A Health Promotion Intervention Can Affect Diet Quality in Early Childhood

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Abstract

Initiatives to promote children’s nutrition and prevent childhood obesity are vital. Dietary patterns are a useful way to characterize whole diets, though no previous early childhood health promotion trial to our knowledge has assessed intervention impact using this approach. This research aimed to assess the effect of a healthy eating and physical activity intervention on young children’s dietary patterns. The Melbourne Infant Feeding Activity and Nutrition Trial Program was a health promotion, cluster-randomized controlled trial involving 542 families. Child diets were assessed by multiple 24-h recalls postintervention at ~18 mo of age. An Obesity Protective Dietary Index (OPDI) was created and dietary patterns were also assessed by principal components analysis (PCA). These outcomes were used to compare intervention and control participants to test the effectiveness of the intervention. Children in the intervention arm scored higher (15.6 ± 5.9) than those in the control arm (14.5 ± 6.7) for the OPDI (scores out of 30, P = 0.01). Three dietary patterns were identified by PCA; however, the scores did not substantially differ between the intervention and control arms. In conclusion, this paper presents novel results in both the evaluation of an early childhood health promotion intervention and the assessment of child dietary patterns. The results highlight the capacity for such an initiative to improve child diets and the need for further research in this area. J. Nutr. doi: 10.3945/jn.113.177931.

Introduction

Children’s diets in developed countries are on average low in fruits and vegetables and high in energy-dense, nutrient-poor (or noncore) foods, even at young ages (1–3). Suboptimal dietary intakes contribute to the development of overweight and obesity and are associated with chronic disease and comorbidities throughout the lifespan (4,5). Additionally, diet patterns are likely to track across life stages (6) and diet quality appears to decline as children age (7). Efforts in nutrition promotion for obesity prevention should therefore commence in early childhood to set healthy dietary trajectories for life, as demonstrated by a number of studies currently underway (8–10).

Appropriate evaluation of such interventions is vital to assess effectiveness and to identify the improvements needed to enhance the intervention program. Given that obesity prevention interventions typically target numerous dietary behaviors, the use of dietary patterns to inform and assess such interventions is likely to be a valuable addition to assessment of usual primary outcomes such as energy or individual food group intakes (11,12). Analysis of dietary patterns is a technique to assess multiple dietary components together. Dietary patterns reflect the way foods are eaten, namely in combination as part of a whole diet, rather than as separate nutrients or food groups. Health outcomes such as weight or waist circumference are likely to be affected by the whole diet and hence associated with dietary patterns (11–13). There are a number of methods available for assessing dietary patterns, namely data-driven approaches such as principal components analysis (PCA) and cluster analysis, in addition to diet quality indices (14). As yet, few studies have utilized dietary patterns analysis to assess health promotion interventions, particularly in children, with only one study known to have utilized a data-driven approach (15).

The Melbourne Infant Feeding Activity and Nutrition Trial (InFANT) Program was a health promotion, cluster-randomized controlled trial targeting obesity-protective behaviors. Some key aims of the study were to increase intakes of fruits and vegetables and reduce noncore foods (including noncore beverages).
(16); thus, assessment using a whole-of-diet approach was considered useful. Given the novelty of using dietary patterns in this context, this study employed 2 distinctly different approaches to consider the merits of each. A diet quality index can be purpose constructed specifically to assess dietary components relevant to the intervention. Conversely, the data-driven approach of PCA identifies whole dietary patterns as they exist in the population. Few studies in adults have utilized both methods concurrently (17,18) and no similar published studies among children have been identified.

The aim of this study is to assess the impact of the Melbourne InFANT Program intervention on children’s diets as assessed by dietary patterns and a diet quality index. Additionally, these analyses will offer a novel opportunity to compare the use of 2 methods of dietary patterns analysis to evaluate an intervention.

Materials and Methods

Intervention. The Melbourne InFANT Program was a cluster-randomized controlled trial conducted in Melbourne, Australia from 2008 to 2010 (16). Ethical approval was granted by the Deakin University Ethics Committee (ID no.: EC 175–2007) and by the Victorian Office for Children (ref: CDF/07/1138). This was a low-dose, community-based, health promotion trial with key targets of improving child diet quality, increasing physical activity, and reducing sedentary behavior, and reducing BMI-Z-score. Only dietary outcomes will be considered in this paper. In brief, families from across Melbourne, Australia were recruited via first-time parents’ groups, which are run in local areas by Maternal and Child Health Nurses, and attract approximately two-thirds of new mothers (19). The inclusion criteria were provision of written, informed consent, being first-time parents, and speaking English. Following recruitment of 14 randomly selected local government areas in Melbourne, parents’ groups within those areas were randomly selected and approached by project staff. Groups recruited were then randomly allocated to either the intervention or control arm using sequentially numbered envelopes. Randomization at each step of the recruitment process was conducted by an independent statistician using a random number schedule. Sample size calculations have been reported elsewhere (20), with 62 parents’ groups calculated to be able to show a 25% difference in vegetable intake between trial arms based on prior Australian consumption data (21) and allowing for within-parent group clustering.

Those in the intervention arm were invited to attend 6 group sessions facilitated by a dietitian for a period of 15 mo (16). Sessions took an anticipatory guide approach and included peer discussion of facilitators and barriers to improving dietary intakes and food-related behaviors. Some of the key messages promoted in the intervention included division of responsibility in child feeding (22), healthy parental modeling of eating, provision of fruits and vegetables at each meal and snack time, and limiting provision of noncore foods. Participants were provided with purpose-designed written resources and a DVD reinforcing these messages. The control group received the usual care available to them in their local area including information about infant feeding, and no similar published studies among children have been identified.

Demographic data collection. At baseline, when children were 4 mo of age, mothers completed a self-administered questionnaire. They reported their child’s birth date as well as their own education level, birth date (from which maternal age at childbirth was calculated), and prepregnancy height and weight (from which maternal BMI was calculated).

Dietary data collection. At the conclusion of the intervention, parents completed 3 unscheduled 24-h recalls by telephone. These were conducted on nonconsecutive days and included 2 weekdays and 1 weekend day. Parents were provided with a purpose-designed food measurement booklet, which incorporated original photographs of measured food quantities based on available serving size information (21), together with pictures from the food model book used in the 2007 Australian Child Nutrition and Physical Activity Survey (23). A 5-pass, computer-assisted, standardized recall process was developed and utilized based on the method validated by the USDA (24) and also the method utilized in the United States’ Feeding Infants and Toddlers Study (2). The recalls were conducted by trained research staff who were blinded to the treatment arm of the participants. Coding of food items was also completed by trained blinded staff by using the Australian Food Supplement and Nutrient Database (2007) (25). That database was updated in 2007 with additional foods relevant for young children and for the purposes of this study, infant-specific foods were added to that database when necessary. The coding of all interviews was checked for completeness and accuracy by a dietitian. Participants who completed <2 recalls were excluded; thus, all analyses are based on mean intakes during 2 (n = 26) or 3 (n = 372) days. Those with energy intakes > 3 SDs from the sample mean were also excluded.

Generation of dietary patterns by PCA. As outlined in Supplemental Table 1, all recorded foods and beverages were classified into 51 mutually exclusive groups based on foods used or eaten in similar ways and foods with similar nutritional composition. PCA with varimax rotation was conducted and the number of factors to extract was determined by considering eigenvalues > 1.5, the point at which the scree plot leveled and the interpretability of the factors obtained (14). Foods with an absolute value factor loading ≥ 0.15 were considered to contribute to the pattern, with this cut point determined by considering the interpretability of the dietary patterns and the overall range of loadings observed in the data (26). Each participant’s score for each factor was calculated by summing the standardized observed intakes of the food items with loadings ≥ 0.15, multiplied by the factor loadings (26). Items that loaded in the same direction on more than one factor (cross-loading) were only retained on the factor with which they correlated most highly (27). Factors were labeled according to items with the highest positive loadings (28).

Dietary index score calculation. A review of previous diet quality indices found no measures appropriate for this population that assessed servings of noncore foods (29–36). Therefore, an Obesity Protective Dietary Index (OPDI) was created to assess the key dietary targets of the Melbourne InFANT Program, namely, whether intakes of fruits and vegetables increased and intakes of noncore foods decreased (16). Fruit and vegetable intakes were assessed by weight (grams), whereas noncore foods were assessed by energy content (kJ), similar to the way that servings of these foods are defined in the Australian Guide to Healthy Eating (37). The foods included are described in Table 1. The noncore food group primarily focused on foods likely to be eaten as snacks. The fruits and vegetables groups included contributions from mixed dishes by using an approach similar to the disaggregation method utilized to calculate MyPyramid Food Groups by the USDA (38).

Scores on the OPDI were determined by the data distributions in the study, proportion for each of the 3 index items (fruits, vegetables, and noncore foods). Intakes of all participants for each index item were divided into 11 quantiles, which corresponded to scores of 0–10, with 10 representing the healthiest intakes. Thus, for the fruit and vegetable items, high scores reflected higher intakes, whereas for the item assessing noncore foods, the scoring was reversed. The potential total score range for the OPDI was therefore 0–30, with 30 representing the healthiest score. Construct validity of the OPDI was assessed using Pearson’s correlation coefficient to test associations between OPDI scores and intakes of energy and key nutrients of public health importance related to the index components. Dietary fiber, β-carotene, and vitamin C were considered to reflect the fruit and vegetable food groups and saturated fat and sodium were considered to reflect the noncore food groups. Nutrient intake distributions were assessed for normality using Q-Q plots and non-normal distributions were transformed for analysis (β-carotene log transformed and vitamin C square root transformed). Correlations were assessed both with and without adjustment for energy intake,
similarly to the final models assessing the intervention effect on diet patterns. This considers both total and proportional intakes and thus assists in understanding whether the index reflects more total food or also change in composition of the diet.

**Statistical analyses.** To describe the OPDI scores for each trial arm, means were calculated and means ± SDs are presented in text. Linear regression analyses were conducted to compare OPDI and PCA-derived patterns’ scores between intervention and control arms, because scores were continuous and considered normally distributed (assessed by Q-Q plots). The statistical program used was STATA version 11.1 (39) and intention-to-treat principles for analysis of completers were employed. All analyses controlled for clustering (by first-time parents’ group) as well as variables likely to influence child diets: child age at the time of the first dietary recall, maternal education level, and maternal age at childbirth. Analyses did not control for other demographic variables such as maternal BMI or child gender (due to collinearity with other included covariates) or child BMI Z-score (which was not associated with the dietary patterns). Analyses were conducted both with and without controlling for energy intake. Consistent with another study that did not assess young children’s diets at baseline (40), these analyses did not utilize longitudinal dietary data and did not assess change in intake, because collection of dietary data were not considered meaningful when children were aged only 4 mo at baseline and primarily consuming milk.

**Results**

Details of the sample and participant flow have been provided elsewhere (20) and descriptive data are summarized in Table 2. The demographic characteristics did not differ between intervention and control arms at baseline (20). Of the 398 participants who provided sufficient data for this analysis (which was at least two 24-h recalls), 3 were excluded based on energy intakes >3 SDs from the sample mean; hence, the final sample for dietary analyses was 395. Those with a higher education level were more likely to complete the recalls (82% of university educated compared with 72% of nonuniversity educated; *P* < 0.01), but there were no differences in completion rates based on maternal BMI, age at childbirth, or trial arm allocation. Mean child age at the first recall was 18.0 ± 1.5 mo. There was no difference in age at first recall between intervention and control arms when compared with the use of ordered logistic regression (*P* = 0.51). The median number of days between a participant’s first and last recall was 10, and 69% of participants completed the recalls within a 2-wk period.

**Patterns derived by PCA.** Three dietary patterns were identified by PCA, which in total explained 12.3% of the total variance in food intakes (Supplemental Table 2). The first pattern was characterized by positive loadings of fruit, legumes, and meat meals with high vegetable content, and negative loadings of sweet drinks, crisps and savory snacks, potato with fat, and red meat. While the strongest loadings were negative (sweet drinks, and crisps and savory snacks), pattern labels focused on positive loadings; thus, this pattern was labeled “fruit.” For the second pattern (labeled “vegetables”), cooked, nonstarchy vegetables, starchy vegetables other than potato, potato with no fat, and red meat loaded positively, whereas milk loaded negatively. The third pattern (labeled “vegemite and bread”) was characterized by positive loadings of vegemite, bread, margarine, water, and confectionary and sweet snacks.

Linear regression analyses to compare factor scores for the 3 PCA-derived dietary patterns between control and intervention arms revealed no significant differences (Table 3). There was also no substantial difference in results when adjusting for energy intake.

**OPDI.** Pearson’s correlations indicated that scores on the OPDI were positively (*P* < 0.01) correlated with intakes of energy (0.18), dietary fiber (0.55), β-carotene (0.51), and vitamin C (0.40), but not with intakes of saturated fat (−0.02) or sodium (0.03). When adjusted for energy intake, the correlations altered only for saturated fat (−0.19) and sodium (−0.11) and both were significant (*P* < 0.05). The mean OPDI score for the intervention arm was 15.6 ± 5.9 from a possible score of 30 and the mean score for the control arm was 14.5 ± 6.7. After multivariable adjustment, including energy intake, the predicted OPDI score in the intervention group was 1.33 points (95% CI: 0.28, 2.39) higher than for the control group (Table 3).

**Discussion**

The Melbourne InFANT Program resulted in a higher OPDI score for children participating in the intervention compared with the control arm at the intervention’s conclusion. Thus, the intervention achieved a key objective of improving the quality of children’s diets. This reflected an accumulation of small differences across the range of intervention targets that comprised this index, i.e., increased fruit and vegetable intake and decreased noncore food intake (20). For illustration, a 1-point increase on the OPDI is equivalent to shifting up one quantile in the distribution of any one of the composite items, equating to an ~20-g increase in vegetables, 27-g increase in fruit, or 117-kJ decrease in noncore foods (based on the mean difference in median values from one quantile to the next). Although small differences, in the context of the dietary intake of very young children, these represent meaningful outcomes of a low-dose intervention. Small improvements in early childhood dietary patterns may be most relevant if sustained or magnified through tracking across life stages; hence, longer term follow-up to assess

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**Table 1** Items included in the OPDI

<table>
<thead>
<tr>
<th>OPDI item</th>
<th>Foods included</th>
<th>Amount of intake for minimum score (lowest quantile)</th>
<th>Amount of intake for maximum score (top quantile)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fruit, g</td>
<td>All raw, cooked, tinned, and dried fruit (not juice)</td>
<td>&lt;57</td>
<td>&gt;268</td>
</tr>
<tr>
<td>Vegetables, g</td>
<td>All raw and cooked vegetables, reported individually or in mixed dishes, including potato without added fat (not potato cooked in fat)</td>
<td>&lt;25</td>
<td>&gt;172</td>
</tr>
<tr>
<td>Noncore foods, kJ</td>
<td>Juice, soft drink, cordial, sweetened milks, sweet and savory biscuits, crisps, confectionary, cakes, pastries, buns, and takeaway foods</td>
<td>&gt;600</td>
<td>0</td>
</tr>
</tbody>
</table>

1. Intakes of each food group were divided into 11 quantiles to allocate scores of 0–10 within each food group. OPDI, Obesity Protective Dietary Index.

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5. Vegemite is an Australian concentrated yeast extract spread with added salt, made by treating yeast with acid, and fortified with thiamine, riboflavin, and niacin.
whether the modest impacts of this intervention are sustained will be important (41).

Interestingly, there were no differences between arms for the dietary patterns derived by PCA. This contrasts with the results for the OPDI and could be explained by a number of reasons. Primarily, the development of the OPDI was conceptually driven and specifically designed to assess differences in the key intervention outcomes. Conversely, the PCA-derived patterns were data driven; hence, the food items included were not necessarily relevant to intervention targets. In the case of the vegemite and bread pattern, it contained relevant foods, but healthy and unhealthy items loaded in the same direction, so any intervention effects may have cancelled each other out. Although the fruit and vegetable PCA patterns contained items relevant to the intervention and loading in the same direction, it may be that differences between arms for those few specific items were too small to be significant but that when combined in the OPDI, the cumulative effect of those small differences was significant. Additionally, it seems that the noncore foods index item was the main contributor to the difference in OPDI scores between trial arms (20), but such foods were not all included in the predominantly fruit and vegetable PCA-derived patterns.

This comparison of 2 different but complementary methods of dietary patterns analysis raises consideration of whether patterns derived by PCA are an ideal method for assessing intervention effectiveness, as data-driven dietary patterns reflect broader food intakes than intervention targets. This is the first intervention known to have assessed dietary outcomes utilizing PCA, so there is much work left to be done in establishing the most appropriate and useful method. Additionally, conducting PCA for diets of young children provides specific challenges given the relatively limited number of foods consumed. This may contribute to the small amount of variance in food intakes explained by each of the patterns.

Creation and definition of food groupings for PCA is challenging, because the benefits of retaining more groups must be balanced against use of food groups with a high percentage of nonconsumers (14). Data from food recalls and records provides a particular challenge in reflecting infrequently consumed foods compared with FFQs, where frequencies of less than once per week can be estimated. Ultimately, 51 food groupings were created for the PCA in this study, which is consistent with a study of infant dietary patterns where 56 food groups were retained from FFQ data for PCA (42). However, this is more food groups than used by other studies of dietary patterns in children under 5 y using other methods such as cluster analysis (34,43–46). The large number of food groups utilized in this study offers greater discrimination between core and noncore

| TABLE 2 | Participant characteristics for intervention and control arms¹ |
|---|---|---|
| | Total sample | Control | Intervention |
| First-time parents recruited | 528 | 266 | 262 |
| Male children, % | 53 | 54 | 52 |
| Child age at baseline, mo | 3.6 ± 1.0 | 3.6 ± 1.0 | 3.7 ± 1.1 |
| Child age postintervention, mo | 18.0 ± 1.5 | 17.9 ± 1.3 | 18.1 ± 1.7 |
| Child birth weight, g | 3392 ± 593 | 3371 ± 636 | 3393 ± 547 |
| Child BMI Z-score at baseline | −0.47 ± 1.03 | −0.52 ± 0.97 | −0.41 ± 1.09 |
| Ever breastfed, % | 97 | 97 | 97 |
| Mother’s age at childbirth, y | 31.9 ± 4.3 | 31.7 ± 4.5 | 32.1 ± 4.2 |
| Maternal prepregnancy BMI, kg/m² | 23.1 (20.6–26.7) | 23.0 (20.6–26.6) | 23.4 (20.6–27.0) |
| Underweight (BMI <18.5), % | 4.2 | 4.3 | 4.1 |
| Healthy weight (BMI 18.5 to <25.0), % | 60.8 | 62.1 | 59.3 |
| Overweight (BMI 25.0 to <30.0), % | 21.9 | 21.9 | 22.0 |
| Obese (BMI ≥30.0), % | 13.1 | 11.7 | 14.6 |
| Maternal education at baseline, % | | | |
| Tertiary qualification | 55 | 57 | 52 |
| Diploma or trade certificate | 25 | 23 | 26 |
| High school education or lower | 21 | 20 | 22 |

¹ Values are means ± SDs, medians (IQRs) or percents. Baseline n = 502-522 (n varied because not all participants provided complete data at baseline) and postintervention n = 395.

| TABLE 3 | Trial arm differences in dietary patterns and diet quality |
|---|---|---|---|
| | Base model¹ | Energy-adjusted model² |
| | Regression coefficient (95% CI) | P value | Regression coefficient (95% CI) | P value |
| Factor 1: fruit | 0.10 (−0.12, 0.32) | 0.37 | 0.11 (−0.12, 0.33) | 0.34 |
| Factor 2: vegetables | 0.16 (−0.08, 0.38) | 0.15 | 0.16 (−0.07, 0.38) | 0.17 |
| Factor 3: vegemite and bread | −0.02 (−0.28, 0.23) | 0.85 | 0.00 (−0.26, 0.25) | 0.97 |
| OPDI total score³ | 1.20 (0.14, 2.27) | 0.03* | 1.33 (0.28, 2.39) | 0.01* |

¹ Linear regression analyses controlled for child age at the first recall, maternal education level, maternal age at childbirth, and clustering by parent group. *P < 0.05. OPDI, Obesity Protective Dietary Index.

² Linear regression analyses controlled for child daily mean energy intake, child age at the first recall, maternal education level, maternal age at childbirth, and clustering. *P < 0.05.

³ Potential score range 0–30.
foods but may be responsible for the relatively small amount of variance explained by each pattern (47).

With regard to the validity of the OPDI, it was not necessarily unexpected that scores were not significantly correlated with saturated fat or sodium intakes prior to energy adjustment, because this index did not include all noncore foods. Additionally, full-cream dairy products are likely to be a major source of total fat and saturated fats in this age group (48) but are not included in this index. The weak but significant correlation between energy intake and diet quality is consistent with findings in other studies of young children (31,49). This association probably reflects that higher diet quality is often associated with higher food consumption overall (50) and that the inclusion of only selected noncore foods (representing snack intake) in our index did not overcome this.

This is only the second study known to have published primary diet-related results of a health promotion intervention with children under 2 y of age and to have included >200 participants and utilized multiple 24-h recalls or records for dietary assessment. The other was the Special Turku Coronary Risk Factor Improvement Project (40), which aimed to reduce coronary risk factors, and has shown significant effects on intakes of total fat, cholesterol, unsaturated fat, and boys’ intakes of fruits and vegetables at various ages (51,52). However, that trial involved intensive individual counseling sessions from 6 to 24 mo of age, with additional biannual sessions thereafter (40), which is unlikely to be feasible in a public health setting. Similarly, another recent Australian obesity prevention trial has reported improved child vegetable intakes, though intakes were assessed by FFQ and that was a relatively intensive intervention (involving 8 home visits) (53). The low-dose, group-based nature of the Melbourne InFANT Program intervention offers higher public health utility but may explain the modest improvement in child diet quality.

A strength of this study was engagement with an existing system and involvement of existing social groups, as parents reported that they learned from discussion with their peers as well as from the intervention facilitators (20). However, in interpreting these results, it is important to consider the one-third of parents who do not join such groups, and also that these participants were all first-time parents. Therefore, these findings may not be generalizable to all parents. Further important considerations, which form future research questions, include understanding whether the intervention was more or less successful for subgroups such as lower-educated mothers (moderation analysis) and understanding which aspects of the intervention may have contributed to the observed effect on child diet (mediation analysis) (54).

Strengths and limitations of the data collection and coding methods must also be considered. A limitation of this study was the loss of participants from baseline, particularly those with a lower education level. Although a relatively high retention rate was achieved, the number who completed the dietary data collection was fewer, though 75% completion is not dissimilar to other studies (53,55). The use of multiple 24-h recalls, which involve a greater time commitment for parents compared with an FFQ, may have contributed to participant noncompletion. However, the use of multiple 24-h recalls is also a strength of this study, as this rigorous method allowed detailed categorization of foods for PCA. The low number of prescheduled diet recalls (4%) is another strength of this study, reducing the likelihood of participants altering their child’s diet due to assessment compared with other studies such as the Australian Child Nutrition and Physical Activity Survey that prescheduled all diet recalls (23).

A further strength was the calculation of fruit and vegetable intakes for the OPDI using the disaggregation method. More commonly, studies do not count fruits and vegetables in mixed dishes (44,56,57) and therefore likely underestimate total intakes; alternatively, in studies of adults, a constant estimate of the fruit and vegetable content may be applied across all mixed dishes (58). However, given that the Melbourne InFANT Program intervention aimed to increase vegetable intakes via techniques such as increasing the vegetable content of mixed dishes, it was important to consider the contributions of those meals.

In conclusion, this study has shown that a low-dose health promotion intervention can positively affect diet quality in early childhood, though further research is needed to test this finding in more diverse population groups. These findings from this low-dose trial are important given that small cumulative differences in diets across the lifespan and across the community may ultimately contribute to significant improvements in diet and obesity outcomes in a public health context. This study also suggests that using a dietary outcome tailored to the aims of the intervention is likely to be important and that a diet quality index may be a useful way to do this while retaining a whole diet assessment approach. Future investigation regarding use of dietary patterns to assess health promotion interventions will be valuable to add to this research.

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Literature Cited


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