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PEDIATRIC ORIGINAL ARTICLE

Evaluation of an intervention to promote protective infant feeding practices to prevent childhood obesity: outcomes of the NOURISH RCT at 14 months of age and 6 months post the first of two intervention modules

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OBJECTIVE: To evaluate a universal obesity prevention intervention, which commenced at infant age 4–6 months, using outcome data assessed 6 months after completion of the first of two intervention modules and 9 months from baseline.

DESIGN: Randomised controlled trial of a community-based early feeding intervention.

SUBJECTS AND METHODS: Six hundred and ninety-eight first-time mothers (mean age 30 ± 5 years) with healthy term infants (51% male) aged 4.3 ± 1.0 months at baseline. Mothers and infants were randomly allocated to self-directed access to usual care or to attend two group education modules, each delivered over 3 months, that provided anticipatory guidance on early feeding practices. Outcome data reported here were assessed at infant age 13.7 ± 1.3 months. Anthropometrics were expressed as z-scores (WHO reference). Rapid weight gain was defined as change in weight-for-age z-score (WAZ) of $> +0.67$. Maternal feeding practices were assessed via self-administered questionnaire.

RESULTS: There were no differences according to group allocation on key maternal and infant characteristics. At follow-up ($n = 598$ (86%)), the control group infants had higher BMI-for-age z-score (BMIZ) (0.42 ± 0.85 vs 0.23 ± 0.93, $P = 0.009$) and were more likely to show rapid weight gain from baseline to follow-up (odds ratio (OR) = 1.5, confidence interval (CI) 95% = 1.1–2.1, $P = 0.014$). Mothers in the control group were more likely to report using non-responsive feeding practices that fail to respond to infant satiety cues such as encouraging eating by using food as a reward (15% vs 4%, $P = 0.001$) or using games (67% vs 29%, $P < 0.001$).

CONCLUSIONS: These results provide early evidence that anticipatory guidance targeting the 'when, what and how' of solid feeding can be effective in changing maternal feeding practices and, at least in the short term, reducing anthropometric indicators of childhood obesity risk. Analyses of outcomes at later ages are required to determine if these promising effects can be sustained.

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Keywords: childhood obesity; randomised controlled trial; infant; feeding practices

INTRODUCTION

The need for prevention of childhood obesity is universally accepted.[1–3] Most prevention trials have targeted preschool or older children with largely disappointing outcomes, at least in part because the interventions started after feeding practices and eating patterns were established and more difficult to modify.[4–6] The plasticity of infancy offers an opportunity to establish healthy eating behaviours rather than change entrenched habits.[7] The rationale for early feeding interventions to prevent childhood is plausible and strong but to date very few randomised controlled trials (RCTs) have commenced in infancy.[1,8]

Infant feeding practices 'program' taste preferences, texture tolerance and appetite regulation[7,9,10] and lay the foundation for child eating behaviours that support dietary quality and energy balance and persist into adulthood.[11–15] Repeated exposure to a range of flavours and textures increases food acceptance and intake.[14,16,17] Responsive feeding whereby mothers match their responses to infant cues of hunger and satiety supports intrinsic intake regulation.[10] Protective infant feeding practices include appropriate exposure and responsive feeding and are potentially an important target for obesity prevention interventions. Our overarching hypothesis is that early feeding practices can support the development of 'protective' eating habits that confer some resilience as the child grows up in the contemporary obesogenic environment.

The aim of this study was to evaluate a universal obesity prevention intervention that commenced in infancy. It tests the hypothesis that, compared with self-directed usual care, anticipatory guidance on early feeding practices for first-time mothers commencing when their infants are 4 months of age will result in (i) an increased prevalence of protective feeding practices related to food exposure and responsive feeding and (ii) a reduction in anthropometric indicators of obesity risk.

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SUBJECTS AND METHODS

Study design

NOURISH was an RCT conducted in the capital cities of two Australian states: Brisbane, Queensland and Adelaide, South Australia. The protocol has been described elsewhere.[18] Briefly, the intervention comprised two group education modules that were each delivered over 3 months, commencing when the infants were 4–6 and 13–15 months of age. Data were collected at four time points: (i) within 72 h of birth; (ii) baseline: infants aged 4–6 months, before the first module; (iii) 9 months from baseline: infants aged 13–15 months, 6 months after completion of the first and immediately before commencement of the second module and (iv) 18 months from baseline, children aged 2 years, 6 months after the second module. This paper reports on outcomes 6 months after completion of the first module and as such evaluates the short-term effectiveness of the first intervention module. Further funding has been secured to undertake two additional outcome assessments when the children are 3.5 and 5 years of age, which will provide evaluation of the combined long-term efficacy of both intervention modules. In summary, this paper reports data from the first of four outcome assessments scheduled at 14 months and 2, 3.5 and 5 years of age.

Approval was obtained from 11 Human Research Ethics Committees covering Queensland University of Technology, Flinders University and all the recruitment hospitals (QUT HREC 00171 Protocol 0700000752). The trial was registered with the Australian and New Zealand Clinical Trials Registry Number (ACTRN) 12608000056392.

Recruitment and participants

Recruitment took place in 2008 and 2009 at four hospitals in Adelaide and three in Brisbane, which covered the major public maternity services in both cities. In Australia, $>99\%$ of births occur in hospital.[19] A two-stage recruitment strategy was used. A consecutive sample of first-time mothers ($\geqslant 18$ years old) who had delivered a healthy term infant (>35 weeks, >2500 g) were approached while still in hospital (Stage 1). Additional eligibility criteria included no documented history of domestic violence or intravenous drug use; no self-reported eating or psychiatric disorder; facility with written and spoken English, and ability to attend group sessions. Depending on the requirements of sites and local legislation, recruitment was by hospital-employed midwives paid by study funds, study-employed staff or doctoral students enrolled in NOURISH-related projects.

Mothers who consented and provided contact details at Stage 1 were re-contacted by mail for full enrolment when their infant was aged 4–6 months (Stage 2). Further eligibility criteria were still living locally (that is, could attend intervention sessions), no serious infant health problems, and a maternal score on the Kessler 10 Psychological Distress Scale (K10)[20] below 30 (not indicative of high maternal psychological distress).

Allocation

Mothers consenting at Stage 2 completed the baseline measurements at child health clinics geographically distributed across each city. Subsequently, individual dyads were allocated randomly to the intervention or control group by a statistician external to the study. A permutated-block schedule with blocks of four within each assessment clinic location was used to minimise design or cluster effects related to likely socio-economic similarities within participants attending the same assessment or intervention session venue.

Treatment components

The intervention was a comprehensive skills-based program that used a cognitive behavioural approach and focused on the feeding and parenting practices that mediate children's early feeding experiences. It commenced when the children were 4–6 months of age and comprised two modules of six fortnightly group sessions (10–15 mothers per group), each of 1–1.5 h duration. Interactive group sessions were co-led by a dietitian and psychologist at a choice of days and times, and at the same child health centres as those used for measurements. The focus for participants was on healthy eating patterns and growth, rather than obesity prevention. Content included anticipatory guidance on the 'when, what and how' of solid feeding. Two overarching themes underpinned both modules. Theme 1: repeated neutral exposure to unfamiliar foods and limiting exposure to unhealthy foods to promote the development of healthy food preferences. Theme 2: responsive feeding that recognises and responds appropriately to infant cues of hunger and satiety to maintain infants' innate capacity to self-regulate intake and avoid overfeeding. These were translated into five key parent messages (i) the way we feed young children affects the foods they will like and their health: *'learning to like, liking to eat'*[21], (ii) listen to and trust your child: *'parent provide, child decide'*[22], (iii) habits are formed early and track to adulthood, (iv) set good examples for your child and (v) your relationship with your child is important. Module I addressed introduction of solids and emphasised Theme 1 as well as healthy infant growth and requirements, variability of intake within and between infants, type (variety, texture), amount and timing (snacks) and trust in hunger and satiety cues. Module 2 focused on managing toddler feeding behaviours and Theme 2 including strategies to manage food refusal, neophobia, dawdling, fussing, developmental need for autonomy and testing limits and role modelling healthy food choice and availability. Intervention participants were provided with a workbook and an information resource for other carers. Although not excluded, only five fathers attended intervention sessions.

Module 1 was delivered by 9 dietitians and 10 psychologists who worked in pairs to facilitate a total of 30 groups over a 3-month period across the two sites. Various strategies were used to ensure intervention quality and fidelity. These included use of standardised training, procedural manual and presentation materials, fortnightly teleconference reviews between facilitators and independent observation of 15% of sessions. Detailed process evaluation data, including staff ratings of sessions for quality of facilitation, content fidelity and group processes, will be presented elsewhere.

The control group received self-directed access to usual community child health services, which were similar in both states and largely targeted at high-risk families. Universal services, at mothers' initiative, potentially included child weighing, individual appointments with a child health nurse or access to information via a website or a telephone help line.

Measurements

Birth weight was obtained from hospital records. All demographic and behavioural data were collected using self-administered questionnaires. Anthropometric measurements were undertaken by trained study staff blinded to participant allocation status and not involved in intervention delivery. Infant naked weight and recumbent length and maternal height and weight (shoes removed) were measured at child health clinics using the standard equipment available. Duplicate weights and lengths were taken with a third measure (most commonly length) taken if there were concerns about accuracy (for example, child wriggling). The average of the two closest measures was used.

Z-scores for weight-for-age (WAZ) and BMI-for-age (BMIZ) were calculated using the software program WHO Anthro version 3.0.1 (Department of Nutrition, World Health Organization, Geneva, Switzerland) and macros.[23] From these, change in raw z-score was calculated (birth to baseline, baseline to follow-up, birth to follow-up). Rapid weight gain was defined as a change in WAZ of $>+0.67$, which equates to the width of a percentile band on infant growth charts.[24]

Maternal feeding practices

In 2007 when the study was designed, the Infant Feeding Questionnaire (IFQ)[25] was one of the few validated tools available to assess maternal feeding practices in infants. Mothers retrospectively recall their feeding practices and beliefs over the first 12 months of their child's life. Seven scales are formed from 5-point Likert-style responses to 20 items. Minor modifications were made to accommodate use of the IFQ as a concurrent measure and in an Australian sample with high rates of breast feeding and pilot study feedback. These included (i) wording changed from past to present tense and 'Australianised' (for example, 'being unsettled' replaced 'fussiness') and (ii) addition of a 'not applicable' response category for three items that assumed that the infant was formula fed (for example, adding cereal to the bottle). Over half the sample selected 'not applicable' on these three items and they were excluded from analysis. As a result two of the original seven scales could not be calculated. In our sample, the internal consistency of the five remaining scales was *Awareness of infant satiety and hunger cues* (four items; $\alpha = .75$); *Using food to calm fussiness* (two items; $r = 0.48$, $P < 0.01$); *Feeding on schedule* (two items; $r = 0.60$, $P < 0.01$); *Concern about infant under-eating and being underweight* (four items; $\alpha = 0.82$) and *Concern about infant overeating and being overweight* (three items; $\alpha = 0.66$). For all scales, the internal consistency was considerably higher in our sample than that reported in the original development sample.[25]

To evaluate the impact of the two key intervention themes related to exposure and responsive feeding, individual questions regarding mothers' general perceptions of their child's eating behaviour and specific strategies they used in response to infant refusal of either unfamiliar foods (neophobia) or familiar foods (cues of satiety) were included. These questions were previously used in our pilot study[26] and were based on clinical experience of the investigators. Mothers were asked to indicate extent of agreement (four-point scale) with two statements: 'Compared with other children of similar age, my child is very easy to feed' and 'Do you think your child is a picky or fussy eater?' Two items addressed the 'parent provide, child decide'[27] theme (i) 'Who decides what your child eats—you or your child?' and (ii) 'Who decides how much food your child eats—you or your child?' (1 = you only, 2 = mostly *you, 3 = you and your child equally, 4 = mostly your child, and 5 = your child only*). Mothers indicated how often (*1 = never, not often, sometimes, often, 5 = most of the time*) they used specified strategies to manage refusal of unfamiliar ($n = 4$ questions) and familiar ($n = 8$ questions) food. For analysis, scales were dichotomised to provide a description of the frequency of the responses as well as enable a group comparison (Table 4).

Covariates

Covariate data were collected at Stage 1 (Table 1), including from 309/701 who did not consent to recontact. Socioeconomic status was determined using Socio Economic Indexes for Areas score for the Index of Relative Advantage and Disadvantage with scores below the 7th decile (sample median) used to indicate relative disadvantage.[28] At baseline, infant feeding details (ever breastfed, ever had solids) and current feeding mode (breastfeeding, formula feeding or a combination) were recorded.

Statistical analysis

Sample size calculations were based on expected meaningful differences at the 18-month follow-up in prevalence of selected impact outcomes, including a selection of the indicator behaviours for protective feeding practices that are reported here. Further detail of the specific outcome variables and assumed differences based on our pilot study of children aged 12–36 months[26] are given in the protocol paper.[18] Assuming 80% power and type I error of 5% (two-tailed) we sought 265 per group at the 18-month follow-up assessment and to enrol 830 based on an expected 35% attrition rate. Anthropometric variables were considered as secondary outcomes in the original protocol and excluded from sample size calculations as there were no data on likely or meaningful effect sizes of an intervention commencing in infancy.

An intention to treat analysis was employed as far as missing data permitted (no imputations were made). Comparison of the control and intervention groups on a range of maternal and child covariates, including anthropometric variables, demonstrated no baseline differences; no adjustment for covariates was undertaken. Accordingly, comparisons between groups on anthropometric outcome variables (except for conditional growth indices as described below) used independent samples *t*-tests and likelihood ratio chi-square tests for continuous and dichotomous outcome variables, respectively. Changes in conditional WAZ (birth to baseline, baseline to follow-up and birth to follow-up) and conditional BMIZ (baseline to follow-up) were compared between groups after adjusting for (i) time (days) between assessments and (ii) initial (that is, birth/baseline) z-score using Analysis of Covariance. Statistical adjustment for initial z-score (via regression analysis, standardised residuals or the present method) is recommended as an alternative to raw change scores as it controls for regression to the mean.[29–31]

Mean scores on the five (of seven, see above) IFQ[25] subscales were calculated and were synchronously analysed in Multivariate Analysis of Variance to control for inflation of type 1 errors associated with performing separate univariate analyses on related constructs.

All outcome data were double entered and checked before analysis and all statistical tests were computed using PASW/SPSS Version 18 (SPSS Inc., Chicago, IL, USA). A *P*-value of 0.05 (two-tailed) was used throughout to indicate statistical significance.

Table 1. Characteristics of $N = 2094$ first-time mothers who consented at Stage 1 and were allocated ($n = 698$) or not allocated[a] ($n = 1396$)

Variable[b]	*Allocated (n = 698)*	*Not allocated (n = 1396)*[a]	
		Did not Consent (n = 885)	*Could not recontact (n = 511)*
Maternal age at delivery (years)[c] ($n = 2087$)	30.1 ± 5.3	28.0 ± 5.5	26.2 ± 5.5
Maternal education (University degree)[d] ($n = 2078$)	58 (406)	36 (311)	27 (137)
Born in Australia/New Zealand[d]	78 (542)	77 (667)	75 (376)
Married/Defacto[d] ($n = 2062$)	95 (659)	90 (778)	83 (421)
Intend to breastfeed exclusively[d] ($n = 2088$)	93 (652)	90 (794)	87 (441)
Smoked during pregnancy[d] ($n = 2081$)	12 (85)	21 (185)	32 (164)

(*n* values) reflect missing data; Stage 1: when participants first approached in hospital post delivery. [a]Excluding an additional 75 participants who became ineligible. [b]Based on data provided at Stage 1. [c]Mean ± s.d. reported. [d]Proportion % (count) reported.

RESULTS

Participant flow is shown in Figure 1. Of those who consented to recontact and were contactable at Stage 2, 44% ($N = 698$) were allocated. The most common reasons for non-consent were time ($n = 532$), returned to work ($n = 237$), not interested ($n = 158$), transport problems ($n = 146$) and no need for feeding advice ($n = 105$). Characteristics of mothers who consented at Stage 1 and were allocated ($n = 698$) and mothers who did not consent or could not be recontacted at Stage 2 ($n = 1396$) are shown in Table 1. There were no differences according to group allocation on key maternal and infant characteristics at baseline (Table 2). Average attendance was 3.0/6 sessions and the most common reasons given for non-attendance were return to work and transport. At follow-up assessment, total attrition was 14% ($n = 100$; intervention, $n = 61$, 17%, control, $n = 39$, 11%). There were no substantive differences between infants available and those not available for follow-up assessment in terms of birth weight, baseline z-scores or change in weight-for-age (birth to baseline). Mothers differed only in terms of age at delivery (completed, Median = 31, range = 18–46 years, did not complete, Median = 27, range = 18–38 years), university education (completed, 62%, did not complete, 34%), and living with a partner (completed, 96%, did not complete 90% defacto/married). Characteristics of non-completers did not vary as a function of group allocation; analysis was the same as for characteristics for allocation (Table 2) and revealed no allocation group differences (data not shown).

Anthropometric outcomes

Child anthropometrics at baseline and follow-up are presented in Table 3. There were no group differences between length z-scores at baseline (control 0.39 ± 0.98 vs intervention 0.27 ± 0.95; $P = 0.12$, respectively) or follow-up (0.54 ± 1.09 vs 0.0.52 ± 0.99; $P = 0.76$). The conditional growth analysis from the Analysis of Covariance adjusting for (i) time (days) between assessments and (ii) initial (birth or baseline z-score) gave the same results. There was no group difference in the prevalence of rapid weight gain from birth to baseline (control 15%, $n = 52$ vs intervention 12% $n = 43$; $P = 0.32$). However, children in the control group (35%, $n = 102$) were more likely than those in the intervention group (25%, $n = 67$) to show rapid weight gain from birth to follow-up (odds ratio (OR) = 1.6, confidence interval (CI) 95% = 1.1–2.4; $P = 0.008$) and baseline to follow-up (control 48%, $n = 140$ vs intervention 37%, $n = 102$; OR = 1.5, CI 95% = 1.1–2.1; $P = 0.014$). Only 3% ($n = 15$) showed slow weight gain defined as a change in WAZ from baseline to follow-up < -0.67 with no group effect ($P = 0.12$).

Maternal feeding practices

With respect to feeding mode at follow-up, a third of mothers were still breast feeding their infant (control 32% vs

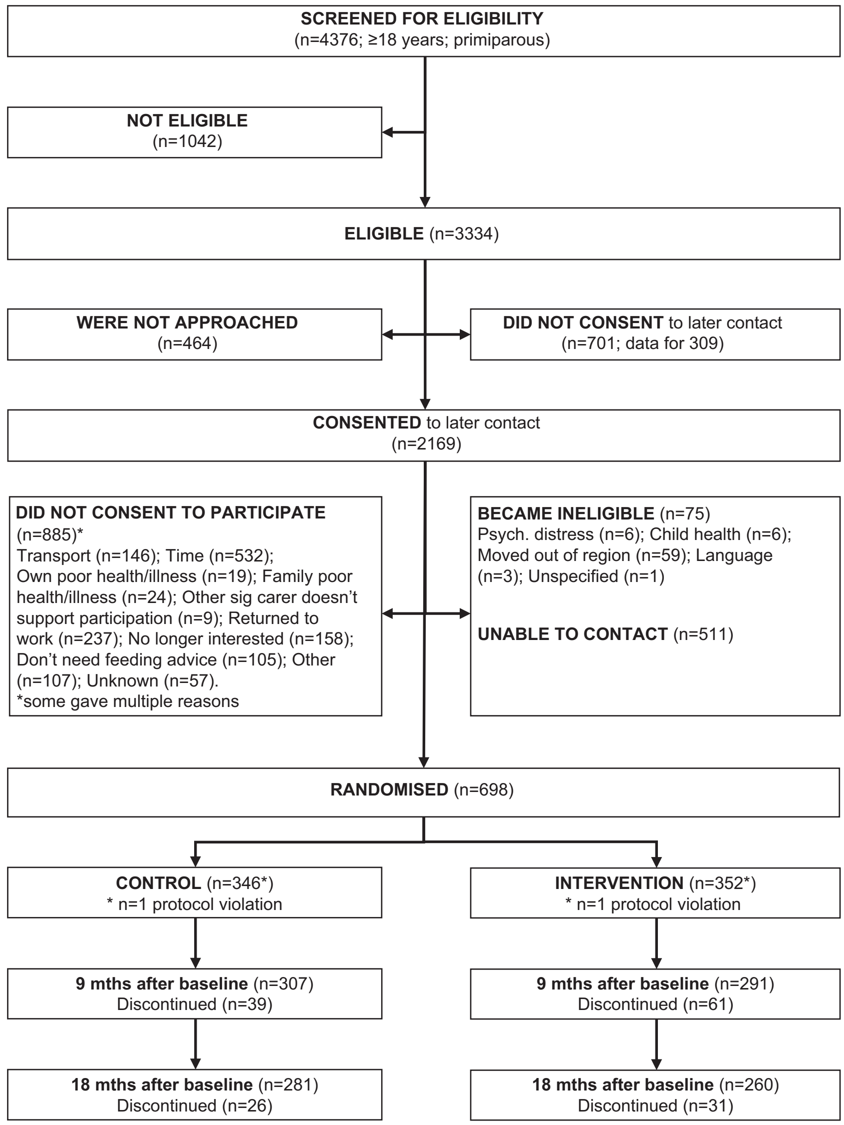

Figure 1. Participant flow through the study.

intervention 33%; $P=0.78$). There was no group difference in the age at which solids were first introduced regularly (control 22.7 ± 4.9 weeks vs intervention 22.8 ± 4.4 weeks; $P=0.85$). Maternal feeding practices as reported on the IFQ and the frequency of strategies used in response to refusal of both unfamiliar foods (neophobia) and familiar foods (signal of satiety) are presented in Table 4.

Based on the IFQ, the mean score for the concern about underweight scale was higher than that for the overweight scale, but there were no group differences (Table 4). Intervention mothers reported a slightly higher awareness of cues than control mothers ($P=0.007$). Mothers in the intervention group were more likely than those in the control group to report it was mostly/only their child who decides deciding *how much* the child eats (76% vs 44%; OR $=4.1$, CI 95% $=2.8$–5.9; $P<0.001$). There was no difference in the proportion of intervention vs control mothers reporting it was *mostly/only* the parent deciding *what* foods the child (71% vs 76%, respectively; OR $=1.2$, CI 95% $=0.8$–1.8; $P=0.28$).

In terms of refusal of unfamiliar foods, there were no group differences in the mothers' perceptions of their child's feeding behaviour: that is, proportion of mothers reporting that their child was easy to feed (85% *strongly agree/agree*; $P=0.71$); was a picky or fussy eater (29% *very/somewhat*; $P=0.17$); or was *unwilling/very unwilling* to eat unfamiliar foods (5%; $P>0.999$). However, only 68% of mothers *very often/often* offered their child unfamiliar foods ($P=0.93$). Specific maternal strategies used in response to neophobia are shown in Table 4.

In response to the question 'Does your child ever refuse food they usually eat?' 265 (49% control vs 51% intervention; $P=0.49$) mothers replied 'yes' vs 'hardly ever'. There were no differences in key maternal/child covariates between the two subsamples created using this dichotomous response. The frequencies of specified responses to refusal of familiar foods (signal of satiety) reported by the relevant subsample based on refusal of familiar foods are also shown in Table 4. Mothers from the intervention group reported less frequent use of 2/5 strategies ($P<0.001$) that override child satiety signals and more frequent use of 1/2 strategies ($P=0.07$) that respond appropriately to these signals.

DISCUSSION

This is one of the first large RCTs to evaluate a universal obesity prevention intervention starting in the first 12 months of life.[8]

Our results suggest that early anticipatory guidance that encourages responsive feeding and appropriate management of neophobia and innate taste preferences is associated at 14 months of age with reduced growth-related indicators of future obesity risk. The results also suggest that such intervention can impact on maternal feeding practices which potentially mediate these anthropometric outcomes.

At 14 months of age, with the exception of length, all the anthropometric variables were consistently lower in the intervention group. Rapid weight gain in the first 2 years of life is a well-established risk factor for obesity.[24,32,33] The change in WAZ from birth to baseline was identical for both groups, but over the 9-month follow-up period half the control infants showed rapid weight gain compared with only a third of intervention infants. The mean BMIZ at follow-up was also higher in the control group. There were no differences in length between the groups and the prevalence of slow weight gain[34] was very low (3%) and similar in both groups, indicating no adverse intervention effects on overall growth.

Table 2. Baseline characteristics of mothers and children ($N=698$) allocated to the control group ($n=346$) compared with the intervention group ($n=352$)

Variable	*Control*	*Intervention*	*Total*
Mother			
Education (University degree)	58 (199)	59 (207)	58 (406)
Smoked during pregnancy	11 (40)	13 (45)	12 (85)
Born in Australia	79 (270)	78 (272)	78 (542)
Married/Defacto	95 (327)	95 (332)	95 (659)
SEIFA Index of Relative Advantage and Disadvantage (relative disadvantage ⩽7th decile)	34 (117)	32 (113)	33 (230)
Age at delivery (years)	29.9 ± 5.3	30.2 ± 5.3	30.1 ± 5.3
BMI	26.2 ± 5.5	25.8 ± 5.1	26.0 ± 5.3
Infant			
Gender (female)	50 (173)	51 (181)	51 (354)
Birth weight (kg)	3.5 ± 0.4	3.5 ± 0.4	3.5 ± 0.4
Birth weight z-score	0.38 ± 0.87	0.39 ± 0.88	0.38 ± 0.87
Age (months) at baseline assessment	4.3 ± 1.0	4.3 ± 1.0	4.3 ± 1.0
Current feeding mode[a]			
Fully/exclusively breast fed	55 (170)	60 (191)	57 (361)
Formula only	27 (83)	26 (84)	27 (167)
Combination (formula + breast fed)	19 (59)	14 (44)	16 (103)
Ever breast fed[a]	96 (266)	98 (250)	97 (516)
Ever given solids[a]	34 (114)	34 (115)	34 (229)

Abbreviations: BMI, body mass index; SEIFA, Socio-economic Indexes for Areas.[26] % Within group (count) reported for dichotomous variables; mean ± s.d. reported for continuous variables. [a]Data collected from questionnaire administered at baseline.

To our knowledge there is only one other RCT to date that has reported anthropometric outcomes of an intervention initiated before 12 months of age which specifically aimed at reducing childhood obesity risk. Paul *et al.*[35] recently reported on an evaluation of two interventions (singly and combined) delivered via two nurse home visits at infant age 2–3 weeks and 4–6 months. One intervention provided advice on soothing strategies to prolong sleep and the other on the timing and process of solid introduction. Outcome data at 12 months of age ($n=110$; 69% retention) suggested that the combined interventions were associated with lower weight-for-length percentiles (33rd vs 50th percentile; $P<0.01$) and conditional weight gain (based on residuals; -0.39 vs 0.08). Concerns have been raised regarding potential below average growth of the combined intervention group, suggested by weight-for-length percentiles below 50th percentile and negative conditional growth residuals at 1 year of age.[1] Overall, our trial adds substantially to this evidence. With a much larger sample our results also indicate that feeding interventions commencing in infancy may have positive effects on anthropometric indicators of future obesity risk with no evidence of adverse effects on growth.

Food refusal of both unfamiliar and familiar foods is common in infants and even more so in toddlers.[7,21,26,36] In healthy children, food refusal usually reflects neophobia or is a signal of satiety. Carer interpretation of and response to food refusal is potentially one of the most important factors defining the early feeding experience and environment.[10] We have previously shown that many mothers of children aged 1–3 years may not understand that these behaviours are normal, and anxiety related to food refusal and concern that their child will become underweight (but not overweight) is prevalent.[26] These perceptions and concerns are important as they are likely to strongly influence maternal feeding behaviours. Despite the anticipatory guidance framework of the intervention that aimed to assist mothers to have realistic expectations of behaviours related to early solid feeding, there were no group differences in the extent to which mothers' perceived their child as fussy or difficult to feed or were concerned regarding their child's weight status. As reported elsewhere[25,26] concern regarding underweight appeared to be more prevalent/stronger than overweight, suggesting poor congruence with the actual risks. It will be interesting to see if any group differences emerge at later follow-up when the prevalence of food refusal is expected to increase.

Innate food preferences such as the rejection of novel foods (neophobia) and bitter/sour foods and a preference for sweet foods are readily modified by familiarity. Repeated exposure to a

Table 3. Anthropometric data (mean ± s.d.) at birth, baseline[a] and follow-up[b] for children enrolled in the NOURISH trial

	Weight-for-age z-score		P *value*	*BMI-for-age z-score*		P *value*
	Control	*Intervention*		*Control*	*Intervention*	
Raw z-scores						
Birth	0.38 ± 0.87	0.39 ± 0.88	0.99			
Baseline	− 0.03 ± 0.91	− 0.04 ± 0.93	0.95	− 0.26 ± 0.98	− 0.36 ± 0.98	0.18
Follow-up	0.60 ± 0.85	0.47 ± 0.90	0.08	0.42 ± 0.85	0.23 ± 0.93	< 0.01
Change in raw z-scores						
Birth to baseline	− 0.42 ± 1.01	− 0.44 ± 0.99	0.92			
Baseline to follow-up	0.62 ± 0.68	0.53 ± 0.75	0.08	0.65 ± 0.84	0.61 ± 0.95	0.05
Birth to follow-up	0.22 ± 1.06	0.06 ± 0.97	0.05			

P-value for test of difference between groups. [a]Baseline: $n=696$; female 51%; age mean ± s.d. 4.3 ± 1.0 months. [b]Follow-up: control group $n=293$, female 52%, age 13.7 ± 1.3 months; intervention group $n=273$, female 51%, age 13.7 ± 1.3 months; note: weight/length not available at follow-up for 32/598 children retained at follow-up.

Table 4. Feeding practices and related concerns at follow-up (infant age 13.7 ± 1.3 months; 51% female) of mothers enrolled in the NOURISH trial

Item	*Control*	*Intervention*	*Difference (P value)*
Infant Feeding Questionnaire (IFQ)[a]	$n=275$	$n=254$	
Awareness of infant satiety and hunger cues	4.1 ± 0.5	4.2 ± 0.5	0.007
Using food to calm fussiness	2.2 ± 0.7	2.2 ± 0.7	0.38
Feeding on schedule	2.8 ± 1.0	2.7 ± 1.0	0.13
Concern about infant under-eating and being underweight	2.0 ± 0.7	2.0 ± 0.8	0.61
Concern about infant overeating and being overweight	1. 5 ± 0.6	1.4 ± 0.5	0.25
Response to refusal of unfamiliar foods (neophobia)[b]			
Times offered a food before deciding whether liked (< 6 times)	70 (192)	33 (82)	<0.001
Assume child dislikes; do not offer again[c]	10 (26)	6 (15)	0.15
Disguise food[c]	67 (182)	46 (113)	<0.001
Offer with liked food[c]	94 (256)	94 (235)	1.00
Response to refusal of familiar foods	$n=130$	$n=135$	0.49
Non-responsive feeding strategies–override satiety cues[b,d,e]			
Insist child eats it	21 (27)	15 (20)	0.26
Offer milk drink instead	23 (30)	24 (30)	1.00
Offer liked food instead	90 (116)	84 (113)	0.20
Encourage to eat: Turn mealtime into a game	67 (87)	29 (39)	<0.001
Encourage to eat: Offer food reward	15 (20)	4 (5)	0.001
Encourage to eat: Offer non-food reward	10 (13)	8 (10)	0.52
Responsive feeding strategies - respond appropriate to satiety cues[b,d,e]			
Offer no food until next usual meal/snack time	33 (42)	47 (63)	0.017
Accept that child may not be hungry; take food away	90 (117)	96 (128)	0.098

IFQ: 5-point Likert-style scale with 1 = never, 2 = rarely, 3 = sometimes, 4 = often, 5 = always.[23] [a]Continuous variables based on multivariate analysis of variance; mean ± s.d. reported. [b]Dichotomous variables based on likelihood ratio chi-square test; % within group (count) reported. [c]Response Options: *never, not often, sometimes often*, dichotomised and % sometimes/often reported. [d]Only participants who answered 'yes' to the item *Does your child ever refuse food they usually eat?* $n=265$. [e]Response options: *never, not often, sometimes, often, most of the time, dichotomised and % sometimes/often/most of the time reported*.

range of flavours and textures increases familiarity and has been shown to increase acceptance and intake, particularly in infants.[14,16,17] Mothers in the intervention group appeared to be more persistent in reoffering new foods and less likely to disguise new foods. These behaviours are likely to support improved dietary variety and quality in both the short and longer term.[12,14,16,37]

The extent to which mothers recognise and match their responses to their infant's cues of hunger and satiety (responsive feeding) is critical in supporting the child's innate capacity to self-regulate intake.[10] In practical terms, responsive feeding interprets general food refusal as signalling the child is not hungry and/or is satiated. Non-responsive feeding is characterised by excess overt control and has been associated with children's eating behaviour, weight status and dietary quality.[7,10,38] It includes practices such as explicit encouragement and praise, coercion, coaxing and the use of alternative liked foods or rewards.[27,39,40] We have previously shown that such non-responsive practices were common and hence they were a target for our intervention.[26] About half the mothers reported refusal of familiar foods with no difference in prevalence between groups. However, mothers in the intervention group were less likely to use non-responsive feeding strategies, specifically encouragement to eat through use of games or food rewards. They were more likely to interpret refusal of familiar food and wait until the next usual meal/snack to offer food again. While mothers in both conditions reported a high awareness of hunger and satiety cues, the intervention group scored higher on this construct and were almost twice as likely to report trusting their child to decide how much to eat. Overall, these results suggest the intervention was successful in promoting a number of protective feeding practices that support expanded food preferences and child self-regulation of intake.

Strengths of this study include a large sample size with good retention, outcomes assessed by trained study staff blinded to group allocation and analysis according to allocated group, regardless of level of attendance. The intervention format was group-based and consistent with other community child health programs available at the time in Queensland and South Australia.

The study also has some important limitations. Our decision to use a usual care rather than a true attention control group does not allow us to preclude the possibility that the health professional and peer contact produced the treatment effects. However, we were unable to identify 18 h (to match intervention contact) of content that would not potentially impact on obesity risk and would be sufficiently relevant to justify the cost and participant burden. Despite our rigorous sampling strategy and strong retention, there is evidence of selection and retention bias. Hence, the generalisability of these results and the broader applicability of the intervention are unknown, particularly to mothers with more than one child and/or born outside Australia. Various authors have highlighted the need for studies with participants from a range of social and cultural backgrounds.[10,41,42] The IFQ results should be treated with caution as the items are a mixture of beliefs and practices, internal consistency of 3/5 scales was <0.7 and two scales comprised only two items. Despite these limitations, as one of the first and largest RCTs of its kind, NOURISH represents a major advance over the largely observational and cross-sectional evidence for the potential role of early feeding practices in obesity prevention. It is important to note that this paper provides evidence of short-term efficacy and that longer term follow-up is required to determine if these early promising results can be sustained.

CONCLUSION

Our results provide promising evidence that anticipatory guidance commencing in infancy that targets the when, what and how of solid feeding results in an increased prevalence of protective feeding practices and, at least in the short term, reduces anthropometric indicators of obesity risk. Interventions that focus on intrinsic drivers of eating habits such as food preferences and intake regulation need to be evaluated as the child's eating environment widens beyond predominantly family control. Given the full impact of early maternal feeding practices on obesity risk may take time to manifest, our planned evaluation of the combined effect of both modules of the NOURISH intervention when children are 2, 3.5 and 5 years will determine longer term efficacy of this universal primary obesity prevention intervention.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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AUTHOR CONTRIBUTIONS

LD and AM led the conception, design and successful funding application for NOURISH. DB contributed methodological expertise to the RCT design and analysis protocols. Analysis was mentored by DB and undertaken by KM. RP and JN developed the intervention and RP had substantial input into recruitment, intervention delivery and data acquisition. The manuscript was drafted by LD and KM. All authors contributed to interpretation of the data, provided critical input into manuscript preparation and approved the final version to be published.

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