Maternal and Pediatric Nutrition Journal
ISSN: 2472-1182

Kavian et al., Matern Pediatr Nutr 2015, 1:1
DOI: 10.4172/2472-1182.1000101

Research Article
Open Access

Assessing Dietary Intake and Growth of Infants

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Abstract

Objective: Early cessation of breastfeeding and introduction of solids is common in Australia, which may have implications for child growth and obesity risk. This study aimed to contrast usual energy and macronutrient intake of infants against requirements according to feeding modality (n=670) and determine whether early introduction of solids and cessation of breastfeeding were independently associated with rapid growth (weight gain z-score ≥ 0.67) between birth to age six months (n=220).

Methods: An analysis of data from mothers and infants participating in the NOURISH and South Australian Infant Dietary Intake (SAIDI) studies was undertaken. Both studies enrolled mothers on the postnatal wards from 11 large hospitals in South Australia and Brisbane consecutively. Anthropometric data, infant feeding practices and three days of infant dietary intake data were collected at birth and again when infants were aged 4-8 months.

Results: Usual energy intakes were above estimated requirements for infants aged 4-<6 months (2764 kJ vs. 2505 kJ) and 6-8 months (2857 kJ vs. 2601 kJ), as were mean protein intakes 4-<6 months (14 g vs. 10 g), and 6-8 months (18 g vs. 14 g). The intake of carbohydrate and protein was higher for infants who were formula-fed only or mixed-fed compared to infants who were fully breastfed. Fat intake was higher in breastfed only infants compared with the formula-fed only group. The proportion of infants with rapid weight gain was 36% and infants were almost three times more likely to experience rapid weight gain if a mother breasted for less than four months (adjusted OR=2.68, 95% CI=1.27-5.65).

Conclusion: Higher protein intake may contribute to rapid weight gain in this group. These data are important in elucidating the influence of early nutrition on subsequent health and weight status. More support is needed for mothers to increase duration of breastfeeding and increase awareness of infant hunger and satiety cues during feeding.

Keywords: Dietary assessment; Formula feeding; Breast feeding; Energy intake; Protein intake; Introduction of solids; Rapid weight gain

Innovations

There is evidence that rapid weight gain in infancy is associated with childhood obesity [1] and adult chronic disease [2]. Previous studies showed benefits of slower weight gain associated with breastfeeding compared with formula feeding [3]. Infant feeding practices in Australia fall well short of recommendations, with our previous publication [4] reporting 58.3% of mothers ceased breastfeeding before 6 months and 33% introduced solids to their infants before 4 months. The growth and nutritional implications of these feeding practices are not clear.

There are few large-scale national surveys of infant feeding patterns in Australia [5,6] and these focus broadly on feeding mode rather than nutrient intake. Only one South Australian survey has assessed the nutritional adequacy of infants' diets [7]. Similarly, there are relatively few studies in other industrialised countries reporting dietary intake of infants. These studies which include infants ranging in age from 4 to 12 months indicate that there is a trend towards excess energy or macronutrient intake amongst infants who consume infant formula [8-11]. In turn, excess protein intake from milk has been proposed as a mechanism for rapid weight gain in infancy [12]. Given the clear links between rapid weight gain and later obesity risk [1] this study aimed to contrast usual energy and macronutrient intake of infants against nutrient reference values [13] according to feeding modality (breast or formula feeding, with or without solids) and determine if early age of cessation of breastfeeding and early age of introduction of solids were independently associated with rapid growth between birth to age six months.

Materials and Methods

Study population

This is a cross-sectional analysis of data from two studies: NOURISH a randomised controlled trial of an intervention promoting healthy feeding practices among first-time mothers [14] and the South Australian Infants' Dietary Intake (SAIDI) study, a longitudinal study of feeding practices of infants from 0-2 years [15]. Eligibility criteria were: mothers aged 18 years and over, facility with written and spoken English and infant born healthy, term (≥ 37 weeks of gestation) and weighing 2500 g or more. Mothers were ineligible if there was a documented history of substance abuse or self-reported mental disorder and infants were ineligible if there was a congenital abnormality or chronic condition affecting feeding. First-time mothers resident in metropolitan Adelaide and Brisbane were recruited for NOURISH but all new mothers regardless of parity, living in metropolitan Adelaide

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Received November 03, 2015; **Accepted** November 12, 2015; **Published** November 17, 2015

Citation: Kavian F, Scott JA, Perry R, Byrne R, Magarey A (2015) Assessing Dietary Intake and Growth of Infants. Matern Pediatr Nutr 1: 101. doi: 10.4172/2472-1182.1000101

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or regional South Australia were eligible for enrolment into SAIDI. Recruitment took place in three hospitals in Brisbane and eleven hospitals in Adelaide and regional South Australia between Feb 2008 and March 2009.

Recruitment protocol

Both studies used the same protocol and followed a two-stage recruitment process [16] (Figure 1). Mothers were recruited consecutively within 72 h of delivery and before discharge from hospital to obtain consent for future contact, and recontacted three to seven months later for final consent to further participation [14]. These studies were conducted according to the Declaration of Helsinki and approved by eleven Human Research Ethics Committees covering Queensland University of Technology, Flinders University and all the recruitment hospitals.

Measurement

Questionnaire

Socio-demographic characteristics of the mothers including age, education level, marital status and self-reported pre-pregnancy weight status were collected at initial recruitment using a self-completed questionnaire. Non-consenters provided sociodemographic characteristics via a short interviewer-administered questionnaire. Infant birth details including birth weight and infant gender were collected from medical records for consented mothers. Data collected when infants were aged 4-8 months included child dietary intake, infant feeding practices adapted from the Longitudinal Study of Australian Children [6], maternal smoking and drinking habits (how often do they currently smoke cigarettes and how often do they have a drink containing alcohol) and anthropometric assessment. Those declining to participate at the second contact were asked to complete a brief questionnaire to supplement stage one recruitment data in order to assess potential selection bias as seen from Figure 1.

Anthropometrics

Anthropometric measurements were taken by trained research staff using standardised procedures [17]. Bare infant weight and length were measured using a Tanita Digital Baby Scale Model BD-590 to 0.1 g accuracy and a Seca-210 measuring mat (accuracy 0.5 cm), respectively. Only clean nappies (diapers), singlets and underwear were allowed. Infants in regional areas were measured by the local Child Health clinic staff or their general practitioner.

Due to the wide age range of infants (4-8 months), only infants who were close to six months (between 5.5 and 6.5 months) of age were selected for the analysis of rapid weight gain (n=220) (Table 1). Weight-for-age Z scores were calculated using WHO growth standards [18]. Infant weight gain from birth to six months was determined as the difference between weight-for-age Z score at 6 months and birth. A z-score difference of >0.67 was defined as rapid weight gain [19].

Dietary intake assessment

Dietary intake data were collected via a 24-hour dietary recall and a 2-day dietary record. A food record pack was provided to each mother at the measurement clinic (or posted to regional areas). This included instructions on how to keep a food record, a food record booklet for mother to complete, a second booklet to be given to any carers who

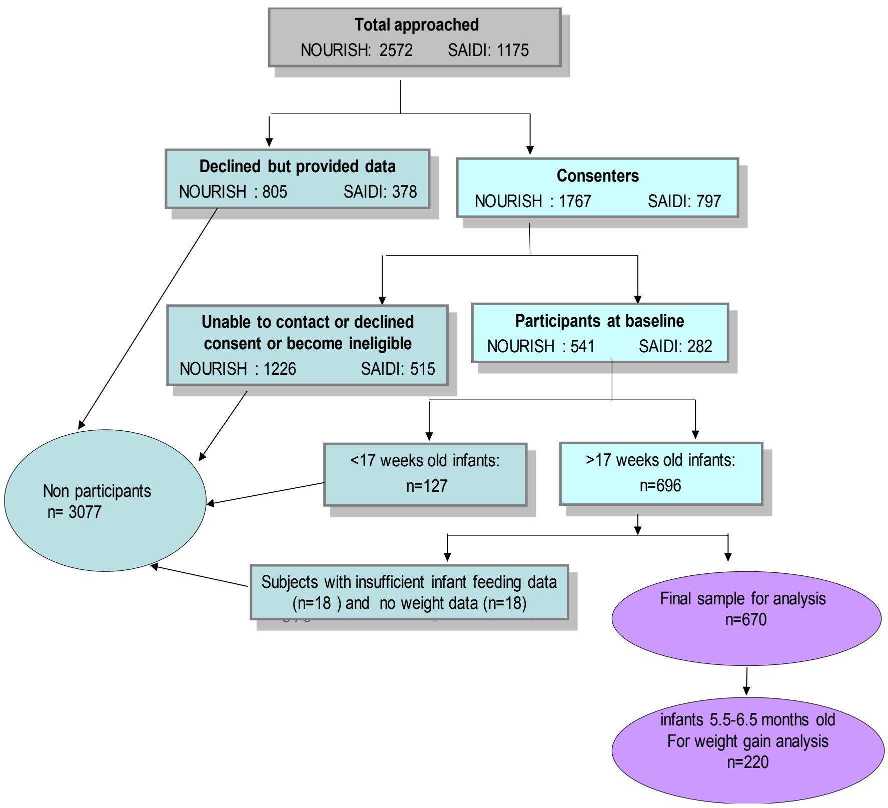

Figure 1: Source of 670 participants providing dietary intake data included in this study- Source of 670 participants providing dietary intake data included in this study.

Characteristics	Total sample (n=670)	Sample included in weight gain analysis (n=220)
Maternal characteristics		
Age, years, mean (SD)	30.7 (5.3)	31.6 (5.1)
Mothers born in the Australia, % (n)	83 (557/670)	91 (199/218)
Marital status- not Partnered, % (n)	6 (42/667)	3 (7/219)
University education, % (n)	50 (329/661)	43 (94/220)
Partner university education, % (n)	35 (229/ 656)	26 (56/217)
Mother BMI- overweight, % (n)	18 (120/663)	22 (46/211)
Infant characteristics		
Sex- Male % (n)	49 (327/662)	48 (105/220)
Birth weight, kg, mean (SD)	3.5 (0.4)	3.6 (0.5)
First born % (n)	69.4 (463/)	46.5 (99/213)

Not overweight considered as BMI<24.9 kg/cm^2 and overweight if BMI ≥ 25 kg/cm^2.

Table 1: Demographic characteristics of the study sample.

may feed the infant during the recording period and a printed visual aid depicting six different spoon sizes (heaped, round and flat teaspoons and tablespoons), a ruler and images of metric cup sizes. The 24-hour dietary recall was conducted via telephone by trained dietitians using multiple pass methodology [20]. In the first pass mothers were asked to report everything their infant consumed during the past 24 h period beginning at midnight on the previous day, the second pass include time, amount and brand of foods, recipe of homemade foods with ingredients' quantities and amount consumed by infant. The third pass probed for detailed information such as additions to foods and specific amount consumed and the forth pass was a final review to confirm what had been reported.

Following completion of the dietary recall, mothers were allocated two days to record all foods and drinks consumed by their infant. Non-consecutive days were assigned to ensure that three days of intake included two week days and one weekend day. A reply-paid envelope was provided for return of the completed food record booklet. Study staff checked record booklets on receipt and contacted mothers if there were any uncertainties or missing information.

The duration of breastfeeding episodes was used to estimate the amount of breast milk consumed. This method has been used in other studies [21] and is a reliable method for estimating breastmilk consumption in comparison to stable isotope methods [11]. A breastfeed starting within 30 minutes of the previous feed was not considered a new feed and duration was added to the previous feed, up to a maximum of 10 minutes. Similarly, breastfeeds of less than two minutes were not considered long enough to contribute to nutrient intake. Intake was estimated as 12.5 ml per minute for age 4-<5 months, 11.2 ml per minute for 5-<6 months, and 10 ml per minute for six months or older to a maximum of 10 minutes per feed.

Dietary intake data were entered into the nutrient analysis program FoodWorks® version 2009 using the AUSNUT 2007 data-base [22], excluding supplements. As the database contained limited commercial infant food products and infant formulae, study staff added new items obtained from several sources including manufacturer's information and product labels. Home-prepared dishes were entered as individual items if they contained three or less ingredients, otherwise the dish was entered as a recipe. Each FoodWorks® file was checked for the subject ID, quantities of food and drink consumed, total energy and macronutrient intakes and any suspicious entries were checked against the hardcopy.

The food data were exported from the FoodWorks® database into an Access database and merged with an eight-digit food-group code. This database was imported into SPSS 18.0.1 (2009) for analysis.

Estimation of usual intake

Energy and macronutrient intakes were determined for each of the three days and exported to C-side software version 1.02 [23]. This software accounts for within-subject and between-subject variation in the dietary data, adjusts for days without intake data and transforms not-normally distributed data. Outcomes are percentiles and mean of usual energy and macronutrient intake and the proportion above or below defined cut-off values. We used C-side software to estimate usual intake distribution for energy (kJ per day), fat (g per day; percentage of total energy intake [%EI], protein (g per day; %EI), and carbohydrate (g per day; % EI). These were compared with the Nutrient Reference Values (NRV) for energy, protein, fat and carbohydrate which are based on the nutrient composition of breast milk [13].

Estimated Energy Requirement (EER) was calculated by adding an age-specific growth requirement to the estimated energy expenditure for two subgroups; infants aged 4-<6 months EER (KJ) = [(89 × weight (kg) -100) + 56] × 4.2], and infants aged 6-8 months EER (KJ) = [(89 × weight (kg) -100) +90] × 4.2] [13]. To assess adequacy of energy intake, Estimated Energy Requirement (EER) distribution was compared with the distribution of usual energy intake derived via the C-side program [23]. For macronutrients, requirements for infants 4-8 months are expressed as Adequate Intake (AI). Estimates of the mean of usual intake were compared with AIs.

Infants were allocated to one of six feeding groups according to the nutrient sources of their diet: 1. breast milk without solids, 2. breast milk with solids, 3. combination of breast and formula milk without solids, 4. combination of breast and formula milk with solids, 5. formula milk without solids and 6. Formula milk with solids; where solids were defined as any non-breast or formula milk (food and beverage items). Results are presented according to two age groups, 4-<6 months and 6-8 months, corresponding to NRV age groups, and feeding modality as shown in Table 2.

Statistical Analysis

Descriptive analyses were used to report sample characteristics such as proportion for categorical variables and means and standard deviation (SD) for continuous variables. The characteristics of respondents and non-respondents were compared using the appropriate parametric or non-parametric tests e.g., chi-square or t-test.

The identification of statistically significant differences between age groups or feeding groups in terms of energy and macronutrients intake was not possible as the individual adjusted data are not available in exported data from the C-side program. Group mean (SD) and percentiles were the only outputs from this program.

The exposure variables age of duration of breastfeeding and introduction of solids were dichotomised as 4 months (≤ 4 months) and after 4 months (>4 months). These cut-points were chosen on the basis that approximately half of infants had experienced these events by 4 months. The relationship between the outcome (rapid weight gain) and the exposure variables: duration of breastfeeding and age of introduction of solids and confounding variables: sociodemographic variables (mother's age, birth order of the infant, infant sex, mother's education, partner's education, SEIFA decile (Socio-economic Index For the Areas) and recruitment site) and health-related variables (infant birth weight, maternal weight status, smoking status and alcohol

			Energy (KJ/d)			Protein (g/d)			Carbohydrate (g/d)			Fat (g/d)		
		n	EER	Usual intake	SD	AI§	Usual intake	SD	AI	Usual intake	SD	AI	Usual intake	SD
4–<6 months	BM* only	120	2407	2557	482	10	12	2.2	60	68	12.7	31	36	5.8
	BM and solids	120	2628	2662	692	10	13	4.1	60	76	21.5	31	34	6.1
	BM and FM † only	29	2448	2937	545	10	14	3.1	60	77	13.6	31	40	6.1
	BM and FM and Solids	43	2551	2987	506	10	16	3.7	60	86	16.6	31	36	5.1
	FM only	48	2643	2710	364	10	14	2.1	60	71	9.9	31	34	4.8
	FM and Solids	92	2836	2958	561	10	17	4	60	86	16.6	31	32	6.2
6–8 months ǀ	BM and solids	92	2577	2594	590	14	14	5.2	95	78	18.8	30	29	6.9
	BM and FM and Solids	38	2534	2694	628	14	17	5.4	95	82	17.9	30	28	6.1
	FM and Solids	48	2661	3267	556	14	24	6.7	95	98	18.7	30	31	6.9

*BM: Breast Milk

†FM: Formula Milk

‡n≠ 670 as one infant's main drink was cow's milk

Requirements for carbohydrate, protein and fat for infants <12 months presented as Adequate Intake (AI).Insufficient numbers of infants aged 6-8 months consuming milk only diets to present these data for BM only, FM only and BM& FM groups

Table 2: Mean intakes of energy† and macronutrients according to feeding mode (n=669) ‡.

consumption) were investigated using logistic regression. Mother's country of birth, marital status were not included in this analysis as only 3.2% of mothers in this sample were not-partnered and only 8.7% of mothers were born overseas. Explanatory variables were tested in a bivariate analysis and entered into the multivariate logistic regression analysis using the Enter method.

Results

Description of sample

At the first postnatal contact 2564 women agreed to subsequent contact for enrolment in the study and provided relevant details. Subsequently we were unable to contact 661, 87 became ineligible, 993 declined consent and the remaining 823 provided signed consent and underwent baseline assessment. Complete data from a total of 670 infant aged 4-8 months were available for analysis, of whom 66% were NOURISH and 34% SAIDI study participants (Figure 1). Participant mothers and their partners had higher education levels than non-participants (P<0.001). Mothers who had a partner and those who were primiparous (P<0.001) and were born in Australia (P=0.008) were more likely to participate. Table 1 presents characteristics of mothers and infants for the whole sample (n=670) and for those included in the rapid weight gain analysis (n=220).

Dietary intake in comparison to requirements

Figure 2 presents estimated probabilities of the distribution for infant usual daily energy compared with Estimated Energy requirements (EER) and macronutrients compared with AIs. Across the distribution the discrepancy between EER and usual intake varied from EER being 663 kJ and 725 kJ higher at the bottom of the distribution (10^{th} percentile) to being 595 kJ and 943 kJ lower at the upper end (95^{th} percentile) for infants 4-<6 months and 6-8 respectively. Mean ± SD of usual energy intake was 2764±561 kJ and 2857± 715 kJ for infants 4-<6 months and 6-8 months respectively. Mean usual energy intake was approximately 10% higher than the mean EER for both age groups.

The mean usual fat intake was 10% above the AI (34 g vs. 31 g) in infants aged 4-<6 months but no different in infants aged 6-8 months. Mean usual intake of protein was above the AI for both age groups (14 g vs. 10 g for infants aged 4-<6 months and 18 g vs. 14 g for infants aged 6-8 months respectively). For infants aged 4-<6 months, mean usual carbohydrate intake exceeded the AI (75 g vs. 60 g) but was lower than the AI for infants aged 6-8 months (82 g vs. 95 g).

Percentage of total energy intake from fat, protein and carbohydrate

Percentage of energy derived from fat decreased from a median (Interquartile range) of 48% (44-53%), for infants aged 4-<6 months to 38% (35-43%) for infants aged 6-8 months. In contrast the contribution of protein to energy increased from a median of 9% (8-9%) for infants aged 4-<6 months to 10% (9-12%) for infants aged 6-8 months. Carbohydrate intake followed a similar pattern to protein contributing 43% (42-46%) for infants aged 4-<6 months up to 48% (46-51%) for infants aged 6-8 months.

Dietary intake according to feeding mode

Mean energy and macronutrient intakes based on feeding mode are presented in Table 2. There were insufficient infants aged 6-8 months to present data for milk only groups. In all feeding modes and both age groups, mean usual energy intake exceeded EER. In the younger age group, the discrepancy was greatest for those who consumed formula with breast milk, with or without solids. The intake of protein and carbohydrates with respect to requirements were lower for infants who were breastfed compared to infants who were mixed-fed or formula-fed only but fat intake was slightly higher in breastfed only infants compared with the formula-fed only group. Amongst infants aged 6-8 months mean intake of protein was lower for infants who received breast milk only and solids (14 g) versus those who received formula only with solids (24 g).

Rapid weight gain and its associates

The prevalence of the weight-gain Z-score above 0.67 SD, indicative of rapid weight gain was higher in this sample compared with the WHO growth standard [18] as the reference population (36 vs. 25%).

Table 3 shows factors associated with rapid weight gain and their unadjusted and adjusted odds ratios. In the final model the main non-modifiable factor associated with rapid growth in infancy was gender. Male infants were more likely to experience rapid growth compared with female infants (adjusted OR=2.24 (95% CI=1.1-4.5). There were no significant relationships between other baseline factors and rapid growth after controlling for a number of covariates (gender, maternal age, education and smoking during pregnancy and birthweight).

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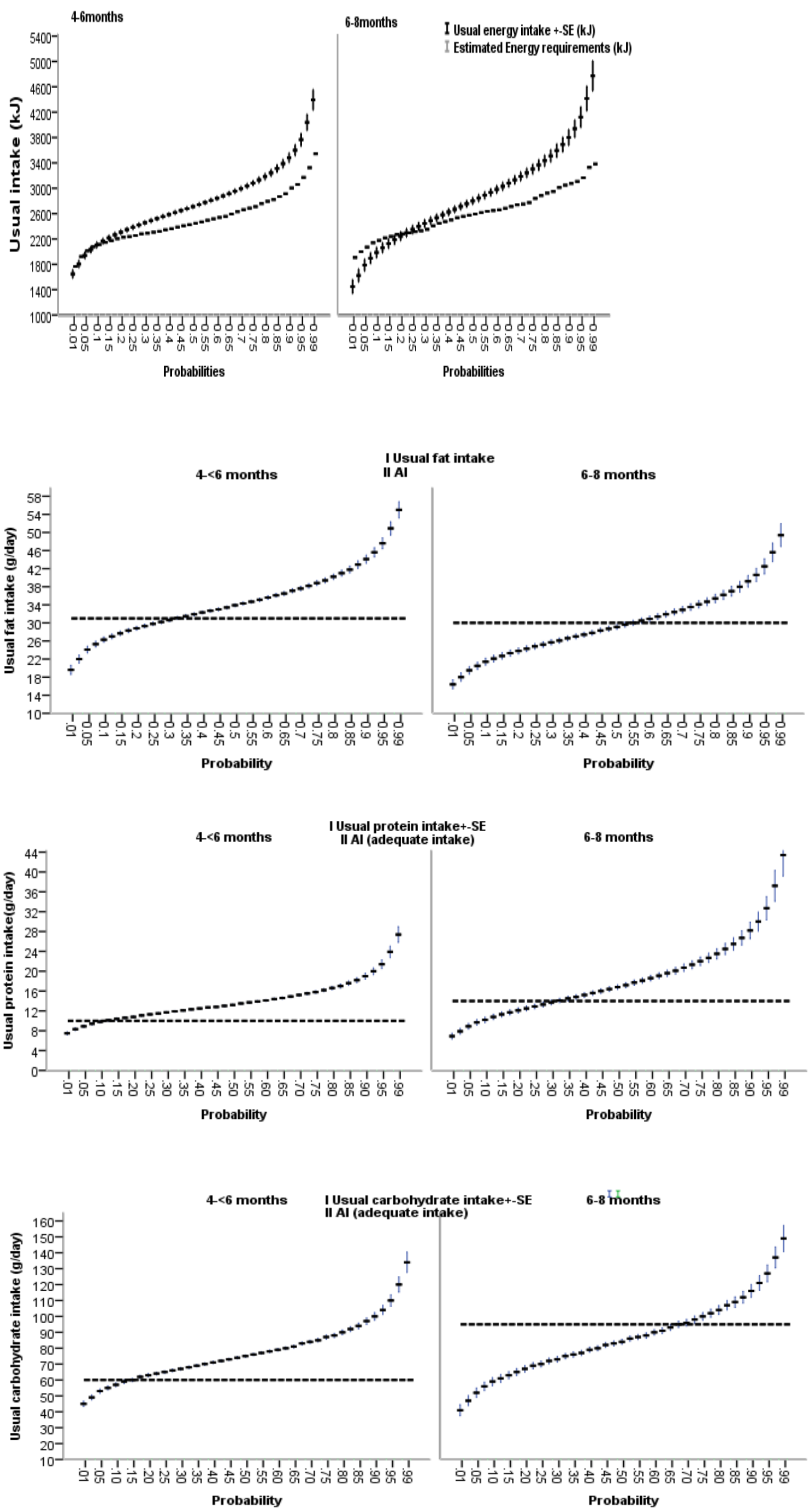

*Usual intake distributions derived from C-side program adjusted for days without intake data across 3-day of intake as well as skewed data. † Estimated energy requirements were calculated as Total Energy Expenditure= [(89 X wt (kg)) -100] + energy needed for growth: 4-6 months= 56 kcal; 7-12 months=22 kcal and converted to kJ by multiplying by 4.2 [13]. Requirements for carbohydrate, protein and fat for infants younger than one year are in the form of Adequate Intake (AI) [13].

Figure 2: Usual* daily energy (kJ) and macronutrients intakes of infants 4-8 months estimated from 3-day intake in comparison to their Estimated Energy Requirements (EER)† and macronutrients'. Adequate Intakes (AI) (Usual intakes are represented with the symbol + recommended intakes are presented with the symbol)

Factors	Crude OR‡(95% CI)	P value	Adjusted OR (95% CI)	P value
Lower birth weight (<3499 g) vs higher birth weight (≥3500g)	1.08 (0.52-1.92)	0.77	1.08 (0.56-2.07)	0.12
Male gender vs female	1.98 (1.10-3.56)	0.02	2.02 (1.06-3.85)	0.03
Shorter duration of breastfeeding§ (≤4 mo) vs longer (>4 mo)	2.14 (1.13-4.06)	0.02	2.68 (1.27-5.65)	0.01
Early solid foods (≤4mo) vs solids introduced (>4mo)	1.26 (0.33-1.89)	0.59	1.84 (0.68-5.00)	0.22
No smoking vs smoking	1.25 (0.27-2.36)	0.69	1.05 (0.32-3.43)	0.92
Mother non tertiary educated vs tertiary	1.35 (0.76-2.40)	0.3	1.83 (0.89-3.75)	0.09
Father non tertiary educated vs tertiary	1.05 (0.53-1.96)	0.94	1.28 (0.59-1.67)	0.52
Mother being overweight (BMI≥25 kg/cm^2) vs not overweight (BMI <24.9 kg/cm^2)	1.29 (0.72-2.32)	0.37	1.14 (0.60-2.16)	0.67
First born child vs others	1.31 (0.74-2.36)	0.35	1.75 (0.87-3.36)	0.11
SEIFA decile (1-5) vs (5-10)	1.47 (0.82-2.63)	0.18	1.79 (0.77-4.16)	0.17
Alcohol consumption ≥2 times/week vs never/rarely	1.55 (0.76-3.15)	0.22	1.75 (0.7-3.91)	0.17

*Rapid weight gain defined as weight gain Z-score > 0.67 from birth to six months calculated using WHO growth standards

‡Crude odds ratios imply likelihood of displaying rapid weight gain

§Breastfeeding duration was classified as ≤4 mo and >4 mo for meaningful comparisons within the sample

Model adjusted for mother's age and infant's birth weight (continuous variables).

Table 3: Factors associated with rapid weight gain* in infancy (n=220).

Duration of breastfeeding was the only independent exposure predictor; there was more than a 3-fold increase in the likelihood of displaying rapid weight gain if mother breastfed for less than four months (adjusted OR=2.68 (95% CI=1.27-5.65)).

Discussion

This is the first study to evaluate infant energy and macronutrient intakes against the current NRV for Australia and New Zealand [13]. Mean energy and macronutrient intakes were above the dietary recommendations. Firm conclusions cannot be drawn about the adequacy of usual intake of macronutrients because estimated average requirements (EAR) have not been established for infants younger than one year [13]. All nutrient requirements are in the form of adequate intake (AI). Populations with a mean at or above the AI can be assumed to have a nutritionally adequate diet [24]. There is no upper limit (UL) intake set for infants, so the proportion of infants in this study with excessive intakes cannot be determined.

In the recent nationally representative UK survey [11] on diet and nutrition of 2683 infants and young children aged 4-18 months, the mean daily intake of total energy for infants aged 4-6 months was 2900 KJ which is similar to this sample at 2764 KJ. However, energy intake in our sample was lower than in the US Feeding Infants and Toddlers Study (FITS) [10] (2272 KJ vs. 2764 KJ in infants aged less than six months and 2857 KJ vs. 4099 KJ in infants six to 11 months). The variation between study findings for the second half of the first year of life can in part be attributed to the greater mean age of infants in the FITS compared with the present study (age range 6-8 months in our study vs. 6-11 months in the FITS study). Macronutrient intake was also higher in FITS except for protein in infants younger than six months, which was similar to the present study. The method used in this study for estimating breast milk intake may also be a factor contributing to the lower values. We used the duration of a breastfeed to quantify milk intake, whereas FITS assigned a constant breast milk volume based on the infant's age in months and the total amount of other milks. Other methodological differences exist between the two studies. For instance, FITS used a single 24-hour dietary recall and a random sub-sample for a second 24-hour dietary recall whereas this study used a single 24-hour dietary recall and 2-day dietary records on all infants.

In our study mean protein intakes were well above the AI in both age groups which is similar to findings in the recent UK survey [11]. While protein intake exceeded requirements for all of the younger infants (4- <6 months) irrespective of feeding mode, it was notably higher in those who received formula. This pattern persisted into 6-8 months when the protein intake of formula fed infants receiving solids was 71% higher than that of breastfed infants receiving solids. This is similar to the findings of other studies, which show formula fed infants consume significantly more protein [7,8,25]compared to breastfed infants.

The protein content of standard infant formula is higher than that of breast milk, and protein intake is known to stimulate insulin and insulin-like growth factor 1 metabolism leading to cell proliferation, accelerated growth, and increased adipose tissue [26]. Evidence implicating the risk of higher protein content of infant formula on rapid weight gain is provided by a large multi-centre European randomised controlled trial [27]. Growth of infants fed a standard infant formula was compared with that of infants fed a lower protein formula and growth of both groups was compared with a reference group of breastfed infants. Energy intakes in both formula groups were identical at 3, 12 and 24 months and slightly higher in the low protein formula group at 6 months. Significant differences in weight emerged at 6 months of age, and at 24 months the weight for length z score of infants in the lower protein formula group was significantly lower (p=0.005) than that of the higher protein formula group and did not differ from that of the breastfed reference group. Further follow up of this trial suggests that reducing the protein content of infant formula may reduce the risk of obesity associated with formula feeding [28].

Another explanation for the observed differences in dietary intake between breast and formula fed infants relates to potential differences in appetite control. Breastfeeding is infant-led with infants ultimately controlling their intake whereas formula feeding is parent-led and it is common practice to encourage infants to finish the bottle [29]. Infants fed from a bottle (formula or expressed breast milk) early in infancy are more likely to empty the bottle or cup in later life than those who are directly fed from the breast [30] and there is further evidence to suggest that direct breastfeeding during infancy is associated with greater appetite regulation in childhood [31]. Coercive feeding practices may compromise an individual's ability to regulate their energy intake.

In this study, the percentage of infants who had rapid growth was slightly higher among those infants who were introduced to solids earlier, however, this relationship was not statistically significant (Adjusted OR (95% CI) = 1.84 (0.68-5.00). This finding is consistent with two published studies [32,33] but contrasts with a third study that reported a significant association between the early introduction of solid foods and weight gain between the ages of 3-6 months [34].

A key strength of this study is the use of three days of intake data and using C-side [23] to maximise sample size and provide estimates of energy and nutrient intake indicative of usual intake. The only published study providing estimates of usual intake is FITS from the United States which collected a second 24-hour dietary recall on a random sub-sample of participants [35]. In contrast with FITS, our study used duration of individual breastfeeds during the recording period and an age-specific flow rate to quantify the amount of breast milk, rather than a constant amount.

While every attempt was made to approach all eligible mothers over a defined period, non-response bias due to participant motivation has affected the generalisability of this study. The study sample represented a highly educated and predominantly Caucasian cohort of mothers.

This study provides further evidence of differences in the macronutrient intake of formula fed and breastfed infants. In particular, the higher protein intake of formula-fed infants observed in this and other studies may contribute to rapid weight gain in infancy and higher obesity risk in later life of formula fed infants. There is a need for nutrition support directed to mothers who are feeding formula milk to their infants. Effective interventions that promote healthy feeding practices such as raising awareness of hunger and satiety cues and avoidance of coercive feeding practices need to be developed and targeted at mothers who choose to formula feed their infants.

Acknowledgment

FK was involved in the recruitment and data collection for both NOURISH and SAIDI studies, undertaking the analysis and interpretation of data and drafted the manuscript. AM and JS led the design of the studies. AM was involved in managing both studies. RP had responsibility in development and implementation of studies. RB was involved in the recruitment and data collection for NOURISH study. All authors contributed to the revised drafts of the manuscript. The authors sincerely thank all our study staff who contributed to the implementation of the projects. The authors are grateful to the mothers who agreed to be involved in the projects and devoted their time for the purpose of the research.

Conflict of interests, Source of funding and Authorship

The study was funded by a National Health and Medical Research Council Project (Grant 426704); SA Health; Food Standard Australia and New Zealand; Meat and livestock Australia and Heinz Australia.

The authors declare that they have no conflict of interests.

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