Original Paper

Implications of the Weaning Pattern on Macronutrient Intake, Food Volume and Energy Density in Non-Breastfed Infants During the First Year of Life

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Key words: energy density, intake volume, energy intake, lipids, weaning

Objectives: To evaluate the implications of the patterns of weaning on the intake of macronutrients, energy intake, food volume and the energy density in healthy infants in the Mediterranean area of Spain.

Subjects and study design: Cross-sectional study of 120 clinically-healthy, non-breastfed infants at the ages of 4, 6, 9 and 12 months randomly recruited from three pediatric out-patient clinics. Nutrition data were obtained from the infant's food preparer using the 24-hour dietary recall method.

Results: Energy intake/kg body weight was within the recommended daily allowance and did not vary significantly with age (423 kJ/kg body weight at 4 months and 443.7 kJ/kg at 12 months). There was a progressive decrease in the intake volume ($p<0.001$) in which carbohydrate-rich foodstuffs were the major factors, and an increase in the energy density ($p<0.001$) in which the protein-rich items were the principal contributors. Lipid intake diminished progressively ($p<0.01$) to a nadir of 26.4% of energy intake at 9 months of age. In each of the meals there was a tendency towards a progressive increase in energy intake with age. This increase was achieved by a significant increase in energy density ($p<0.001$ in all meals, except dinner $p<0.05$). Conversely, the intake volume of breakfast, lunch and dinner remained essentially unchanged between 6 and 12 months while that of the mid-evening meal decreased markedly.

Conclusion: Increased energy requirements for growth is achieved, mainly, by an increase in the energy density rather than the intake volume during food-item diversification in the non-breastfed infant. Cereals were the central food item in the weaning diet in our study sample and which adequately compensates, in terms of energy requirement, for the early reliance on the lipids contained in milk.

INTRODUCTION

During the first months of life an infant grows at a considerable rate and the energy cost of this growth is the major component of energy expenditure, after that of basal metabolism [1,2]. As such, the energy requirements of the infant are extraordinary compared to the adult and the energy ingested has to be sufficiently elevated to cover the energy requirements for the rapid growth in infancy. The energy content of a diet is governed by two factors: food volume and energy density (ED) and, although these factors are independent, both are instrumental in determining the common objective: the attainment and maintenance of an adequate energy intake [3]. Since the food volume that any individual, especially an infant, can ingest in any one meal is limited, the ED becomes a fundamental factor when increased energy intake is necessary to satisfy increased energy requirements.

In developing countries in which the weaning diet is predominantly composed of cereals with low ED, the food volume that needs to be consumed by the infant to cover its energy requirements may be excessive and, as such, could predispose the child to an inadequate energy intake and malnutrition [4–8]. In industrialized countries as well [9] there is a paucity of information on the variations in ED in relation to the diversification of food-item substitution in weaning diets in the first year of life together with the dietary changes influencing ED

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Journal of the American College of Nutrition, Vol. 17, No. 3, 256–262 (1998)
Published by the American College of Nutrition

and, more particularly, on the reliance on lipids for the energy requirements in the infant relative to the known intake of the adult.

The objectives of the present study were: to assess the effect of the changes in food volume and ED on energy intake; to describe the changes in foodstuff diversification in the first year of life in a sample of infants in a Mediterranean population in Spain; and to quantify the contribution of lipids to the dietary intake of the infant.

MATERIALS AND METHODS

Subjects and Study Design

A cross-sectional study was designed to assess the nutritional repercussions of changes incorporated into the diet of those infants who were being weaned from milk. The study subjects were randomly recruited from the infants attending three well mother-and-child out-patient pediatric clinics in Reus (a Mediterranean city of approximately 100,000 inhabitants in Catalunya, N.E. Spain). The subjects were clinically healthy young children between 3.5 and 13 months of age. Excluded were those who, at the time of recruitment, were still being breastfed because of the difficulties of estimating, with any degree of certainty, the quantities of milk ingested. The final study sample contained 120 children. The sample was divided into four groups with respect to age at the time of assessment: 4 months (n = 22), 6 months (n = 35), 9 months (n = 31) and 12 months (n = 32).

Evaluation of Nutritional Intake

The recording of nutritional data was by the method of 24-hour dietary recall. The questionnaire was completed at the time of the clinical visit. The interview, in every case, was with the person in charge of the child's feeding (usually the mother but not universally so) and utilized a photographic record of portion-size and commercially-available food items so as to help with determining the quantities/qualities of foodstuffs consumed. To evaluate the quantities of some of the ingredients (such as the cooking oils used in the preparation of the meal) a standardized table of the quantities usually used in the preparation of local dishes was consulted [10].

For the evaluation of the nutrient content of the diets, the Table of Foodstuff Composition developed by INSERM-ISTA (France, 1977) was used. The different food items had, originally, been grouped and coded into 252 classes but we subsequently regrouped them into 66 groups based on specific dishes of our region [10]. Since the INSERM-ISTA Table does not include certain items such as, bottled milk supplements, strained-food preparations etc., the food-table data-base was amplified using nutritional data supplied by the manufacturers of the weaning products.

Using the food-composition tables, the energy values of the macro- and micro-nutrients were determined. Concurrently, the food volume (including the amount of water used to re-constitute the food preparations but not the amount of water drunk), the amount ingested, the energy density (energy intake divided by the volume of food ingested), percentage of energy and nutrients contained in each group of food items and percentage of energy carried by the macronutrients were analyzed.

Anthropometric Measurements

Weight and height were routinely measured. Body weight was measured with a sensitive beam balance (±10 g) with non-detachable weights. Measurements of infant length were performed using a measuring board with one fixed end-piece and the other movable. Measurements were to within 0.4 cm.

Statistical Analyses

The data were analyzed using the SPSS/PC+ statistical package. Analysis of variance (ANOVA) was performed to evaluate differences between age groups with respect to the different variables measured. Simple linear correlation was performed on variables in the total sample and within age groups. Multiple linear regression analysis (MLRA) was performed with food volume, ED and energy intake as the dependent variables and the food items were the variables explaining the observed variance. Multiple linear regression analysis was also performed to assess the relationship between ED and the different macronutrients. Unless otherwise stated, the results are expressed as the mean±standard deviation.

RESULTS

Table 1 summarizes the percentage of the total energy carried by each of the principal groups of foodstuffs as well as the percentage of consumers of these food items in each of the four age groups studied. At 4 months of age, milk was still the main source of nutrients but cereals and fruit were being introduced in the majority of the infants in the study. Similarly, vegetables and roots/tubers were being introduced in 27% of the cases. At 6 months of age the only food item not introduced in any of the infants' diets was egg; the rest of the food items (with the exception of fish and milk derivatives that were still being consumed by a small percentage of the infants) were present in the diet of the majority of the infants studied. At this age there was a significant diminution in the proportion of energy from milk; a decrease that appeared to be compensated-for by the increase in the role of other food groups. The same trend was observed between the ages of 6 and 9 months. At 12 months of age the importance of milk continued to decline, but less markedly so. A slow decline in the percentage contribution of vegetables, roots/tubers and fruit was observed as well. Eggs appeared for the first time in the diet in the oldest age group. At 4 months of age, the foodstuffs with lower ED (vegetables,

Table 1. Percentage of Total Energy of Each Group of Food Items and the Percentage of Consumers of the Respective Foodstuffs

Food item	4 months n = 22	%c	6 months n = 35	%c	9 months n = 31	%c	12 months n = 32	%c
Meat	11.6 ± 2.7	9	11.1 ± 7.0	66	12.1 ± 6.7	81	15.7 ± 9.6	81
Eggs	0.0	0	0.0	0	0.0	0	6.3 ± 2.1***	16
Fish	0.0	0	10.1 ± 3.5***	6	12.1 ± 4.5*	19	14.1 ± 5.2	19
Milk	72.7 ± 17.7	100	45.1 ± 16.1***	100	36.0 ± 8.6**	100	30.9 ± 8.6*	100
Milk products	0.0	0	7.1 ± 4.1***	14	9.1 ± 3.5*	48	10.9 ± 5.4	66
Cereals	14.5 ± 8.5	73	19.2 ± 11.8	97	24.7 ± 10.1*	100	25.6 ± 6.9	100
Vegetables	3.8 ± 1.5	27	4.7 ± 2.1	83	4.3 ± 1.7	90	4.1 ± 2.1	69
Roots and tubers	7.1 ± 2.1	27	8.2 ± 3.2	86	7.6 ± 3.7	81	6.8 ± 1.8	72
Fruit	12.9 ± 5.5	64	12.6 ± 6.3	86	10.4 ± 5.7	61	8.0 ± 5.5	78
Visible fats	1.1 ± 2.3	27	1.6 ± 3.4	71	1.8 ± 3.2	19	2.4 ± 2.6	66

%c = % consumers. * $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$ with respect to the younger age-group.

fruits and roots/tubers) contributed 23.8% of the energy while that of cereals was 14.5% while, at 12 months of age, these percentages were reversed to 18.9% and 25.6%, respectively.

Table 2 summarizes the changes in the different nutritional parameters in the different age groups. The energy intake, expressed as per unit body-weight, did not change appreciably while, at the same time, the intake volume decreased ($p<0.001$). The diminution was most marked between 6 and 9 months of age ($p<0.01$). Conversely, the ED increased ($p<0.001$); the changes being more marked between the 6 to 9 months ($p<0.01$) and more gradual between 9 to 12 months ($p<0.05$). During the study, the intake of carbohydrates per unit infant body weight did not vary, unlike that of the proteins which increased ($p<0.001$) and that of the lipids which decreased ($p<0.01$). The most significant decrease in the lipid intake was observed between 4 to 6 months.

In the analysis of energy intake values, carbohydrates appeared to correlate better than lipids ($r = 0.85$; $p<0.001$ for carbohydrates and $r = 0.63$; $p<0.001$ for lipids). There was no significant association between the intake volume and ED. Conversely, in the overall study sample, the ED was significantly correlated with energy intake ($r = 0.66$; $p<0.001$). On MLRA, the macronutrients ingested were significantly correlated with intake volume ($R^2 = 0.52$; $p<0.001$), and, of which, the carbohydrates were the most important constituent. ED was also significantly correlated with macronutrient intake ($R^2 = 0.51$; $p<0.001$) but, in this instance, the protein component was the major contributor ($r = 0.68$, $p<0.001$), followed by the lipids ($r = 0.46$; $p<0.001$) and the carbohydrates ($r = 0.45$, $p<0.001$).

Table 2 also contains biometric (height and weight) data of the four groups of infants studied. The weight and height measurements were consistent with adequate nutritional status in all the groups of infants. In all age groups, the mean weight and height of the infants of our study was similar to published values of Spanish populations [11].

Table 3 summarizes the percentage contribution of the macronutrients to the total energy intake in the four groups of infants. Between the ages of 4 to 12 months, the contribution of the proteins rose progressively ($p<0.001$), that of the lipids

Table 2. Summary of the Dietary Constituents and Anthropometric Changes over the Weaning Period

Variable	4 months n = 22	6 months n = 35	9 months n = 31	12 months n = 32	p
Energy (kJ/kg body weight)	423.0 ± 54.4	480.3 ± 125.6*	472.3 ± 107.3	443.7 ± 111.0	0.001
Animal protein (g/kg body weight)	1.8 ± 0.4	2.7 ± 1.2**	3.2 ± 1.7	3.7 ± 2.1	0.001
Vegetable protein (g/kg body weight)	0.5 ± 0.3	1.1 ± 0.6***	1.2 ± 0.4	1.1 ± 0.4	0.001
Total protein (g/kg body weight)	2.3 ± 0.5	3.8 ± 1.3***	4.4 ± 1.8	4.8 ± 2.2	0.001
Carbohydrates (g/kg body weight)	13.7 ± 2.4	16.8 ± 5.5*	16.1 ± 3.7	13.7 ± 3.9*	0.815
Lipids (g/kg body weight)	4.1 ± 0.8	3.5 ± 1.1*	3.3 ± 1.1	3.4 ± 0.9	0.017
SFA (g/kg body weight)	1.6 ± 0.4	1.3 ± 0.4**	1.2 ± 0.4	1.5 ± 0.6*	0.305
MUFA (g/kg body weight)	1.8 ± 0.4	1.4 ± 0.5**	1.4 ± 0.5	1.5 ± 0.5	0.007
PUFA (g/kg body weight)	0.6 ± 0.1	0.6 ± 0.2	0.6 ± 0.2	0.5 ± 0.2	0.022
Food intake (g/kg body weight)	137.9 ± 19.6	143.0 ± 25.6	125.8 ± 19.2**	109.8 ± 23.8	0.001
ED (kJ/g of dietary intake)	3.1 ± 0.4	3.3 ± 0.5*	3.7 ± 0.5**	4.1 ± 0.7*	0.001
Weight (kg)	7.2 ± 0.9	7.8 ± 0.9*	8.5 ± 0.9	9.9 ± 1.2***	0.001
Height (cm)	63.9 ± 2.9	66.9 ± 2.6***	71.0 ± 3.0***	75.2 ± 4.6***	0.001

* $p < 0.05$ ** $p < 0.01$ ***$p < 0.001$ p = F test probability of linear term.

Table 3. Contribution of the Major Classes of Nutrients Expressed as a Percentage of the Total Energy Intake

Nutrient	4 months (n = 22)	6 months (n = 35)	9 months (n = 31)	12 months (n = 32)	P (overall)
Proteins	9.0 ± 1.7	13.3 ± 3.5***	15.7 ± 3.3**	18.0 ± 4.9*	<0.001
Lipids	36.6 ± 5.7	27.4 ± 6.2***	26.4 ± 5.1	29.4 ± 5.4*	<0.001
Carbohydrates	54.2 ± 5.7	58.4 ± 6.8*	57.1 ± 5.8	51.8 ± 8.3**	<0.001
SFA	14.1 ± 2.8	9.8 ± 2.4***	9.7 ± 2.0	12.4 ± 4.1**	<0.001
MUFA	16.3 ± 2.9	11.2 ± 3.2***	10.7 ± 2.9	12.7 ± 4.9	<0.001
PUFA	5.4 ± 1.3	4.8 ± 1.3	4.6 ± 0.9	4.1 ± 1.3	0.004

* $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$; all with respect to the previous age group.

varied slightly between groups (reflecting changes in the individual fatty acid moieties) but tending to decrease overall ($p<0.001$) while that of the carbohydrates, although varying slightly between some groups, remained stable overall (p = NS).

Table 4 shows the mean values for energy intake, food volume and ED of the four principal meals of the day in the four age groups. In general, the trends in energy intake and ED were towards an increase with age with minor variations within the different meals. Conversely, food volume increased much less markedly and, indeed, decreased by 28.7% between the 6 and 12 months of age in the mid-evening meal.

DISCUSSION

In our study we use the term "weaning" to refer to the introduction of different food items when maternal lactation or milk-formula supplementation result in insufficiencies for the continued normal growth of the infant [12]. The age of introduction of these complementary food items has varied greatly in the past 60 years [13,14].

The consensus is that the ideal age is between 4 to 6 months [12] but recent studies have shown that, in Spain, weaning is introduced earlier [15,16]. In these studies the data show that, at 4 months, almost half of the infants had already received some other type of food apart from milk. The supplementary food groups most commonly employed were cereals, followed by pureed fruit and vegetables. This early weaning has also been observed, recently, by Skinner et al [17]. The data from our present study indicates that 23.3% of the nursing mothers had initiated some form of food-item diversification before the generally-recommended age. Table 1 shows, for example, that at 4 months of age, the majority of the infants consume cereals (73%) and fruit (64%) and a considerable percentage (27%) consume vegetables and roots/tubers. Interestingly, 9% of the infants studied had already begun to consume meat at 4 months and, by 6 months of age, this percentage had reached 66%. The contribution of milk to the total energy intake decreased dramatically between 4 and 6 months. The decline was not compensated for by any increase in the consumption of milk-derived products so that, by the age of 12 months, milk itself represented only 10% of the total energy intake and the sum of the percentages of the energy from milk and milk-derived products had declined below that consumed at 4 months of age;

Table 4. Energy Intake, Food Volume and Energy Density (ED) for Each Daily Meals in Each Age Group Studied

	4 months n = 22	6 months n = 35	9 months n = 31	12 months n = 32	p linear term	% of increase between 6–12 months
Breakfast						
Energy (kJ)	631.4 ± 116.0	818.9 ± 276.2**	969.2 ± 394.9	954.2 ± 265.1	<0.001	14.2
Food intake (g)	215.9 ± 36.4	247.3 ± 47.6**	259.2 ± 64.2	252.8 ± 50.5	0.014	2.2
ED (kJ/g)	2.9 ± 0.3	3.3 ± 0.7*	3.7 ± 0.9*	3.8 ± 0.5	<0.001	13.2
Lunch						
Energy (kJ)	684.3 ± 152.8	924.0 ± 327.6**	1062.0 ± 412.8	1259.9 ± 486.6	<0.001	26.7
Food intake (g)	208.4 ± 34.2	283.5 ± 74.1***	282.6 ± 61.9	288.3 ± 94.7	0.001	1.6
ED (kJ/g)	3.3 ± 0.7	3.3 ± 0.9	3.7 ± 0.95	4.7 ± 2.4*	0.001	29.8
Mid-evening meal						
Energy (kJ)	610.1 ± 172.1	696.9 ± 229.3	729.7 ± 322.9	826.3 ± 376.5	0.008	15.7
Food intake (g)	222.5 ± 63.3	242.3 ± 74.5	217.0 ± 81.5	188.2 ± 81.5	0.05	−28.7
ED (kJ/g)	2.8 ± 0.6	3.3 ± 3.0	3.6 ± 2.0	5.1 ± 2.9*	<0.001	35.3
Dinner						
Energy (kJ)	754.3 ± 127.9	979.6 ± 331.0**	1040.1 ± 314.9	1062.0 ± 369.5	<0.001	7.7
Food intake (g)	225.8 ± 33.6	261.0 ± 45.9**	265.6 ± 42.5	264.0 ± 59.4	0.01	1.1
ED (kJ/g)	3.4 ± 0.7	3.7 ± 0.9	3.8 ± 0.8	4.0 ± 1.0	0.018	7.5

* $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$ with respect to the preceding group.

showing already at these ages the pattern of low consumption, typical of this region, compared to other countries [18].

In the present study, the energy contribution of cereals increased progressively up to a level of about 25% of the total energy intake and, when that of fruit, vegetables and roots/tubers are added, represents 47% of the total energy of the diet. As we have previously documented [10,19], it is of note that the contribution of energy derived from vegetables at this stage in life is never matched at any other stage in life. The assessments in our study indicated that olive oil plays a minor role in the diet of the infant being weaned (compared to the adult counterpart) since the type of food preparation of the habitual infant food items requires very low quantities of oil.

In underdeveloped countries, food-item substitution of vegetable origin form an important part of the weaning diet and which has been associated with problems of malnutrition [4,7,8]. It is probable, nevertheless, that the quality of the cereals and/or processed-vegetable products used in infant nutrition in industrialized countries are different from that of underdeveloped countries in that the food preparations available in the former countries are often constituent-enriched by the manufacturers of these products.

The progressive introduction of different food items into the diet of the infant being weaned implies a series of changes to the nutritional level. In a study conducted by Butte [2], a calculation was made of the necessary energy requirements for non breast-fed infants during the first year of life starting with total energy expenditure (TEE) measured using the double-labeled water method. The estimated requirements were 363.9 kJ/kg between 4 and 6 months, 369.1 kJ/kg between 6 and 9 months and 398.2 kJ/kg between 9 and 12 months of age. These values were lower than the energy intake values observed in all the groups of our study (423.0 kJ/kg, 480.3 kJ/kg, 472.3 kJ/kg and 443.7 kJ/kg for 4, 6, 9 and 12 months of age, respectively). The existence of these differences could be explained on the basis of the present method of assessment being indirect, the amounts ingested are not all completely metabolized.

To test whether the energy intakes were sufficient compared to the requirement, we calculated, using the formula of Beaton [20], the percentage of children with a probability of having an energy intake below the RDA [21]. We observed that only 1.6% of children had a probability of having an inadequate intake while that the majority (80.8% of the children) had an energy intake greater than the RDA.

The energy requirements for growth are important in the first months of life and, hence, satisfactory growth indices may be considered good indicators that all nutrient necessities are being covered [2]. In the analysis of the anthropometric data of the infants of our study, we observed a normal development in terms of height and weight [11]. With respect to weight alone, we observed a degree of slow-down in weight gain between 6 and 9 months. Whether this was related to the differences in the food content at this age or it was a physiological phenomenon is difficult to establish.

Several studies have demonstrated that the volume intake is, together with the ED, one of the main factors that influences energy intake. When there is a diminution of the ED of the diet, the food volume would need to increase to maintain a suitable level of energy intake [3]. This phenomenon had been observed in 1972 by Booth [22]; in an experiment conducted with rats maintained on a low ED diet the volume ingested increased while the reverse occurred on high ED diets. Similarly, in the 1970s Fomon [23] conducted a study in which two groups of infants were fed with different ED diets (normal formula or skimmed milk preparations). The children with the lower ED diet consumed a larger volume of food than their high ED diet counterparts. However, when the ED was greatly diminished, the compensatory increase in volume intake was limited and did not rise linearly. The results obtained in our study showed that the food volume ingested per kg body weight remained elevated at 4 to 6 months of age (values around 140 g/kg body weight) and then declined significantly. This diminution of the volume was not accompanied by a diminution in the energy intake. The food volume that can be ingested by a person, especially a small infant, in one meal is limited, hence the ED plays a critical role in the energy intake. In a meta-analysis of diverse studies in which dietary contents had been manipulated so as to compare the relationships between ED and energy intake, Poppitt et al [24] observed that, when all the food items were changed (so as to induce a large change in the ED of the diet), there was a compensatory increase in the volume intake so as to maintain energy intake.

Few studies have been conducted in industrialized countries assessing the ED of diets of small children [25]. Comparing our data with that of a study conducted in Holland by Dagnelie [9] in a group of infants between 6 and 16 months of age receiving a macrobiotic diet and a control group, the results of our study indicated an ED greater than that of the control group of Dagnelie (in that the infants between 6 to 8 months had an ED of 3.1 kJ/g and those of 10 to 12 months 3.4 kJ/g) and much higher that of the group of infants on the macrobiotic diet (2.5 kJ/g for the 6 to 8 month group and 2.3 kJ/g for those between 10 to 12 months of age). Similarly, the ED of our infants' diets ranged from above the 50th percentile to almost the 90th percentile of those values reported in a study of Danish children [4]. As with the infants in those studies (with exception of the group of children with the macrobiotic diet), in our study as well there was a tendency towards a progressive increase of ED of the diet with age ($p < 0.001$) but this progression was slightly more intense between 6 and 12 months; the period over which a diminution of the food volume per kg of body weight occurred but with a maintenance of the energy intake.

In developing countries, an increase in food volume (but not necessarily of the energy intake) can result in malnutrition during weaning and could be explained, probably, on the ED of the weaning diet being low [4,7,8].

When analyzing nutritional equilibrium (Table 3), we observed that the percentage of energy contributed by proteins increased such that at 12 months it was slightly above the RDA. With respect to the other two macronutrients, the percentage of energy contributed by carbohydrates increased between 4 and 6 months ($p<0.05$), stabilized at 9 months and diminished at 12 months. This was accompanied by a brisk diminution in the contribution of lipids to the energy intake. In newborns, lipids contribute approximately 50% of the energy [26], while at 4 months this percentage was observed to diminish, in the present study, to 36.6% and to continue to diminish between 4 and 6 months ($p<0.001$) and to appear to plateau-out at 27% of the total energy intake. Between 6 and 9 months of age there was a stabilization and only at 12 months we begin to observe a slight recuperation in the role of lipids in the energy intake. Despite this, it is important to highlight that the percentage, in our population, remains below 30% even though the consensus is that the intake of lipids, at these ages, should not be restricted [4,27].

In the correlation analyses of lipids, carbohydrates and energy we observed that it was the carbohydrate component that largely influenced the energy intake while the role of lipids was secondary and only began to have a certain relevance in the group at 12 months of age. This fact could be explained by the brisk diminution in the consumption of milk and its replacement by other types of foodstuffs such as cereals, fruit and roots/tubers in the diet of these infants. This is in concordance with the results of the study by Michaelsen et al [25] in which it was observed that when weaning food items are being introduced at 4 months of age there is a decrease in the lipid content of the diet. Although the contribution of lipids in the weaning diet is low this does not appear to adversely affect the energy balance at this age. However, it is important to note that lipids are not merely an energy source but are also an important aspect of the rapid growth of the infant since PUFAs, for example, are essential for the maturation of nervous and sensory systems [28].

When the different meals are assessed separately (Table 4), we observe variations in the three parameters (energy intake, food volume and ED) of the diet. In general the increases in the energy intake parallel those of food volume and ED. At breakfast (9 a.m.), lunch (1 p.m.) and dinner (9 p.m.) the significant increases in food volume are accompanied by an increase in the ED but, at tea time (5 p.m.) there is a significant decrease in the food volume accompanying the increase in the ED demonstrating, clearly, the value of this parameter in the increase in energy intake.

When analyzing the changes between the different age groups we observe that the change in intake volume explains, in large part, the increase in the energy intake that occurs between 4 and 6 months of age and is most evident in the breakfast, lunch and dinner meals while, in this period, only in the breakfast there is a significant change in the ED. On the other hand, the increases producing a change in the 6 to 12 months are a result of the ED, in the breakfast as well as in lunch and tea.

When assessing the changes in the diet which occur during the first year, we observe that at breakfast the ED increase is explained, in large part, by the addition of cereals to the milk after 6 months of age. At lunch this same progressive increase of the ED is determined by the addition of meat to the usual pureed vegetables after 6 months of age and the progressive introduction of cereals together with the meat and vegetables up to the 12 months of age. In the case of tea-time, the diet is progressively more varied with the introduction of cereals (biscuits, rusks, bread) and milk products (yogurt, cheese) accompanying the pureed fruit that are introduced at 4 months of age. The variations that are observed at dinner are less and consist in a progressive increase in the addition of cereals in the milk.

In conclusion, in the study sample of our Mediterranean population, the energy intake of the weaning diet was adequate for the infant's energy requirements. The energy intake/kg body weight was maintained, not by an increase in intake volume but by increases in the ED of the diet. The food volume was determined by the carbohydrate-rich foodstuffs while that of energy density by the protein-rich items. Cereals constituted the main component of food item diversification which was accompanied by a progressive incorporation of meat. Milk formula contribution continues to be a relevant constituent of the diet but the contribution diminishes rapidly and, although partly replaced by milk derivatives, does not appear to be a major contributor in the eventual diet at 12 months of age. All these changes induce a decrease in the contribution of lipids to the diet and indicates that this component is not a major factor determining the ED of our weaning diet.

ACKNOWLEDGMENTS

We wish to thank Drs. P. Lambán, A. Moreno and R. Clivillé for their help in subject recruitment and Dr. A. Xifró for his help with the statistical analysis. Translation, editorial assistance and orthography were by Dr. Peter R. Turner of *t-SciMed* (Reus, Spain).

This investigation was funded, in part, by BLEDINA (Spain).

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Received March 1997; revision accepted December 1997.