Review

Excess nutritional risk in infants and toddlers in a Spanish city

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Abstract: Adequate dietary intake is vital for infants' growth and development. The aim was to analyse food consumption and energy and nutrient intakes in a group of healthy Spanish infants and toddlers. Cross-sectional study. 154 infants were assessed at 6 months, and followed at 12 and 30 months. Clinical history, anthropometry, type of feeding, food consumption and energy and nutrient intakes (24-hours recall) were estimated. Advice about food consumed, estimated average requirements, the prevalence of inadequate intakes and percentage of adequacy of the recommended dietary allowance were applied. Toddlers had an excessive daily consumption of meat (>51.3g/day), milk (>545g/day), fish (>20.8g/day) and free-sugar foods (>30.5g/day). This consumption was related to a very high intake of proteins (>18%) and free sugars (>10%), at 12 and 30 months, as a percentage of daily energy intake. The mean prevalence of inadequacy intakes was above 48% for iron at 6 months, and 68% and 87% for vitamin D at 12 and 30 months, respectively. At 6 months, infants who were breastfed had greater adequacy in energy and nutrients to recommended dietary, while infants fed infant formula had a higher intake (>120% compared with RDA) in vitamins E, C, B1, B2, pantothenic acid, B6, B12 and folic acid. The contribution of micronutrients in infant formula should be reviewed, appropriate protein and free sugars should be provided during complementary feeding, as well as strategies to avoid vitamin D deficiency since childhood; and continue with the promotion of breastfeeding.

Keywords: Infant, Toddler, Food consumption, Energy and nutrient intake

Introduction

Adequate dietary intake during childhood is essential to ensure the child's optimal growth and development [1], achieve intellectual and immune development and prevent the diseases that manifest themselves at a later time and which are the main causes of morbidity and mortality [2, 3]. In recent years several studies have observed [4, 5] how nutrition during the child's first thousand days, from conception up to 2 years of age, has a strong impact on the risk of developing overweight and obesity in later years.

Various studies on American and European infants and young children have shown that the dietary intake of this population group is far from that recommended by organizations such as the WHO (World Health Organization) [6], EFSA (European Food Safety Authority) [7–10] and IOM (Institute of Medicine) [11–15]. Specifically, there was a lower consumption of vegetables [16, 17], polyunsaturated fatty acids [9], iron [18], vitamin D [19] and iodine [20], which could lead to nutritional deficiencies in this age group. Meanwhile a higher intake was observed in proteins [21–23], saturated fatty acids [24] and free sugars [23, 24], the high consumption of which has been associated with an increased risk of obesity in later stages [25, 26].

In Spain, to our knowledge there is only one study (Alsalma Study) [21] that has analysed the intake of nutrients in infants under 3 years of age. It concluded that 95.9% of Spanish infants and toddlers aged between seven months and three years of age exceeded the recommended daily protein intake by the RDA [11]. However, in addition to the description of the nutritional adequacy made by the authors, it would be interesting to describe the food consumption by analyzing the effect of different types of feeding on the adequacy of energy and nutrients, emphasizing the consumption of free sugars and at early ages.

Despite recent research pointing to the great effect that nutrition during the first 1000 days of life could have on health in later stages, there are very few studies that describe diet at such early ages. The aim of the study was therefore to analyse food consumption and energy and nutrient intakes in a group of healthy Spanish infants and toddlers at 6, 12 and 30 months of age.

Material and methods

Design and sample

This is a cross-sectional study of infants and toddlers from birth to 30 months. The infants were recruited at birth in the reference hospital in the Baix Camp region. The recruitment period was held from march 2008 to december 2009, during which the newborns were visited two alternate days a week, at the maternity ward, to offer participation in the study to those met the inclusion criteria: to be Caucasian, born at term (≥37 weeks) and without any know disease. The exclusion criteria were to born with low birth weight (<2500g) include multiple births, to have anemia or haemolytic disease, to present severe birth defects, immunodeficiency or hypothyroidism or other diseases requiring intensive care, to belong to families who did not understand Catalan or Spanish.

A total of 194 newborns from the Defensas study [27] were included at birth, of which 79% participated at 6 months (154) and provided completed data on their food consumption, 70% at 12 months (136) and 42% at 30 months (81). These losses are associated with a loss of interest on the part of the family or a lack of data for the analysis. All participants attended the Paediatric Unit. The study was approved by the hospital's Ethical Committee and with the Declaration of Helsinki. Written informed consent was signed by all parents.

The sample size was sufficient to detect significant differences between groups in the main variables if they exist, with a bilateral contrast, an alpha risk of 0.05 and a beta risk of 0.2%. With the results of the study, 81 subjects in infant formula group and 20 subjects in the breastfeeding group were needed to assess the percentage of energy adequacy, and 96 subjects in infant formula group and 24 subjects in the breastfeeding group were needed to assess the percentage of protein adequacy (with a standard deviation of 31 for energy and 68 for protein). The sample size was sufficient to detect significant differences in the percentage of energy adequacy or inadequacy at 6 months, accepting an alpha risk of 0.05 and a beta risk of 0.2 in a two-sided test, 36 subjects are necessary. The standard deviation is assumed to be 32. To detect significant differences in the percentage of protein adequacy or inadequacy at 30 months, accepting an alpha risk of 0.05 and a beta risk of 0.2 in a two-sided test, 90 subjects are necessary. The standard deviation is assumed to be 27 (version 7.12, Granmo, IMIM Hospital del Mar, Barcelona, España).

Measurements and data collection

Pregnancy and birth of the infants were recorded (Table I). Table II shows the anthropometric and food consumption data at 6, 12 and 30 months. We also collected data on clinical history, nutrition and anthropometry from the paediatricians and nutritionists who conducted the interviews following a standardization method for the collection of study variables.

Obstetrical and perinatal variables

Infant gender, gestational age at birth, type of delivery, infant feeding (breastfeeding and infant formula), Apgar score (at the 1st, 5th and 10th minutes after birth), without obvious pathology. Prenatal drug consumption (nicotine) data were collected using a survey specifically designed for this study. To encourage candid responses, the information was collected by researchers (and not by obstetricians) in a separate room and data confidentiality was assured.

Anthropometric measurements

Weight, height and cranial perimeter were recorded at birth and at 6, 12 and 30 months. All infants and toddlers' anthropometric measurements were collected by two trained research nutritionists and standardized. Infant weight was measured with a SECA electronic weighbridge (Vogel and Halke GmbH & Co, Hamburg) to an accuracy of 5 g. Infant length was measured to the nearest 0.1cm using a length board (model PE-RILB-STND, Perspective Enterprises Measuring Equipment). At 30 months, weight and height were measured by means of an electronic scale with a stadiometer (model SECA 764, Hamburg, Germany). The cranial perimeter was measured using a flexible tape measure to an accuracy of 1mm. Infant growth indicators such as weight for length at 6 and 12 months and weight for height at 30 months z-scores were calculated using the LMS method [28, 29]. The z-score is equivalent to a standard deviation (SD) score cut-off of between −3 and +3 SDs. The WHO provides cut-offs for the classification of thinness (<−1 and ≥−3), normoweight (≥+1 and ≤+1), overweight (> +1 and ≤+2) and obesity (>+2) [30].

Clinical history: all medical problems suffered and all vaccines received by the toddler during this period were also recorded.

2.2.3 Sociodemographic data: the data recorded were the mother's age and both parents level of education and occupation. The family's socioeconomic level was obtained using the Hollingshead Index (2011) [30], which estimates the parents' social status by grouping occupations into nine categories (from unskilled to highly skilled) and level of education into seven categories (from non-completed primary education to completed higher education). The scores range from 0 to 66 and place parents into one of three categories: low, middle or high.

Food consumption and energy and nutrient intake

The type of feeding and food consumption were recorded through a single 24-hour recall at different time-points (6, 12, 30 months) by an interview with two trained nutritionists and standardised. A random sub-sample of eight 24-hour recalls was independently rated by two nutritionists to determine inter-rater reliability, with the percent agreement was 96%.

Table I. General characteristics of the mother and infant at birth.

		n=154
MOTHERS		
Age of the mother, years		31.5 (4.4)
Socioeconomic level, %	Low	8 (13)
	Medium	53 (81)
	High	39 (60)
Smokers, %		19 (29)
Mode of delivery, %	Normal	67 (103)
	Forceps	12 (20)
	Caesarean	19 (31)
Primiparous, %		52 (80)
NEWBORN		
Gender, male %		46 (71)
Gestational age, weeks		39.6 (1.2)
Breastfeeding, (%)	0 months	78.6 (131)
	4 months	24 (37)
	6 months	16.3 (25)
	12 months	2.7 (4)
BIRTH ANTHROPOMETRY		
Birth weight, kg		3.3 (0.4)
Birth height, cm		49.6 (2.1)
Birth cranial perimeter, cm		34.5 (1.5)
10-min APGAR score		9.97 (0.2)

Values are expressed as mean (standard deviation) or percentage (n).

The introduction of novel food was assessed by a qualitative questionnaire filled out by parents.

The volume of breast milk could not be measured and was therefore estimated according to the child's age: 600mL/day in toodlers older than 6 months [31]. Infant formula was calculated by taking into account that for every 30 ml of water, 4.7g of milk powder (1 scoop) is added, which means that each gram of milk powder is equal to 6.38 ml of reconstituted milk. Breast milk and cow's milk composition were extracted from the Spanish food composition table: Mataix Verdú [32] for cow's milk, and Prof. Ángel Gil [33] for breast milk, from the Treatise on Nutrition.

The food consumption estimate over the 24-hour recall was distributed into 15 food groups: 1 Meat (including all types of organ meats and sausages), 2 Eggs, 3 White and blue fish, 4 Milk (maternal, artificial), 5 Dairy products (yoghurt, cheese ...), 6 Fats and oils (oil, margarine, butter ...), 7 Nuts, 8 Cereals (bread, rice, pasta ...), 9 Potatoes, 10 Legumes, 11 Vegetables, 12 Fruit, 13 Fruit juices, 14 Sweets (sugar, chocolate, sweets, pastry ...), and 15 Sweetened beverages. Energy and nutrient intake is expressed in g/day or ml/day, energy in Kcal/day, all of them ± their standard deviation assuming an error margin of 5%.

We calculated the daily intake of energy and nutrients with REGAL (Répertoire Général des Aliments) food composition table [34], complemented by the Mataix Verdú [32] Spanish food composition table.

This food consumption was compared with the food consumption advice from the Departament de Salut de la Generalitat de Catalunya [35].

As regards simple carbohydrates, the natural sugars were whole fruits, vegetables, milk and cereals (rice, bread, pasta, flour), while the free sugars were sugary dairy desserts, sweetened beverages (natural and commercial fruit juices, soft drinks), sweet cereals (sweetened breakfast cereals, cookies, pastries) and chocolate, sugar and honey, as recommended by the WHO [36].

The calculation for the estimated average requirement (EAR) of energy was based on the weight of the toddlers at 6, 12 and 30 months of age. The international EAR of nutrients developed by the IOM [11] was the most appropriate for comparison of our study sample. The EAR cut-point method was applied to estimate the prevalence of nutrient intake adequacy [37]. To apply this method, information on usual intakes is needed in order to attenuate intra-individual variability [38]. The EAR cut-point was calculated as follows: $z = (x - \mu)/SD$, with x being the EAR and μ the mean nutrient intake, and <1SD (standard deviation). The result was then expressed as a percentage.

We compared the results of our study with the recommended dietary allowance (RDA) for each nutrient as outlined in the dietary reference intakes (DRI) recommended by the National Academy of Sciences [11–15].

Data analysis

The results are presented as percentages, means and standard deviations.

The normality were assessed using Kolmogorov-Smirnov and Shapiro-Wilks tests.

The Student's t-test was used to compare means using Levene's test to assess the homogeneity of variance, and the chi-squared test to compare categorical variables.

The variables were collected on a database and processed using SPSS for Windows version 20.0.

In all cases the level of significance was set at $p<0.05$.

Results

The sample consisted of 154 infants, 46% of whom were boys.

Table I shows the general characteristics of the mother and infant at birth. The average age of the mother was 31.5 years and 78.6% of the infants were breastfed.

Table II shows the anthropometric data and food consumption in infants and toddlers at 6, 12 and 30 months of age. According to the weight-for-height ratio and weight-for-length z-score recommended by the WHO

Table II. Anthropometric parameters and food consumption in infants and toddlers during the first years of life.

	6 months n=154	12 months n=136	30 months n=81
ANTHROPOMETRIC PARAMETERS			
Weight (kg)	7.9 (0.9)	10.1 (1.2)	14.4 (1.6)
Height (cm)	67.4 (2.7)	75.9 (3)	92.8 (4.1)
Cranial perimeter (cm)	43.6 (1.4)	46.3 (1.4)	–
Ponderal index, %*			
• Underweight	7.4 (11)	5.2 (5)	9.9 (7)
• Normoweight	71.3 (110)	63.6 (52)	50.6 (42)
• Overweight	16.7 (26)	19.5 (15)	27.2 (22)
• Obesity	4.7 (7)	11.7 (9)	12.3 (10)
FOODS CONSUMED/DAY			
Meat (g)	17.8 (19.8)	51.3 (88.1)	126 (69.2)
Eggs (g)	0	3.6 (10.1)	13.9 (12.6)
Fish (g)	0	20.8 (28.3)	57.9 (46.8)
Milk (g)	276 (242)	545 (148)	345 (272)
Dairy products (g)	20.1 (44.1)	114 (85.4)	135 (83.2)
Fats and oils (ml)	3.3 (5.6)	14.6 (8.1)	22.5 (9.9)
Nuts (g)	0	0	0.9 (5.2)
Cereals (g)	25.5 (17.4)	55.8 (36.7)	104 (41.2)
Legumes (g)	0.3 (2.3)	5.7 (22.1)	15.8 (26.2)
Vegetables (g)	55.7 (63.4)	207 (176)	100 (75.6)
Fruit (g)	150 (89.4)	155 (154)	103 (71.5)
Fruit juices (ml)	17.8 (31.4)	25.6 (40.2)	61.6 (68.5)
Sweets (g)	0	18.9 (1.7)	26.4 (47.7)
Sweetened beverages (ml)	0	2.3 (21.4)	4.2 (19.6)

Values are expressed as mean (standard deviation) or percentage (n). *The calculation of the ponderal index considered weight for length at 6 and 12 months, and weight for height at 30 months. Feeding recommendations in early childhood (0 to 3 years), Generalitat de Catalunya, 2009. At 6 months for meat, eggs and fish these are 12.5g/day, 25g/day and 17.5g/day respectively; at 12 months for meat, eggs and fish the figures are 20g/day, 30g/day and 30g/day respectively. and at 30 months for meat, eggs and fish the recommendations are 25g/day, 35g/day and 35g/day respectively. At 12–30 months for milk and dairy products the figures are 200ml/day and 125g/day respectively. (–) means there is no data.

[29], 21.4%, 31.2% and 39.5% presented overweight/obesity at 6, 12 and 30 months respectively. We observed that the consumption of meat, eggs, fish, dairy products, fats and oils, cereals, legumes and high-sugar foods increased steadily with age, while the consumption of milk, vegetables and fruit decreased at 30 months.

Figure 1. Meat, milk and fish consumption was much higher than the food consumption advice. Meat consumption was higher at 6 (143%), 12 (256%) and 30 months (502%), and milk was higher at 12 (272%) and 30 months (172%). Also, fish consumption was higher (166%) than recommended at 30 months.

Figure 2 compares the month of complementary foods introduction, according to the type of feeding (breastfeeding or infant formula) received, with the recommendations established by food advice in Catalonia. It is observed that the introduction of foods is in line with the recommendations for most foods.

Table III. The prevalence of inadequate nutrients was higher at 6 months for energy (35.6%) and iron (47.9%). Vitamin D inadequacy was present in almost 68% and 87% of toddlers at 12 and 30 months respectively, percentage of adequacy was much higher than RDA for protein in all ages. This also was observed in other micronutrients such as vitamin A, E, C, B1, B2, niacin, pantothenic acid, B6, B12 and folates.

Figure 3. The main source of protein at 12 and 30 months was of animal origin (around 64% and 63% respectively).

Table IV. Infant formula and mixed-feeding toddlers had higher levels of energy, macronutrients (except lipids) and micronutrients compared to breastfeeding infants. We observed that toddlers fed with infant formula had percentage adequacy much higher than RDA for energy, macronutrients and micronutrients, except for iron and vitamin D, which was more adequate.

Discussion

Our study presents data on food consumption in a group of healthy Spanish infants and toddlers at 6, 12 and 30 months. There is an adequate introduction of complementary foods,

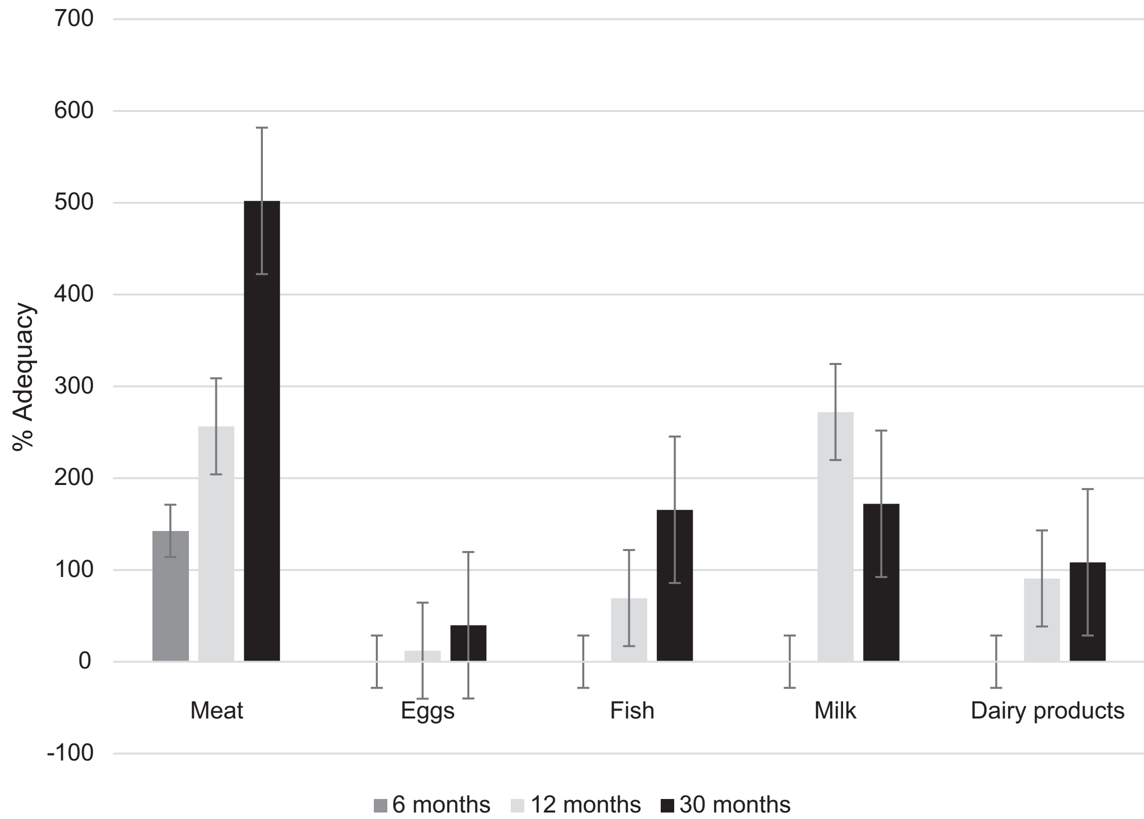

Figure 1. Percentage adequacy to food consumption advice during the first years of life. Error bars represent the standard deviation. Feeding recommendations in early childhood (0 to 3 years), Generalitat de Catalunya, 2009. At 6 months for meat, eggs and fish these are 12.5g/day, 25g/day and 17.5g/day respectively; at 12 months for meat, eggs, and fish the figures are 20g/day, 30g/day and 30g/day respectively; and at 30 months for meat, eggs and fish the recommendations are 25g/day, 35g/day and 35g/day respectively. At 12–30 months for milk and dairy the figures are 200ml/day and 125g/day respectively.

although in excessive quantities as regards meat, fish and milk, which is reflected in excessive intake of proteins, mainly of animal origin. We also observed a large consumption of foods with a high content of free sugars, around 10% higher than recommended [36]. The infants had a very high intake of vitamins and minerals, with the exception of vitamin D and iron (at 6 months). At this age, toddlers who breastfeed have better nutritional adequacy compared to those fed on infant formula.

Most of these Spanish infants were from families of medium or high socioeconomic level. The procedures for taking anthropometric measurements, conducting interviews and completing questionnaires were standardized among those working on the study so as to reduce variability in data collection. The 24-hour recall is a useful method in studies of population with monotonous diets or little food diversity [39].

The food consumption and anthropometry in our sample were similar to those in other studies conducted in developed countries [21, 24]. A high percentage of overweight/obesity was observed at 6 (21.4%), 12 (30.6%) and especially 30 months of age (39.6%). The most recent data on 8-year-old children in Spain [40] showed an 11.6% prevalence of obesity. According to these data, the prevalence of obesity doubles between 3 and 8 years of age [40].

The protein intake at 6, 12 and 30 months was much higher than the values established by the RDA. A mean percentage of protein consumption of 164% over the recommendations was observed in toddlers at 6 months, 279% at 12 months and 461% at 30 months of age, i.e. intake nearly 5 times more than the recommended values. This increasing trend in protein intake has also been observed in infants and toddlers between 13 and 36 months in Spain with energy intakes of 370–441% of the RDA/adequate intake (AI) [21] and other European countries [22, 23].

In infants under 6 months, we observed that most of the protein intake came from infant formula (181% percentage adequacy to the RDA versus 116% breastfeeding). At subsequent ages the main protein sources were meat (with consumption up to 5 times higher than recommended), milk and fish (at 30 months). Protein, especially processed meat, is associated with an increased risk of several major chronic diseases in later childhood such as cancer [41, 42]. Other studies have shown that a high protein intake during the

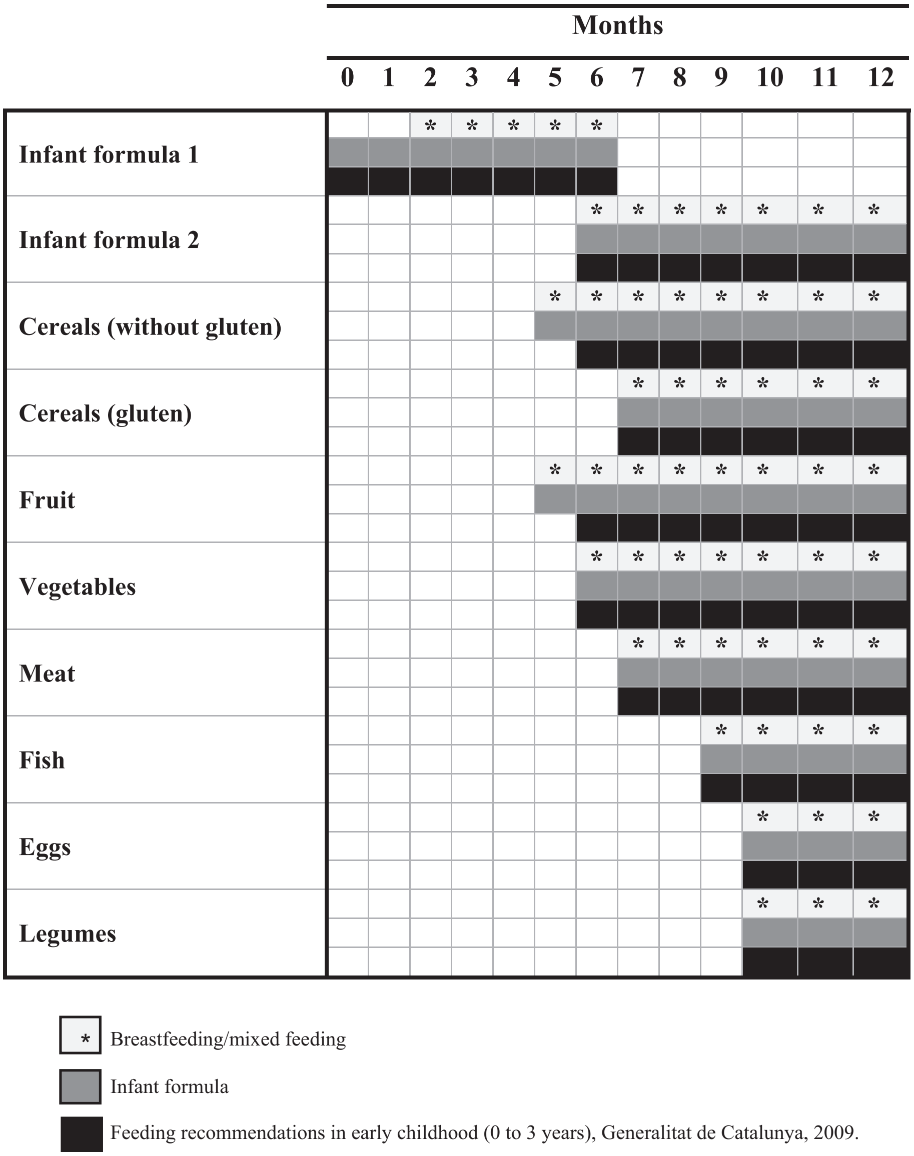

Figure 2. Introduction of complementary foods according to type of feeding up to 12 months of age.

first two years of life increases the risk of overweight and future obesity [21, 43–46]. On the contrary, the consumption of vegetable protein of the toddlers was much lower than the animal. Unlike animal protein, vegetable protein is not associated with accelerated growth and higher body mass index in childhood [47].

Protein intake is known to stimulate insulin and insulin-like growth factor 1 metabolism leading to cell proliferation, accelerated growth, and increased adipose tissue [48]. Evidence implicating the risk of the higher protein content of infant formula on rapid weight gain is provided by a large multi-centre European randomised controlled trial [44].

Complementary feeding for most foods was introduced in a similar way to food consumption advice in Catalonia [35]. However, these data are not observed in most countries, where the introduction of complementary feeding was earlier than recommended [49].

The consumption of foods like fruit juice, sweets and sweetened beverages increased with age. In line with other studies in infants, free-sugar intake was higher (>10%) than recommended by the WHO [36], with two-thirds of infants at 12 months consuming desserts and sweetened drinks and 77% consuming fruit juice [50]. Jardí et al. differentiated between intakes of free and natural sugars and observed that the consumption of free sugars was much higher than recommended at 12 months, and that this intake could be a risk factor for excess weight at early ages [26]. The consumption of vegetables and fruit decreased gradually. This was related to the transition from purees to solid foods. In the case of fruits, vegetables, legumes, pasta, rice, bread,

Table III. Mean daily energy and nutrient intake and proportion of toddlers with inadequate intakes below the EAR and adequacy percentage to the RDA, during the first years of life.

Nutrients	6 months n=103			12 months n=87			30 months n=81		
	Mean intake (SD)	% < 1SD EAR	Adequacy percentage to the RDA	Mean intake (SD)	% < 1SD EAR	Adequacy percentage to the RDA	Mean intake (SD)	% < 1SD EAR	Adequacy percentage to the RDA
Energy (Kcal)	760 (212)	35.6	115 (32.2)	1074 (223)	16.1	132 (27.4)	1367 (343)	11.6	108 (26.7)
Proteins (g)	18 (7.2)	3	164 (65.1)	36.3 (11.1)	0	279 (85.5)	59.9 (15.6)	0	461 (120.4)
Animals (g)	12.3 (7.4)	–	–	23.1 (9.7)	–	–	37.8 (14.6)	–	–
Vegetables (g)	5.6 (3.4)	–	–	13.2 (6.9)	–	–	22.1 (14.3)	–	–
Carbohydrates (g)	105 (31.2)	–	111 (32.8)	137 (29.8)	10.1	106 (22.9)	140 (39.2)	11.2	108 (30.1)
Starch (g)	8.5 (9.3)	–	–	27.1 (17.2)	–	–	28.8 (24.1)	–	–
Free sugars (g)	5.8 (9.6)	–	–	30.5 (29.9)	–	–	33.2 (32.1)	–	–
Natural sugars (g)	20.3 (7.2)	–	–	24.4 (7.6)	–	–	23.5 (7.1)	–	–
Lipids (g)	30.1 (9.6)	–	101 (32.1)	42.2 (12.2)	–	–	62.7 (19.1)	–	–
Saturated fats (g)	7.5 (5.1)	–	–	8.5 (5.3)	–	–	27.7 (7.4)	–	–
Monounsaturated fats (g)	9.2 (5.1)	–	–	14.6 (7.4)	–	–	28.8 (10.1)	–	–
Polyunsaturated fats (g)	3.8 (1.7)	–	–	3.5 (1.8)	–	–	7.4 (3.1)	–	–
Cholesterol (mg)	71.9 (66.8)	–	–	83.1 (69.2)	–	–	223 (88.5)	–	–
Fibre (g)	6.6 (3.3)	–	–	11.1 (5.5)	–	58.2 (28.9)	10.8 (7.4)	–	56.8 (38.7)
Calcium (mg)	462 (195)	–	178 (74.8)	735 (232)	12.9	105 (33.1)	772 (307)	16.0	110 (43.8)
Iron (mg)	6.7 (3.7)	47.9	60.8 (33.4)	9.2 (3.5)	0.1	132 (50.5)	8.2 (3.9)	1.3	118 (56.1)
Magnesium (mg)	80.6 (34.3)	–	107 (45.7)	128 (38.3)	4.1	161 (47.8)	189 (60.9)	0.7	236 (76.1)
Sodium (mg)	214 (67.4)	–	181 (78.2)	509 (405)	–	50.9 (40.5)	1384 (415)	–	138 (41.5)
Potasium (mg)	1166 (535)	–	167 (76.4)	1939 (632)	–	277 (90.3)	2840 (689)	–	91.1 (22.9)
Vitamin A (μg)	598 (190)	–	120 (38.1)	797 (373)	0.9	266 (124)	418 (284)	27.1	139 (94.6)
Vitamin D (μg)	7.4 (4.4)	–	74.1 (43.8)	8.2 (4)	67.8	54.8 (26.6)	3.5 (4.6)	86.9	23.1 (31)
Vitamin E (mg)	8.9 (4.2)	–	178 (84.1)	13.8 (5.2)	3.1	229 (87.2)	7.6 (4.4)	31.8	127 (73.7)
Vitamin C (mg)	106 (39.1)	–	213 (78.2)	120 (41.9)	1	800 (279)	50.8 (29.3)	2	339 (196)
Vitamin B1 (mg)	0.7 (0.3)	–	232 (116)	0.9 (0.2)	0.9	185 (51)	1 (0.3)	0.8	196 (62.5)
Vitamin B2 (mg)	0.8 (0.4)	–	213 (110)	1 (0.3)	0.8	206 (67.4)	1.35 (0.4)	0.2	271 (87.4)
Niacin (mg)	7.6 (2.8)	–	190 (69.8)	9.6 (3.8)	5.8	161 (63.3)	11.4 (3.9)	2.9	191 (65.2)
Pantothenic acid (mg)	3.6 (1.9)	–	201 (107)	4.2 (1.2)	–	208 (62.8)	3.7 (1.1)	–	184 (56.7)
Vitamin B6 (mg)	0.8 (0.4)	–	283 (141)	1.3 (0.4)	0.4	220 (129)	1.2 (0.4)	1.6	541 (263)
Vitamin B12 (μg)	1.1 (0.6)	–	220 (129)	1.6 (0.9)	7.7	177 (96)	2.7 (1.3)	0.3	300 (146)
Folic acid (μg)	133 (60.4)	–	166 (75.5)	182 (61.7)	14.1	121 (41.1)	156 (53.4)	22.9	104 (35.6)

SD: standard deviation. EAR: estimated average requirement; % <1SD EAR: proportion of individuals with mean intakes below the 1SD EAR in analysis of inadequate dietary intakes. The EAR cut-point was calculated as follows: $z = (x - \mu)/SD$, with x being the EAR and μ the mean nutrient intake, and SD. RDA: recommended dietary allowances. Data from DRIs of the Institute of Medicine, 2002 and 2010 (new vitamin D and C values). (–) means there is no data.

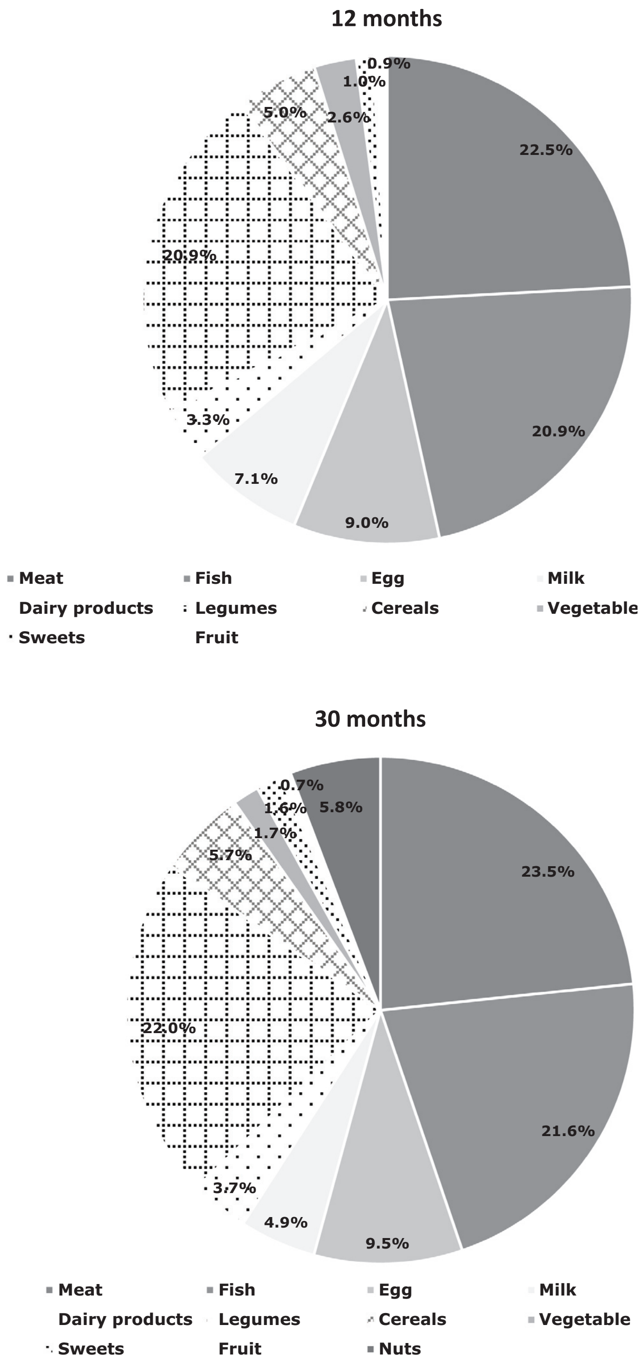

Figure 3. Percentage of protein contributed by different foods at 12 and 30 months of age.

etc., there are no recommendations, but the quantities given must be adapted to the appetite sensation manifested by the toddler [35].

The prevalence of inadequacy of vitamin D was above 68% and 81% at 12 and 30 months, respectively. In those under 12 months this can be explained by exclusive breastfeeding, as the study did not gather data on vitamin supplements. Compared with other studies, the average daily intake was much lower than recommended levels among children of all ages and adults [19, 51, 52]. This could be important for their later health, since there is a relationship between vitamin D deficiency and cardiovascular and metabolic disease risk factors [53, 54]. Vitamin D supplementation is still needed to reach the recommended daily amount of 10 µg, and for this reason the American Academy of Pediatrics and other institutions [55, 56] recommend an intake of 400 IU/day in children under one year and 600 IU/day in older children.

Iron deficiency is the most common cause of anemia in infants and toddlers [57] and an evaluation of iron intake is especially important in the first three years of life. In our study we observed a prevalence of inadequacy of 48% only at 6 months. Our findings coincided with those of Zaragoza-Jordana et al. [52] who also found that iron intake was inadequate at 6 months. Mensink et al. [51] performed a meta-analysis with data from several cross-country epidemiologic studies assessing nutritional intake of different age groups of population and found a low intake of iron but at 12 months of age. On the contrary, Dalmau et al. [21] not observe the low prevalence of adequacy. In our study, these data are no longer observed at 12 and 30 months since the toddlers' diet has diversified by this time. Although the exact requirements for iron during infancy and early childhood are not known, there is reasonable consensus that most healthy breastfed infants born at term do not need exogenous iron until around 6 months of life [58]. However, after 6 months, the need for exogenous iron increases rapidly as the physiological requirement per kg body weight becomes greater than later in life. This is why the low iron content of human milk (0.2–0.4 mg/L) is sufficient to meet the needs of healthy term infants during the first 6 months but not thereafter when the iron requirement is difficult to meet [58].

A high intake for most micronutrients was observed in all ages. Compared to breastfeeding, infant formula contains higher concentrations of most nutrients [59]. In some cases, the higher content of nutrients such as iron, calcium and sodium is to compensate for the lower bioavailability with respect to breast milk [12]. The high nutrient content of infant formula should not be interpreted as reflecting nutrition. Micronutrient intake in infants of 6, 12 and 30 months exceeds – in some cases by more than 160% – recommended levels of vitamins A, E, C, B1, B2, niacin, pantothenic acid, B6, B12 and folats. The study by Jardí et al. [59] has already described this excess of micronutrients in infant formula at these ages.

Our study has certain limitations. For example, infant studies must be strict with scheduled visits, so any delay in visiting meant exclusion from the study which decreased the sample size, even though the small sample size was enough to observe significant differences. Therefore, the

Table IV. Mean daily energy and nutrient intake and adequacy percentage to RDA according to type of feeding at 6 months of age.

	Energy and nutrient intake				Adequacy percentage to the RDA			
	Breastfeeding n=25	Mixed feeding n=34	Infant formula n=98	*p*-value	Breastfeeding[a]	Mixed feeding[b]	Infant formula[c]	*p*-value[(a,b,c)]
Energy (Kcal)	645 (174)	771 (149)	788 (233)	0.045	97.7 (26.3)	117 (22.5)	119 (35.3)	0.041[(a–c)]
Proteins (g)	12.8 (5.2)	16.9 (5)	19.9 (7.5)	0.001	116 (47.1)	153 (45.8)	181 (68.6)	0.001[(a–c)]
Animals (g)	10.5 (8.6)	11.8 (5.2)	13.3 (9.7)	0.105	–	–	–	–
Vegetables (g)	2.3 (0.7)	5.1 (4.9)	6.6 (2.3)	0.001	–	–	–	–
Carbohydrates (g)	80.5 (27.8)	104.1 (22.1)	113 (31.7)	0.001	84.7 (29.2)	110 (23.2)	118 (33.3)	<0.001[(a–c)]
Starch (g)	6.1 (8.7)	5.4 (5.6)	10.2 (10.5)	0.217	–	–	–	–
Free sugars[1] (g)	4.7 (4.8)	5.4 (2.5)	6.8 (6.7)	0.001	–	–	–	–
Natural sugars[2] (g)	19.9 (10.6)	20.3 (12.6)	20.8 (14.8)	0.987	–	–	–	–
Lipids (g)	31.5 (6.1)	32.8 (6.5)	28.8 (11.1)	0.201	105 (20.1)	109 (21.8)	96.1 (37.1)	0.937[(a–c)]
Saturated fats (g)	12.8 (1.1)	10.8 (2.6)	4.9 (4.4)	<0.001	–	–	–	–
Monounsaturated fats (g)	12.5 (3.4)	11.9 (4.8)	7.1 (4.5)	<0.001	–	–	–	–
Polyunsaturated fats (g)	3.9 (0.7)	4.2 (1.1)	3.6 (2)	0.455	–	–	–	–
Cholesterol (mg)	169 (19.5)	117 (44)	23 (24.5)	<0.001	–	–	–	–
Fibre (g)	4.2 (2.3)	5.8 (2.8)	7.4 (3.3)	<0.001	–	–	–	–
Calcium (mg)	275 (92.3)	406 (108)	533 (201)	<0.001	106 (35.8)	156 (41.6)	205 (77.2)	<0.001[(a–c)]
Iron (mg)	2.1 (2)	5.4 (2.4)	8.4 (3.1)	<0.001	19 (18.3)	48.9 (22.1)	76.4 (28.1)	<0.001[(a–c)]
Magnesium (mg)	65.1 (21.9)	72.1 (24.7)	91.9 (34.4)	<0.001	93.1 (45.2)	103.3 (25.7)	306 (98.1)	<0.001[(a–c)]
Sodium (mg)	227 (44.9)	219 (32.3)	208 (80.5)	0.548	189 (52.7)	183 (54.2)	176 (84.3)	0.269
Potassium (mg)	794 (370)	1098 (449)	1292 (555)	0.002	106 (16.9)	157 (26.9)	185 (69.5)	<0.001[(a–c)]
Vitamin A (µg)	542 (125)	619 (148)	605 (216)	0.398	108 (25.0)	124 (29.5)	121 (43.3)	0.673
Vitamin D (µg)	1.5 (2.1)	5.7 (3.3)	9.6 (3.3)	<0.001	14.9 (21.1)	56.6 (32.8)	96.4 (32.9)	<0.001[(a–c)]
Vitamin E (mg)	5 (1.6)	7.9 (2.2)	10.3 (4.5)	<0.001	99.4 (32.2)	158 (44.3)	207 (89.3)	<0.001[(a–c)]
Vitamin C (mg)	67.2 (26.3)	98.3 (27.4)	120 (38)	<0.001	134 (52.6)	197 (54.7)	240 (75.9)	<0.001[(a–c)]
Vitamin B1 (mg)	0.3 (0.2)	0.6 (0.2)	0.8 (0.3)	<0.001	99.7 (55.3)	190 (69.5)	282 (108)	<0.001[(a–c)]
Vitamin B2 (mg)	0.4 (0.2)	0.7 (0.2)	1 (0.4)	<0.001	98.9 (41.4)	168 (52.6)	260 (109)	<0.001[(a–c)]
Niacin (mg)	6.4 (2)	7.9 (1.9)	7.8 (3.2)	0.186	161 (51.4)	197 (47.2)	195 (79.3)	0.244
Pantothenic acid (mg)	2.2 (0.6)	3.3 (0.9)	4.1 (2.2)	0.001	122 (36.5)	183 (48.3)	229 (123)	0.001[(a–c)]
Vitamin B6 (mg)	0.4 (0.3)	0.7 (0.3)	1 (0.4)	<0.001	133 (91.8)	230 (110)	335 (129)	<0.001[(a–c)]
Vitamin B12 (µg)	0.4 (0.2)	0.8 (0.3)	1.4 (0.6)	<0.001	74.1 (39.4)	153 (64.1)	283 (118)	<0.001[(a–c)]
Folic acid (µg)	74.8 (41.2)	121 (45.3)	153 (58.7)	<0.001	93.5 (51.5)	151 (56.6)	191 (73.4)	<0.001[(a–c)]

Values are expressed as mean (Standard deviation). (–) There is no data.
[1]Monosaccharides and disaccharides added to foods by the manufacturer, cook or consumer, plus the sugars that are naturally present in honey, syrups and fruit juices.
[2]Sugars from fruits, vegetables, milk and cereals.
([a,b,c]) The super indexes indicate the significant differences between groups.

results should be interpreted with caution and need to be confirmed by more studies. Even so, our study has certain strengths too. On the one hand, this study provides food data of an age group for which there is scarce data in the literature. On the other hand, this study describes the food introduction, the food consumption by analyzing the effect of different types of feeding on the adequacy of energy and nutrients and the consumption of free sugars at early ages.

In conclusion, the introduction of complementary feeding was adequate, but the amount of protein and free sugars were higher than recommended and lower for vitamin D, mainly at 12 and 30 months. Infants who consumed breastfeeding had more adequate energy and nutrients intakes than that consumed infant formula, except for vitamin D and iron at 6 months. In general we believe that the amounts of food consumed should be adjusted to the energy and nutrient intakes of the infants and toddlers. The observed risk of vitamin D in young children needs confirmation based on the application of preventive strategies.This should be transmitted and evaluated both at health level and by those responsible for the toddler's feeding, since this excess could lead to health risk in pathologies of great concern for public health.

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Conflict of interest

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