodrigues et al., 2006). Intakes of cereals and tubers and fruits were also below the Portuguese dietary recommendations (Rodrigues et al., 2006). It would be helpful to promote the consumption of vegetables in main meals, as well as to increase the consumption of cereals, tubers and fruit throughout the day. We also found that, despite being foods that should not be part of toddlers' diets, sweets and sweet beverages are among the top nine food groups contributing to energy intake of toddlers.

The main strengths of this study are: (1) it is based on a national representative sample (Portugal mainland) - in fact, the *EPACI Portugal 2012* was the first study which provided dietary data about the intake of energy and nutrients, the prevalence of inadequate intakes and main food sources specifically in toddlers ages in Portugal; (2) the utilisation of food diaries as method for dietary intake assessment, which within the methods to record dietary intake is considered the gold standard.

However, some weaknesses must also be considered: only 38% of the sample filled in and returned the 3-day food diaries, although this participation rate is similar to other studies (Marinho et al., 2020; Moreira et al., 2015). Since this subsample (38%) consisted of older and better educated parents who, in general, tend to be better informed and more careful with their children's diet (Costarelli et al., 2022), the inadequacies could theoretically have been higher if the analysis had included all the assessed children.

It is important to consider that the data was reported by parents, which can lead to over or underreporting. Moreover, another weakness of our study was the analysis of sugars intake, which did not allow us to differentiate between added, free and total sugars, meaning a comparison with existing cut-offs that relate only to free sugars could not be made. Finally, since the data collection of the *EPACI* study was made 10 years ago, some food habits may have changed and the collection of updated data would be pertinent. Notwithstanding, these data are valuable as the baseline for further assessments.

CONCLUSIONS

Portuguese toddlers presented high intakes of energy and protein and a low proportion of energy from fat. Milk plays an important role in the diet at this age and was the main food responsible for this imbalance in the diet. An excessive intake of sodium begins at a young age, low intakes of vitamin A was observed in nearly a third of children and 100% of the children consumed less vitamin D than the recommended AI. The main contributor to sodium intake was vegetable soup and salt added to other dishes, reinforcing the importance of the recommendation to reduce salt when cooking at home. These data do not support a universal recommendation of multivitamin supplementation during toddlerhood, but supplementation must be considered for vitamin D.

AUTHOR CONTRIBUTIONS

M.N. was responsible for the coordination of fieldwork and data collection, conducted the treatment of data, performed statistical analysis, contributed to the interpretation of data and wrote the manuscript. E.P. contributed to the study design, was responsible for the fieldwork and data collection supervision, performed data and statistical analysis and revised the manuscript. M.S. performed statistical analysis and interpretation of data. P.G. contributed to the study design and interpretation of the results. C.L. contributed to the study design and revised the final version of the manuscript. C.R. was responsible for the coordination of the project, contributed to the study design, interpretation of data and revised the manuscript. All authors approved the final version of the manuscript.

ACKNOWLEDGEMENTS

The project had institutional support from the General Directorate of Health (DGS). The authors are grateful to all the families involved in *EPACI Portugal 2012* for their participation, to all members of the fieldwork team for their dedication and to all professionals of the health units and other departments for their help.

FUNDING INFORMATION

EPACI Portugal 2012 was funded by Nutricia Early Life Nutrition. The work of M.N. was supported by FCT-Fundação para a Ciência e a Tecnologia through the PhD Grant SFRH/BD/89293/2012. We would also like to thank the scientific collaboration under the FCT project UIDB/50016/2020.

CONFLICTS OF INTEREST

The authors report no conflict of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

ORCID

Margarida Nazareth https://orcid.org/0000-0001-9841-492X
Elisabete Pinto https://orcid.org/0000-0001-9028-8009

REFERENCES

Agostoni, C., Scaglioni, S., Ghisleni, D., Verduci, E., Giovannini, M. & Riva, E. (2005) How much protein is safe? *International Journal of Obesity*, 29(2), 8–13. Available from: https://doi.org/10.1038/sj.ijo.0803095

Alexy, U., Kersting, M., Sichert-Hellert, W., Manz, F. & Schöch, G. (1999) Macronutrient intake of 3- to 36-month-old German infants and children: results of the DONALD study. *Annals of Nutrition and Metabolism*, 43(4), 14–22. Available from: https://doi.org/10.1024/0300-9831.69.4.285

Allen, R.E. & Myers, A.L. (2006) Nutrition in toddlers. *American Academy of Family Physicians*, 74, 1527–1532.

Araújo, J., Severo, M., Lopes, C. & Ramos, E. (2011) Food sources of nutrients among 13-year-old Portuguese adolescents. *Public Health Nutrition*, 14(11), 1970–1978. Available from: https://doi.org/10.1017/S1368980011001224

Benelam, B., Gibson-Moore, H. & Stanner, S. (2015) Healthy eating for 1-3 year-olds: a food-based guide. *Nutrition Bulletin*, 40(2), 107–117. Available from: https://doi.org/10.1111/nbu.12134

Brands, B., Demmelmair, H. & Koletzko, B. (2014) How growth due to infant nutrition influences obesity and later disease risk. *Acta Paediatrica*, 103(6), 578–585. Available from: https://doi.org/10.1111/apa.12593

Brunner, T.A., Casetti, L., Haueter, P., Müller, P., Nydegger, A. & Spalinger, J. (2018) Nutrient intake of swiss toddlers. *European Journal of Nutrition*, 57(7), 2489–2499. Available from: https://doi.org/10.1007/s00394-017-1521-0

Castro-Quezada, I., Román-Viñas, B. & Serra-Majem, L. (2014) The Mediterranean diet and nutritional adequacy: a review. *Nutrients*, 6(1), 231–248. Available from: https://doi.org/10.3390/nu6010231

Costarelli, V., Michou, M., Panagiotakos, D.B. & Lionis, C. (2022) Parental health literacy and nutrition literacy affect child feeding practices: a cross-sectional study. *Nutrition and Health*, 28(1), 59–68. Available from: https://doi.org/10.1177/02601060211001489

Dalmau, J., Peña-Quintana, L., Moráis, A., Martínez, V., Varea, V., Martínez, M.J. et al. (2015) Análisis cuantitativo de la ingesta de nutrientes en niños menores de 3 años. Estudio ALSALMA. *Anales de Pediatria*, 82(4), 255–266. Available from: https://doi.org/10.1016/j.anpedi.2014.09.017

Dekkers, A.L.M., Verkaik-Kloosterman, J., van Rossum, C.T.M. & Ocké, M.C. (2014) SPADE, a new statistical program to estimate habitual dietary intake from multiple food sources and dietary supplements. *Journal of Nutrition*, 144(12), 2083–2091. Available from: https://doi.org/10.3945/jn.114.191288

Devaney, B., Ziegler, P., Pac, S., Karwe, V. & Barr, S.I. (2004) Nutrient intakes of infants and toddlers. *Journal of the American Dietetic Association*, 104(1), 14–21. Available from: https://doi.org/10.1016/j.jada.2003.10.022

Druet, C., Stettler, N., Sharp, S., Simmons, R.K., Cooper, C., Davey Smith, G. et al. (2012) Prediction of childhood obesity by infancy weight gain: an individual-level meta-analysis. *Paediatric and Perinatal Epidemiology*, 26(1), 19–26. Available from: https://doi.org/10.1111/j.1365-3016.2011.01213.x

EFSA (European Food Safety Authority). (2010a) Scientific opinion on dietary reference values for fats, including saturated fatty acids, polyunsaturated fatty acids, monounsaturated fatty acids, trans fatty acids, and cholesterol. *EFSA Journal*, 8(3), 1–107. Available from: https://doi.org/10.2903/j.efsa.2010.1461

EFSA (European Food Safety Authority). (2010b) Scientific opinion on principles for deriving and applying dietary reference values. *EFSA Journal*, 8(3), 1–30. Available from: https://doi.org/10.2903/j.efsa.2010.1458

EFSA (European Food Safety Authority). (2012) Scientific opinion on dietary reference values for protein. *EFSA Journal*, 10(2), 2557–2559. Available from: https://doi.org/10.2903/j.efsa.2012

EFSA (European Food Safety Authority). (2013) Scientific opinion on dietary reference values for energy. *EFSA Journal*, 11(1), 1–112. Available from: https://doi.org/10.2903/j.efsa.2013.3005

EFSA (European Food Safety Authority). (2015) Scientific opinion on dietary reference values for iron. *EFSA Journal*, 13(10), 1–115. Available from: https://doi.org/10.2903/j.efsa.2015.4254

EFSA (European Food Safety Authority). (2017) Dietary reference values for nutrients summary report. *EFSA Supporting Publications*, 14(12), 1–98. Available from: https://doi.org/10.2903/sp.efsa.2017.e15121

EFSA (European Food Safety Authority). (2019) Dietary reference values for sodium. *EFSA Journal*, 17(9), 1–191. Available from: https://doi.org/10.2903/j.efsa.2019.5778

ESPGHAN (European Society for Paediatric Gastroenterology Hepatology and Nutrition). (2013) Vitamin D in the healthy European Paediatric population. *Journal of Pediatric Gastroenterology and Nutrition*, 56(6), 692–701. Available from: https://doi.org/10.1097/MPG.0b013e31828f3c05

ESPGHAN (European Society for Paediatric Gastroenterology Hepatology and Nutrition). (2014) Iron requirements of infants and toddlers. *Journal of Pediatric Gastroenterology and Nutrition*, 58(1), 119–129. Available from: https://doi.org/10.1097/MPG.0000000000000206

ESPGHAN (European Society for Paediatric Gastroenterology Hepatology and Nutrition). (2017a) Complementary feeding: a position paper by the European Society for Paediatric Gastroenterology, hepatology, and nutrition (ESPGHAN) Commitee on nutrition. *Journal of Pediatric Gastroenterology and Nutrition*, 64(1), 119–132. Available from: https://doi.org/10.1097/MPG.0000000000001454

ESPGHAN (European Society for Paediatric Gastroenterology Hepatology and Nutrition). (2017b) Sugar in infants, children and adolescents: a position paper of the European Society for Paediatric Gastroenterology, hepatology and nutrition committee on nutrition. *Journal of Pediatric Gastroenterology* *and Nutrition*, 65(6), 681–696. Available from: https://doi.org/10.1097/MPG.0000000000001733

Eussen, S., Alles, M., Uijterschout, L., Brus, F. & Van Der Horst-Graat, J. (2015) Iron intake and status of children aged 6-36 months in Europe: a systematic review. *Annals of Nutrition and Metabolism*, 66(2–3), 80–92. Available from: https://doi.org/10.1159/000371357

FAO/WHO (Food and Agriculture Organization of the United Nations/World Health Organization). (2003) Diet, nutrition, and the prevention of chronic diseases (report of a joint WHO and FAO expert Consulation). *WHO Technical Report Series*, 916, 1–149. Available at. Available from: https://apps.who.int/iris/bitstream/handle/10665/42665/WHO_TRS_916.pdf?sequence=1

Food and Nutrition Board, I. of M. (2003) Dietary reference intakes. Applications in dietary planning. The nation, Washington, D.C. https://doi.org/10.1111/j.1365-277x.2004.00522.x, 17, 269, 270.

Fox, M.K., Pac, S., Devaney, B. & Jankowski, L. (2004) Feeding infants and toddlers study: what foods are infants and toddlers eating? *Journal of the American Dietetic Association*, 104(1), 22–30. Available from: https://doi.org/10.1016/j.jada.2003.10.026

Fox, M.K., Reidy, K., Novak, T. & Ziegler, P. (2006) Sources of energy and nutrients in the diets of infants and toddlers. *Journal of the American Dietetic Association*, 106(1), 28.e1–28.e25. Available from: https://doi.org/10.1016/j.jada.2005.09.034

Grimes, C.A., Szymlek-Gay, E.A., Campbell, K.J. & Nicklas, T.A. (2015) Food sources of Total energy and nutrients among U.S. infants and toddlers: National Health and nutrition examination survey 2005–2012. *Nutrients*, 7(8), 6797–6836. Available from: https://doi.org/10.3390/nu7085310

Holick, M.F., Binkley, N.C., Bischoff-Ferrari, H.A., Gordon, C.M., Hanley, D.A., Heaney, R.P. et al. (2011) Evaluation, treatment, and prevention of vitamin D deficiency: an Endocrine Society clinical practice guideline. *Journal of Clinical Endocrinology and Metabolism*, 96(7), 1911–1930. Available from: https://doi.org/10.1210/jc.2011-0385

Hörnell, A., Lagström, H., Lande, B. & Thorsdottir, I. (2013) Protein intake from 0 to 18 years of age and its relation to health: a systematic literature review for the 5th Nordic nutrition recommendations. *Food & Nutrition Research*, 57(1), 21083. Available from: https://doi.org/10.3402/fnr.v57i0.21083

HSC Public Health Agency Belfast (2018) 'Nutrition matters for the early years: guidance for feeding under fives in the childcare setting', pp. 1–48.

Huysentruyt, K., Laire, D., Van Avondt, T., De Schepper, J. & Vandenplas, Y. (2016) Energy and macronutrient intakes and adherence to dietary guidelines of infants and toddlers in Belgium. *European Journal of Nutrition*, 55(4), 1595–1604. Available from: https://doi.org/10.1007/s00394-015-0978-y

IOM (Institute of Medicine). (2011) Dietary reference intakes (DRIs): recommended dietary allowances and adequate intakes, vitamins food and nutrition board, Institute of Medicine, National Academies. *Food and Nutrition Board, (1997)*, 10–12. Available from: https://doi.org/10.1111/j.1753-4887.2004.tb00011.x

Karnik, S. & Kanekar, A. (2012) Childhood obesity: a global public health crisis. *International Journal of Preventive Medicine*, 3(1), 1–7. Available from: https://doi.org/10.1201/b18227-7

Koletzko, B., Beyer, J., Brands, B., Demmelmair, H., Grote, V., Haile, G. et al. (2013) Early influences of nutrition on postnatal growth. *Nestle Nutrition Institute Workshop Series*, 71, 11–27. Available from: https://doi.org/10.1159/000342533

Koletzko, B., Brands, B., Poston, L., Godfrey, K. & Demmelmair, H. (2012) Early nutrition programming of long-term health. *Proceedings of the Nutrition Society*, 71(3), 371–378. Available from: https://doi.org/10.1017/S0029665112000596

Kyttälä, P., Erkkola, M., Kronberg-Kippilä, C., Tapanainen, H., Veijola, R., Simell, O. et al. (2010) Food consumption and nutrient intake in Finnish 1–6-year-old children. *Public Health Nutrition*, 13(6A), 947–956. Available from: https://doi.org/10.1017/S136898001000114X

Lopes, C., Oliveira, A., Afonso, L., Moreira, T., Durão, C., Severo, M., *et al.* (2014) Food consumption and nutrition of preschool-age children - results of the generation 21 cohort [in portuguese]. Available at www.ispup.up.pt.

Lopes, C., Torres, D., Oliveira, A., Severo, M., Alarcão, V., Guiomar, S., *et al.* (2015) National Food, nutrition and physical activity survey (IAN-AF 2015-2016)—results report [in portuguese]. Available at: www.ian-af.up.pt.

Mahan, L.K. & Escott-Stump, S. (2000) *Krause's food, nutrition, & diet therapy*. Edited by P.W.B: Saunders.

Manios, Y., Grammatikaki, E., Papoutsou, S., Liarigkovinos, T., Kondaki, K. & Moschonis, G. (2008) Nutrient intakes of toddlers and preschoolers in Greece: the GENESIS study. *Journal of the American Dietetic Association*, 108(2), 357–361. Available from: https://doi.org/10.1016/j.jada.2007.10.042

Marinho, A.R., Severo, M., Correia, D., Lobato, L., Vilela, S., Oliveira, A. et al. (2020) Total, added and free sugar intakes, dietary sources and determinants of consumption in Portugal: the National Food, nutrition and physical activity survey (IAN-AF 2015-2016). *Public Health Nutrition*, 23(5), 869–881. Available from: https://doi.org/10.1017/S1368980019002519

Mello, C.S., Barros, K.V. & de Morais, M.B. (2016) Brazilian infant and preschool children feeding: literature review. *Jornal de Pediatria (Versão em Português)*, 92(5), 451–463. Available from: https://doi.org/10.1016/j.jpedp.2016.06.009

Michaelsen, K.F. (2000) Are there negative effects of an excessive protein intake? *Pediatrics*, 106, 1293.

Michaelsen, K.F. & Greer, F.R. (2014) Protein needs early in life and long-term health. *American Journal of Clinical Nutrition*, 99(3), 718–722. Available from: https://doi.org/10.3945/ajcn.113.072603

Monteiro, P.O.A. & Victora, C.G. (2005) Rapid growth in infancy and childhood and obesity in later life—a systematic review. *Obesity Reviews*, 6(3), 143–154. Available from: https://doi.org/10.1111/j.1467-789X.2005.00208.x

Moreira, T., Severo, M., Oliveira, A., Ramos, E., Rodrigues, S. & Lopes, C. (2015) Eating out of home and dietary adequacy in preschool children. *British Journal of Nutrition*, 114(2), 297–305. Available from: https://doi.org/10.1017/S0007114515001713

Moynihan, P. (2016) Sugars and dental caries: evidence for setting a recommended threshold for intake. *Advances in Nutrition*, 7(1), 149–156. Available from: https://doi.org/10.3945/an.115.009365

Nazareth, M., Pinto, E., Severo, M., Lopes, C. & Rêgo, C. (2021) Association between parental and offspring's body mass index: results from EPACI Portugal 2012. *Public Health Nutrition*, 24(10), 2798–2807. Available from: https://doi.org/10.1017/s1368980021001543

Nazareth, M., Rêgo, C., Lopes, C. & Pinto, E. (2016) Recomendações Nutricionais Em Idade Pediátrica: O Estado Da Arte. *Acta Portuguesa de Nutrição*, 07(20180705), 18–33.

Ong, K.K. & Loos, R.J.F. (2006) Rapid infancy weight gain and subsequent obesity: systematic reviews and hopeful suggestions. *Acta Paediatrica*, 95(8), 904–908. Available from: https://doi.org/10.1080/08035250600719754

Riley, L.K., Rupert, J. & Boucher, O. (2018) Nutrition in toddlers. *American Family Physician*, 98(4), 227–233.

Rodrigues, A.P., Gaio, V., Kislaya, I., Graff-Iversen, S., Cordeiro, E., Silva, A.C. et al. (2019) Sociodemographic disparities in hypertension prevalence: results from the first Portuguese National Health Examination Survey. *Revista Portuguesa de Cardiologia (English Edition)*, 38(8), 547–555. Available from: https://doi.org/10.1016/j.repce.2019.11.006

Rodrigues, S.S.P., Franchini, B., Graça, P. & de Almeida, M.D.V. (2006) A new food guide for the Portuguese population: development and technical considerations. *Journal of Nutrition Education and Behavior*, 38(3), 189–195. Available from: https://doi.org/10.1016/j.jneb.2006.01.011

Rolland-Cachera, M.F., Deheeger, M., Akrout, M. & Bellisle, F. (1995) Influence of macronutrients on adiposity development: a follow up study of nutrition and growth from 10 months to 8 years of age. *International Journal of Obesity*, 19(8), 573–578.

Roma-Giannikou, E., Adamidis, D., Gianniou, M., Nikolara, R. & Matsaniotis, N. (1997) Nutritional survey in Greek children: nutrient intake. *European Journal of Clinical Nutrition*, 51(5), 273–285. Available from: https://doi.org/10.1038/sj.ejcn.1600388

Saavedra, J.M., Deming, D., Dattilo, A. & Reidy, K. (2013) Lessons from the feeding infants and toddlers study in North America: what children eat, and implications for obesity prevention. *Annals of Nutrition and Metabolism*, 62(3), 27–36. Available from: https://doi.org/10.1159/000351538

Saggese, G., Vierucci, F., Prodam, F., Cardinale, F., Cetin, I., Chiappini, E. et al. (2018) Vitamin D in pediatric age: consensus of the Italian pediatric society and the Italian Society of Preventive and Social Pediatrics, jointly with the Italian Federation of Pediatricians. *Italian Journal of Pediatrics*, 44(1), 40–51. Available from: https://doi.org/10.1186/s13052-018-0488-7

Smethers, A.D., Roe, L.S., Sanchez, C.E., Zuraikat, F.M., Keller, K.L., Kling, S.M.R. et al. (2019) Portion size has sustained effects over 5 days in preschool children: a randomized trial. *American Journal of Clinical Nutrition*, 109(5), 1361–1372. Available from: https://doi.org/10.1093/ajcn/nqy383

Spinelli, A., Buoncristiano, M., Kovacs, V.A., Yngve, A., Spiroski, I., Obreja, G. et al. (2019) Prevalence of severe obesity among primary school children in 21 European countries. *Obesity Facts*, 12(2), 244–258. Available from: https://doi.org/10.1159/000500436

Stettler, N., Kumanyika, S.K., Katz, S.H., Zemel, B.S. & Stallings, V.A. (2003) Rapid weight gain during infancy and obesity in young adulthood in a cohort of African Americans. *American Journal of Clinical Nutrition*, 77(6), 1374–1378. Available from: https://doi.org/10.1093/ajcn/77.6.1374

Stettler, N., Zemel, B.S., Kumanyika, S. and and Stallings, V.A. (2002) 'Infant weight gain and childhood overweight status in a multicenter, cohort study', *Pediatrics*, 109(2), pp. 194–199.

Syrad, H., Llewellyn, C.H., Van Jaarsveld, C.H.M., Johnson, L., Jebb, S.A. & Wardle, J. (2016) Energy and nutrient intakes of young children in the UK: findings from the Gemini twin cohort. *British Journal of Nutrition*, 115(10), 1843–1850. Available from: https://doi.org/10.1017/S0007114516000957

Valente, H., Padez, C., Mourão, I., Rosado, V. & Moreira, P. (2010) Prevalência de Inadequação Nutricional em Crianças Portuguesas. *Acta Médica Portuguesa*, 23, 365–370.

Vilela, S., Correia, D., Severo, M., Oliveira, A., Torres, D. & Lopes, C. (2019) Eating frequency and weight status in Portuguese children aged 3–9 years: results from the cross-sectional National Food, nutrition and physical activity survey 2015–2016. *Public Health Nutrition*, 22(15), 2793–2802. Available from: https://doi.org/10.1017/S1368980019000661

Wagner, C.L. & Greer, F.R. (2008) Prevention of rickets and vitamin D deficiency in infants, children, and adolescents. *Pediatrics*, 122, 1142–1152. Available from: https://doi.org/10.1542/peds.2008-1862

Walton, J., Kehoe, L., McNulty, B.A., Nugent, A.P. & Flynn, A. (2017) Nutrient intakes and compliance with nutrient recommendations in children aged 1–4 years in Ireland. *Journal of Human Nutrition and Dietetics*, 30(5), 665–676. Available from: https://doi.org/10.1111/jhn.12452

Weaver, L., Harris, J. & More, G. (2008) What foods for toddlers? *Nutrition Bulletin*, 33, 40–46.

Weber, M., Grote, V., Closa Monasterolo, R., Escribano, J., Langhendries, J., Dain, E. et al. (2014) Lower protein content in infant formula reduces BMI and obesity risk 1 at school age: follow-up of a randomized trial. *American Journal of Clinical Nutrition*, 99(5), 1041–1051. Available from: https://doi.org/10.3945/ajcn.113.064071

WHO (World Health Organization). (2015) Guideline: sugars intake for adults and children. *World Health Organization*, 57(6), 1716–1722.

Zuccotti, G.V., Cassatella, C., Morelli, A., Cucugliato, M.C., Mameli, C., Troiano, E. et al. (2020) Nutrient intake in aging infants and toddlers: 3-year follow-up of the Nutrintake study. *International Journal of Food Sciences and Nutrition*, 71(4), 464–472. Available from: https://doi.org/10.1080/09637486.2019.1663798

SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

How to cite this article: Nazareth, M., Pinto, E., Severo, M., Graça, P., Lopes, C. & Rêgo, C. (2023) Prevalence of nutritional inadequacy in children aged 12–36 months: EPACI Portugal 2012. *Nutrition Bulletin*, 48, 101–114. Available from: https://doi.org/10.1111/nbu.12603