Original Article

Bottle and sippy cup use is associated with diet and energy intake in toddlers

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Abstract

The second year of life incorporates a continued shift from a liquid- to solid-based diet. Little is known about the prevalence and dietary impact of bottle and sippy cup use. This paper describes associations between percent of energy consumed via drinking containers (bottles and sippy cups combined) and dietary outcomes, between 1 and 2 years of age. This observational study recruited $n = 299$ low-income, nutrition programme clients from the Bronx, NY, whose 12 month olds consumed ≥ 2 non-water bottles per day. The main exposure variable was percent of energy intake via drinking containers (PEDC), dichotomized at the median into low-percent-energy-from-drinking-containers (LOW-C) and high-percent-energy-from-drinking-containers (HIGH-C) groups, assessed quarterly, for 1 year. We report 24-hour dietary recall nutrient and food serving data by LOW-C vs. HIGH-C. We employed linear mixed models to study associations between PEDC and nutrient intake. PEDC decreased from 52% to 33% between 1 and 2 years of age in both groups. The LOW-C group had higher intake of energy, dietary fibre, iron and sodium, grains, protein-rich foods and sweets. Conversely, LOW-C group had lower intake of Vitamin D and calcium vs. the HIGH-C group. PEDC was inversely associated with total energy intake in a model controlling for baseline age, baseline-weight-for-length and gender ($\beta = -5.8$, $P = 0.029$, 95% confidence interval $(-10.96, -0.6)$). Lower bottle and sippy cup use had significant, albeit mixed association with diet quality in the second year of life, and was associated with higher energy intake. Evidence-based guidelines are needed to determine the appropriate use of those feeding methods.

Keywords: bottle, sippy cup, nutrient intake, solids, child-feeding, toddler.

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Introduction

Infant and toddler diets are marked by a shift from a liquid- to solid-based diet (Skinner *et al.* 2004). For non-breastfed children, especially, weaning from the bottle parallels this shift. Although weaning is recommended by 1 year of age (Hagan *et al.* 2008), bottle use remains common among older children (Bonuck *et al.* 2010; Gooze *et al.* 2011); $\approx 20\%$ of 2 year olds still

use bottles (Kaste & Gift 1995; Gooze *et al.* 2011). Prolonged bottle use has been linked to childhood caries (DenBesten & Berkowitz 2003; Tiberia *et al.* 2007; Robke 2008; American Academy of Pediatric Dentistry 2011), iron deficiency anaemia (Bonuck & Kahn 2002; Brotanek *et al.* 2005) and overweight/obesity (Bonuck & Kahn 2002; Bonuck *et al.* 2004, 2010; Gooze *et al.* 2011). In prior analyses of data from our Feeding Young Children Study (FYCS),

a bottle-weaning intervention decreased bottle use and energy intake, but did not affect overweight status. One reason may be that lidded toddler drinking cups [including spill proof (with valves) cups and non-spill proof cups], hereafter 'sippy cups', in part, replaced bottles. Sippy cup consumption was comparable in the intervention and control groups for most of the follow up period. Differences in number of sippy cups and ounce consumed were only found at the 15-month follow-up (2.6 vs. 1.9 cups per day and 12.8 vs. 9.4 oz per day in the intervention and control groups, respectively) (Bonuck *et al.* 2013b).

Compared with bottles, data on sippy cup use is limited and does not incorporate nutritional data or sippy cup type specifications. A Canadian study reported that 86% of 1 to 2 year olds used sippy cups, 47% used bottles and 73% percent used an unlidded cup. The most commonly reported drink in sippy cups was fruit juice (81%) followed by milk (39%). Conversely, milk was the most commonly reported drink in bottles (68%), followed by fruit juice (31%) (Sealy *et al.* 2011). In a study of childhood caries, 69% of 1–6 year olds used a bottle, 22% used sippy cups and 6.5% used both. Fruit juice and sweetened teas were most common in sippy cups. Researchers noted that sippy cups and baby bottles were used in a similar manner and caused similar damage to teeth (Behrendt *et al.* 2001). In our prior analysis of FYCS data, 50% of participants used sippy cups at 12 months of age increasing to 80% at 24 months of age (Bonuck *et al.* 2013b). Thus sippy cup use is common among young children and likely extended beyond its original function as a transitional tool.

Much of the most recent data on infants and children's diet was obtained in the two large FITS

studies (The Feeding Infants and Toddlers Study 2002 and 2008) (Butte *et al.* 2010). FITS studied beverage intake patterns at the food and nutrient level; beverages accounted for 43% of total energy at 12–14 months and 36% of energy at 19–24 month of age (Skinner *et al.* 2004). Based upon feeding guidelines, breast fed 9–11 month olds would need to consume 50% of their energy and 42% of protein from complimentary foods to achieve Dietary Reference Intakes recommended amounts (Butte *et al.* 2004). There are no clear guidelines for the appropriate proportion of solid and liquid food in the diet of 1–2 year olds (toddlers) (Skinner *et al.* 2004).

The extended use of bottles and sippy cups and the lack of guidance from a dietary perspective underscore a gap in knowledge about the role of these containers in the toddler diet. Additionally, we previously found that decreased bottle use between 12 and 24 months paralleled increased sippy cup use in both intervention and control groups of FYCS. Therefore, we conducted an observational study, nested within the FYCS cohort, to explore transitions in nutritional intake during the second year of life with emphasis on energy delivered through drinking containers (i.e. bottles and sippy cups). Our research question was: Is a high (vs. low) percent of energy via these drinking containers (PEDC) associated with differences in toddlers' nutrient intake and food servings?

Materials and methods

Study population

The FYCS was a randomized controlled intervention trial enrolling 11–13 month olds consuming ≥ 2

Key messages

- A continued shift from a liquid- to solids-based diet is typical during the second year of life.
- Little is known about toddlers' bottle and sippy cup use, and associated dietary outcomes.
- Bottle and sippy cup contents, combined, constituted 52% of energy intake at 1 year, and 33% at 2 years, among children drinking ≥ 2 bottles per day at 1 year.
- Lower bottle and sippy cup use had significant, albeit mixed associations with dietary quality, and was associated with higher energy intake.
- Future research should incorporate dietary intake from bottles and sippy cups, given their prominence in young children's diets.

bottles of milk or juice per day from two Bronx, New York Women, Infants, and Children (WIC) Supplemental Feeding Programme sites. Main inclusion criteria were: ability of parent/guardian to report the child's past 24-hour dietary intake and child's attendance for anthropometric measures. Exclusion criteria included: child of a non-singleton birth, birthweight <3 lb, 4 oz, and a condition that interfered with developmentally appropriate feeding or growth. Details of the FYCS are published elsewhere (Bonuck *et al.* 2013a,b).

Study Protocols

After randomization, baseline anthropometric, socio-demographic and dietary intake assessments were obtained by bilingual (English-Spanish) research assistants (RAs). Follow-up diet interviews and anthropometric assessments were synchronized with required quarterly visits to WIC. Since attendance at scheduled times was not always accomplished, anthropometric data were obtained through retrospective chart review and dietary interview was completed over the phone. Obtaining additional anthropometrics and interviews was logistically complicated and not as effective. The study was approved by the Institutional Review Board of Montefiore Medical Center. Participants were compensated.

Dietary intake assessment

Trained RAs interviewed a parent or close relative familiar with the child's diet. One dietary recall was collected at every quarterly visit. Although a second 24-hour recall was obtained within 10 days for a subsample of the population, data presented here are based only on the single 24-hour recall attempted quarterly with all study participants.

Twenty-four hour dietary recall assessment was completed using the Nutrition Data System-Research (NDSR) [the Nutrition Coordination Center at the University of Minnesota], which employs a multiple-pass method described in detail elsewhere (Bonuck *et al.* 2013a,b). Briefly, NDSR is a computer system employing multiple-pass method which includes four

steps of data collection: (1) acquire an outline of intake during the preceding 24-hour period; (2) review to explore gaps in time, missed meals etc.; (3) review to obtain more detailed information such as amounts consumed, drinking vessel used; and (4) final review for verification. To assist with portion size identification, the standard NDSR Food amounts booklet, food models, measuring cups and serving bowls, sample cups and bottles were used. Special attention was given to the collection of data on bottles and cups, aided by sample cups, sippy cups and bottles and/or a pictured food amount booklet, no specification was made as to the type of sippy cup spout used. For every beverage item reported by the caregiver, the RA noted if the child used a bottle, cup, sippy cup or other container, e.g. juice box or other pre-packaged beverage.

Anthropometrics

Baseline weight (kg) and length (cm) were measured at the WIC clinic offices. A digital scale (SR Instruments SR241, Tonawanda, NY, USA) was used to weigh the child once while wearing a clean diaper or underwear. Length was calculated from the average of three measurements on a digital infantometer (Stadiometer 447; Infantronic, QuickMedical, Seattle, WA, USA), up to one-sixteenth of an inch with the error range of ± 0.5 cm. Age and sex standardized z-scores were derived from the World Health Organization (WHO) sex and age standardized growth charts (de Onis *et al.* 2006) using the WHO macro for survey data analysis (WHO Anthro, v.3.2.2 2011, SPSS macro).

Covariate measurement

Demographics were collected using a survey administered by the RAs; questions included the child's age, gender, and ethnicity, parent's level of education, nativity and perception of the child's weight status.

Intervention group

A full description of intervention procedure is provided elsewhere (Bonuck *et al.* 2013b). WIC nutri-

tionists delivered the educational intervention at baseline, guided by a flip chart (Hyden *et al.* 2013), presenting messages about three primary potential effects of prolonged bottle use: overweight, dental caries and iron deficiency. It was recommended that parents gradually replace bottles with cups; however, no transitional cup type was specified. Nutritionists were guided to recommend using a lidded cup filled only halfway if a parent was concerned about spillage. The intervention group also received a lidded, hard-spout (no valve), 6 oz sippy cup at baseline and a brochure summarizing key points of the flip chart.

Control group

The Control group received baseline and follow-up assessments followed by standard WIC nutritional counselling that didn't include the educational material of the intervention.

Nutrient analyses

Dietary intake data were collected using NDSR software version 2008 developed by the Nutrition Coordinating Center (NCC; University of Minnesota, Minneapolis, MN, USA). Final calculations were completed using NDSR version 2012. The NDSR time-related database updates analytic data while maintaining nutrient profiles true to the version used for data collection. NDSR provides a complete nutrient profile for all foods in the database. The NCC Food Group Serving Count System consists of nine groups and 168 subgroups. NDSR assigns serving sizes to each food based on the recommendations made by the *Dietary Guidelines for Americans* or the Food and Drug Administration serving sizes.

Statistical analyses

As an observational study, analyses combine data from the intervention and control groups. The main exposure variable was proportion of energy intake via drinking containers (PEDC), i.e. baby bottles and sippy cups combined, analysed both as a dichotomous and linear measure. Study outcomes

included: total energy, macro- and micronutrients, and beverage and food groups intake. The dichotomized exposure variable, grouped the sample as low (LOW-C) and high consumers (HIGH-C), based upon PEDC below/above the median, at each time point. We compared LOW-C vs. HIGH-C outcomes at Time 0 (baseline, mean age 12.6 months) and follow-ups Time 1 (T1, mean age 15.6 months), Time 2 (T2, mean age 18.7 months), Time 3 (T3, mean age 21.7 months) and Time 4 (T4, mean age 24.8 months) with independent *t*-tests or Mann-Whitney U-test, as appropriate. We described longitudinal changes using one-way analysis of variance. For the linear exposure variable, we employed linear mixed models with random intercept. Linear mixed models are well suited for analysis of longitudinal data, as they incorporate all available data in generating estimates (unlike ordinary least squares models which analyse data only from participants with complete data). Models with total energy intake as the outcome variable were adjusted for age, baseline weight-for-length and gender to account for possible effect modification. Models predicting micronutrient density were adjusted for gender and age. Current measure of weight was not available and we chose not to include baseline weight in those models; adjustment for energy intake was incorporated within the outcome variable itself. Statistical analyses were performed using SPSS Version 20 (IBM SPSS, Chicago, IL, USA) with two-tailed *P*-values of < 0.05 considered statistically significant.

Results

Analytic sample

FYCS enrolled $n = 300$ child/parent dyads. One dyad was excluded from the analysis when deemed ineligible after enrolment. Additionally, $n = 9$ dietary interviews were defined as unreliable by the RAs (e.g. parent was not with the child for much of the previous 24 hours) and thus excluded. At 1-year follow-up (mean = 12.2 months, range 9.8–16.7 months), data were available for $n = 104$ (35%) children, retention rates were 33% in the intervention group (49 of 147)

and 37% in the control group (55 of 148). (Bonuck *et al.* 2013b). A detailed analysis comparing those lost to follow-up and those with 1, 2, 3 or 4 follow-ups did not reveal any differences in child's baseline weight-for-length z-score, baseline energy intake, bottle energy intake and number of bottles. Additionally, no difference was found in any of the child or adult demographic characteristics.

Descriptive data

At baseline, 95% ($n = 282$) of caregivers present for interview were mothers, with the remainder being fathers 2% ($n = 7$) and other relatives/caregivers 2% ($n = 7$), for 1% ($n = 3$) no caregiver was identified.

Table 1 presents baseline demographics for $n = 295$ FYCS participants with baseline dietary data included in this analysis. Mean age at baseline was 12.6 months, 48% of participants were boys and 35% were above the 85th percentile of weight-for-length.

Over 55% of mothers and 48% of fathers were born in the United States and over 62% were of Hispanic ethnicity.

Table 2 presents data on drinking container, energy and solids intake at baseline and follow-ups. Between 12 and 24 months, drinking container use declined from 5.5 to 4 per day, as did ounces consumed via drinking containers (34 oz day⁻¹ to 25 oz day⁻¹). Percentage of energy consumed via bottles decreased from 49% to 12%, while percentage of energy consumed via sippy cups increased from 3% to 20%. In post hoc analyses, all baseline drinking container measures differed from other time points. Additionally, some differences were apparent in T1 and T2 distribution of energy intake from bottle, sippy cup and solids.

Table 3 presents nutrient intake by the LOW-C vs. HIGH-C groups. The LOW-C group had higher total energy intake at baseline, T1 and T2 as well as lower percent fat of total energy at baseline and T1. In the

Table 1. Baseline characteristics of FYCS participants

Baseline characteristics ($n = 295$)		n (%) / Mean $\pm$ SD
Child characteristics	Age, months	12.6 $\pm$ 0.48
	Gender-male	142 (48.1)
	Generally healthy	257 (92)
	Total sleep/24h (hours)	11 $\pm$ 1.75
	Race/Ethnicity	
	Non-Hispanic White/Other	18 (6.1)
	Non-Hispanic Black	49 (16.6)
	Hispanic	184 (62.4)
	Biracial or Multiracial	44 (14.9)
	Child anthropometrics	
Child anthropometrics	Weight, kg	10.1 $\pm$ 1.3
	Weight for length z-score	0.56 $\pm$ 1.2
	Weight for age z-score	0.55 $\pm$ 1.1
	Length for age z-score	0.33 $\pm$ 1.2
	$\geq$ 85th percentile weight-for-length	101 (35)
	$\geq$ 95th percentile weight-for-length	58 (20)
Caregiver characteristics	Adult age	28.3 $\pm$ 7
	Education high school or higher	211 (71.5)
	Mother born in US	164 (55.6)
	Father born in US	141 (48.3)
	No child care	196 (67.8)
	Sibling 0	118 (43)
	1 or more	156 (57)
	Perceived child weight	
	Underweight	16 (5.5)
	Right size	260 (89)
	overweight	16 (5.5)

Table 2. Drinking container, energy and solid intake changes from 12 to 24 months of age

Interview	T0 n = 295	T1 n = 205	T2 n = 167	T3 n = 135	T4 n = 104
Age, months (Mean ± SD)	12.6 ± 0.47	15.6 ± 0.55	18.7 ± 0.89	21.7 ± 0.81	24.8 ± 0.89
Months post T0, (Mean ± SD)	0	2.7 ± 0.6	5.8 ± 0.8	8.8 ± 0.8	11.9 ± 0.8
Mean ± SD, range					
Drinking containers*, n	5.5 ± 1.7, 1–12	4.6 ± 1.6, 0–10	4.4 ± 1.6, 0–9	4.1 ± 1.8, 0–9	4 ± 1.8, 0–8
Drinking containers, oz day ⁻¹	34.9 ± 11.9, 8.6–99.7	28 ± 11.4, 0–64	27.5 ± 11.2, 0–62.7	25.7 ± 12.9, 0–66.4	25.4 ± 12.4, 0–63.5
Total energy, kcal day ⁻¹	1120.2 ± 391, 455.1–2764.1	1093.9 ± 378.8, 275.9–2673.2	1163.4 ± 422.7, 254.7–3245.4	1151.3 ± 416.1, 354.7–2731	1140.4 ± 405.2, 560.4–2738.3
Drinking containers total energy, kcal day ⁻¹	563.8 ± 218.3, 148.8–1799.5	427.1 ± 200, 0–1168.3	406.3 ± 186.3, 0–983.1	385.9 ± 223, 0–1293	353.4 ± 201.6, 0–1046.6
% energy from drinking containers	52.5 ± 17.3, 12.2–100	40.5 ± 17.2, 0–97.6	37.4 ± 16.7, 0–96.9	34.8 ± 17.8, 0–94.7	32.6 ± 18.7, 0–95.6
% energy from bottles	49.1 ± 18, 0–100	27.3 ± 21.9, 0–83.8	20.9 ± 20.2, 0–96.9	15.4 ± 20.5, 0–94.7	12.3 ± 20.7, 0–95.6
% energy from sippy cups	3.4 ± 5, 0–25.1	13.2 ± 16.2, 0–73	16.5 ± 16.4, 0–65.4	19.3 ± 17.7, 0–67.5	20.2 ± 16.4, 0–64.2
Solids [†] total energy	556.4 ± 335.6, 0–1922.6	666.8 ± 341.6, 12.9–2140	757.1 ± 415, 8.1–2677	765.3 ± 387.4, 51.6–2648.2	787 ± 377.4, 32–2057.6
Solids [†] % energy	47.5 ± 17.35, 0–87.8	59.5 ± 17.2, 2.42–100	62.6 ± 16.7, 3.1–100	65.2 ± 17.8, 5.3–100	67.4 ± 18.7, 4.4–100

*Bottles and sippy cups.

[†]Assuming primarily solids were consumed outside the drinking containers (bottles and sippys).

Table 3. Nutrient intake in LOW-C vs. HIGH-C (below/above median percent of energy from drinking containers) at 12–24 months of age

Interview (age)	T0 (12.6 months)			T1 (15.6 months)			T2 (18.7 months)			T3 (21.7 months)			T4 (24.8 months)		
Median of % energy via drinking containers*	LOW-C n = 148	HIGH-C n = 147		LOW-C n = 103	HIGH-C n = 102		LOW-C n = 83	HIGH-C n = 84		LOW-C n = 67	HIGH-C n = 68		LOW-C n = 52	HIGH-C n = 52	
Mean (SD)															
Total grams	1531.9 (478.3)	1479.2 (386.7)		1327.6 (466.2)	1401.5 (376.6)		1381.8 (434.2)	1366.7 (411.1)		1308.2 (422.8)	1372.7 (416.9)		1327.5 (363.5)	1349.9 (400.7)	
Total energy (kcal day ⁻¹)	1220.9 ^a (433.3)	1018.9 (313.5)		1154.7 ^a (421.9)	1032.5 (320.2)		1301.8 ^a (458.6)	1026.7 (334)		1215.9 (468)	1087.6 (349.5)		1213.8 (429.2)	1067 (369.3)	
Total Fat (g day ⁻¹)	43.7 ^a (19.6)	39 (15)		40.1 (19.8)	37.1 (13.4)		47.2 ^a (21.9)	35.9 (14.5)		45.8 ^a (23.9)	38.8 (14.7)		42.2 (20.6)	36.7 (16)	
% of total energy	31.9 ^a (6.9)	34.2 (6.6)		30.5 ^a (7.1)	32.4 (6.3)		32.3 (7.6)	31.2 (6.7)		32.8 (7.3)	32.1 (7)		30.7 (6.5)	30.6 (7.2)	
Trans Fat (g day ⁻¹)	1.7 ^a (1.5)	1.1 (0.84)		1.6 (1.2)	1.5 (1)		1.9 ^a (1.5)	1.5 (1.1)		2 (1.6)	1.6 (1)		1.7 (1.5)	1.5 (1)	
% of total energy	1.24 (0.9)	0.99 (0.7)		1.22 (0.8)	1.25 (0.6)		1.3 (0.8)	1.2 (0.6)		1.4 (0.9)	1.3 (0.7)		1.2 (0.97)	1.2 (0.74)	
SFA (g day ⁻¹)	18.6 (8.3)	17.9 (7)		16 (7.6)	17.3 (6.2)		18.6 (9.3)	16.3 (6.6)		18.4 (10.1)	16.8 (6)		16.4 (8)	16 (7.8)	
% SFA of total energy	13.7 ^a (3.6)	15.9 (3.9)		12.3 ^a (3.5)	15.2 (3.7)		12.8 ^a (4.2)	14.4 (3.9)		13.3 (3.8)	14.2 (3.5)		12 (3.5)	13.4 (4.7)	
PUFA (g day ⁻¹)	7.2 ^a (4.1)	5.6 (3.4)		7.2 ^a (5.2)	4.9 (2.6)		8.8 ^a (5.9)	4.9 (2.8)		7.6 ^a (5.6)	5.7 (3.1)		7.6 ^a (5)	5.5 (3.3)	
% of total energy	5.2 (2)	4.8 (2.1)		5.4 ^a (2.2)	4.2 (1.5)		5.9 ^a (2.7)	4.2 (1.6)		5.3 (2.7)	4.7 (2.2)		5.5 ^a (2.4)	4.6 (1.9)	
MUFA (g day ⁻¹)	14.3 ^a (7.4)	12.4 (5.5)		12.9 ^a (6.9)	11.1 (4.6)		15.4 ^a (7.7)	11 (5.1)		15.5 ^a (9.2)	12.5 (5.8)		14.4 ^a (7.6)	11.7 (5.1)	
% of total energy	10.3 (3.1)	10.9 (2.9)		9.9 (3.1)	9.7 (2.5)		10.5 ^a (3)	9.5 (2.5)		11.1 (3.3)	10.2 (3)		10.4 (2.9)	9.7 (2.6)	
Total carbohydrate (g day ⁻¹)	165 ^a (63.4)	133.4 (45.5)		157.4 ^a (58.6)	136.9 (49.8)		173 ^a (62)	138.3 (51.7)		157.9 (61.6)	146.3 (56.2)		162.5 (55.9)	147 (55.3)	
% of total energy	54.1 (8.1)	52.4 (7.6)		55 (9.6)	52.8 (8.2)		53.5 (9.9)	53.9 (8.7)		52.7 (9.8)	53.8 (9.1)		54 (7.2)	55.4 (9.3)	
Total sugars (g day ⁻¹)	88 (37.9)	90.2 (31.1)		79.2 (32.6)	85.3 (30.5)		85.6 (34)	82.3 (31.8)		82 (37)	88.9 (40.2)		84.6 (33.1)	88.7 (34.1)	
% of energy	28.9 ^a (7.1)	35.8 (7.6)		28 ^a (7.4)	33.3 (6.9)		26.8 ^a (7.6)	32.4 (7.4)		27.6 ^a (8.6)	32.6 (9)		27.9 ^a (6.3)	33.7 (7.5)	
Added sugars (g day ⁻¹)	25.6 (25.2)	27.6 (28.7)		26.1 (23.6)	21.9 (23.5)		33.9 ^a (28.2)	21.9 (26.6)		35.7 (32.1)	30.7 (28.4)		34.1 (24.8)	32.6 (24.7)	
% of total energy	7.9 ^a (6.6)	10.4 (9.2)		8.9 (6.9)	7.9 (7.4)		10.4 (8.1)	8.1 (8.1)		11.3 (8.9)	10.7 (8.9)		10.7 (6)	12.6 (9.5)	
Dietary fibres (g day ⁻¹)	9.3 ^a (5.3)	6.1 (3.6)		8.5 ^a (4.5)	6.9 (3.6)		8.7 ^a (5)	7.1 (4.1)		8.4 (4.3)	7 (4)		8.3 ^a (4.3)	6.6 (4.2)	
Dietary fibres (g per 1000 kcal)	7.8 ^a (4.1)	6 (2.9)		7.5 ^a (3.3)	6.7 (3.1)		6.7 (3.3)	6.9 (3.4)		7.1 (3)	6.5 (3.2)		7.3 ^a (3.6)	6.2 (3.6)	
Total protein (g day ⁻¹)	44.3 ^a (16.5)	35.4 (13.1)		43.6 (17.7)	40.4 (13.9)		49.2 ^a (23.1)	40.2 (13.8)		46.1 (18.7)	41.2 (15)		48.7 ^a (18.3)	39.7 (15.7)	
% of total energy	14.8 (3.2)	14.1 (4.1)		15.3 (4.2)	15.8 (3.1)		15.2 (4.2)	15.8 (3.2)		15.5 (4.4)	15.1 (3.1)		16.2 (4)	14.9 (3.4)	
Vitamin D (mcg day ⁻¹)	9.5 ^a (3.6)	11.9 (9.1)		6.8 ^a (3.8)	9.8 (3.4)		7.1 ^a (3.8)	9.1 (3.4)		6.5 ^a (3.7)	8.5 (3.4)		6.2 ^a (3.2)	7.8 (3.9)	
Vitamin D (mcg per 1000 kcal)	8 ^a (2.6)	11.8 (7)		5.9 ^a (2.9)	9.8 (2.9)		5.6 ^a (2.6)	9.2 (3.1)		5.4 ^a (2.7)	8.2 (3.1)		5.2 ^a (2.4)	7.6 (3.4)	
Calcium (mg day ⁻¹)	1046.1 (406.8)	1051.9 (396.2)		832.2 ^a (371.5)	1031.4 (334.3)		859.9 (401.5)	970.6 (335.5)		802.1 ^a (397)	949.2 (403.7)		805.4 (324.5)	901.7 (404.4)	
Calcium (mg per 1000 kcal)	885.8 ^a (279.2)	1060.4 (371.5)		728.5 ^a (266.3)	1025.1 (256.3)		672.1 ^a (244.2)	970.6 (279.4)		679.9 ^a (300.4)	889.5 (275.5)		679.3 ^a (232.7)	855.9 (294.9)	
Sodium (mg day ⁻¹)	1396 ^a (834.3)	885.9 (462.9)		1639.5 ^a (876.5)	1208.5 (591.6)		1951.8 ^a (874.1)	1279.3 (598.1)		1778.2 ^a (869.9)	1356 (582.9)		1866.4 ^a (845.9)	1417.3 (653.7)	
Sodium (mg per 1000 kcal)	1126.5 ^a (457.5)	858.5 (356.8)		1424 ^a (563.9)	1150.7 (373.1)		1501.4 ^a (431.6)	1248 (420.7)		1479.1 ^a (494.3)	1242.7 (408.2)		1538.4 (445.2)	1341.6 (575.9)	
Iron (mg day ⁻¹)	13.3 (9.6)	13.2 (14.6)		10.3 ^a (7)	6.8 (4.8)		9.7 ^a (5.9)	7.7 (4.7)		9 (4.4)	7.5 (5.3)		8.9 ^a (5.2)	6.6 (3.5)	
Iron (mg per 1000 kcal)	11 (7.4)	12.6 (11.4)		9.2 ^a (5.6)	6.5 (4.5)		7.6 (4)	7.6 (4.8)		7.6 (3.6)	7 (4.7)		7.8 (5.4)	6.3 (3.2)	

MUFA, monounsaturated fatty acids; PUFA, polyunsaturated fatty acids; SFA, saturated fatty acids *Median of % energy from drinking containers: at T0 = 51.7%, T1 = 39.8%, T2 = 36.6%, T3 = 34.5% and T4 = 30.1%.

^aP-value < 0.05.

LOW-C group, total sugars percentage of energy was lower at all time points and dietary fibres intake was higher at baseline, T1, T2 and T4. In the LOW-C group, vitamin D density (mcg per 1000 kcal) and calcium density (mg per 1000 kcal) were lower at all time points; sodium and iron absolute intake were higher at all time points and at T1, T2 and T4, respectively.

Table 4 depicts beverage servings in LOW-C vs. HIGH-C. Total milk intake was similar at baseline (LOW-C 2.4 servings per day, HIGH-C 2.3 servings per day) and about one serving lower in the LOW-C group thereafter. A similar pattern was observed for whole milk intake.

Table 5 presents food servings of selected food groups. Minor differences were observed for fruit and vegetable intake. In the grain foods group, LOW-C ate more servings of bread at T1 and T2 and about double (two servings vs. 1.2 servings) the amount of pasta/rice and other cooked grains at T0, T1, T2 and T4. A similar pattern was observed for meat and fish intake and for dairy products (higher at T0, T1 and T2). LOW-C had higher intake of solid fats and sugars (at T0 and T1) and cakes, cookies and other desserts (at T0, T1, T2 and T3).

Table 6 depicts a comparison of intake of selected nutrients to the *Dietary Guidelines for Americans* (USDA & HHS 2010) in LOW-C and HIGH-C. While energy intake exceeded recommendations in both groups, the LOW-C group had larger deviations (122–136% vs. 103–115%). Dietary fibre and vitamin D intakes were lower than recommended in both groups with the LOW-C group having smaller and larger deviations for dietary fibre and vitamin D, respectively throughout follow-ups. Sodium intake of the LOW-C exceeded the upper limit at T1 to T4.

Linear mixed models (Table 7)

In a model controlling for baseline age, baseline-weight-for-length and gender, total PEDC was associated with reduced total energy intake [$\beta = -5.8$, P -value = 0.029, 95% CI (-10.96, -0.6)]; every additional 10% of energy consumed through drinking containers would result in a reduction of total energy

Table 4. Beverage intake in LOW-C vs. HIGH-C (below/above median percent of energy from drinking containers) at 12–24 months of age

Interview (age)	T0 (12.6 months)		T1 (15.6 months)		T2 (18.7 months)		T3 (21.7 months)		T4 (24.8 months)	
	LOW-C <i>n</i> = 148	HIGH-C <i>n</i> = 147	LOW-C <i>n</i> = 103	HIGH-C <i>n</i> = 102	LOW-C <i>n</i> = 83	HIGH-C <i>n</i> = 84	LOW-C <i>n</i> = 67	HIGH-C <i>n</i> = 68	LOW-C <i>n</i> = 52	HIGH-C <i>n</i> = 52
Servings mean (SD)										
Milk (8 oz)										
All types [†]	2.4 (1.6)	2.3 (2)	2 ^a (1.4)	3.1 (1.1)	1.9 ^a (1.1)	2.7 (1.2)	1.8 ^a (1.2)	2.6 (1.5)	1.6 ^a (1.1)	2.4 (1.5)
Whole milk unflavoured	2 (1.6)	2 (1.9)	1.8 ^a (1.4)	2.7 (1.2)	1.7 ^a (1)	2.4 (1.3)	1.5 ^a (1.1)	2.1 (1.3)	1 ^a (1)	1.9 (1.5)
Reduced /non-fat milk unflavoured	0.3 ^a (0.9)	0.25 (0.9)	0.07 (0.3)	0.23 (0.9)	0.1 (0.5)	0.2 (0.9)	0.13 (0.5)	0.2 (0.6)	0.4 (0.7)	0.3 (0.8)
Flavoured milk all types	0.09 (0.3)	0.05 (0.2)	0.09 (0.3)	0.2 (0.5)	0.08 (0.2)	0.1 (0.3)	0.16 (0.4)	0.28 (0.8)	0.2 (0.5)	0.26 (0.6)
Baby formula (5 oz)	1.1 ^a (2.3)	2.4 (3.4)	0.15 (0.55)	0.07 (0.4)	0.13 (0.5)	0.12 (0.5)	0.03 (0.1)	0.17 (0.7)	0.08 (0.4)	0.2 (0.6)
100% Fruit juice (4 oz)	1.1 (1.3)	0.9 (1.2)	1.2 (1.1)	1.2 (1.2)	1.2 (1.3)	1.3 (1.3)	0.8 ^a (1)	1.5 (1.7)	1.4 (1.4)	1.7 (1.9)
All soft drinks [‡] (8 oz)	0.15 (0.4)	0.1 (0.3)	0.29 (0.6)	0.2 (0.4)	0.4 ^a (0.7)	0.2 (0.5)	0.5 (0.8)	0.4 (0.7)	0.4 (0.7)	0.4 (0.7)
Sweetened soft drinks	0.001 (0.01)	0	0.01 (0.08)	0.02 (0.08)	0.02 (0.1)	0.02 (0.1)	0.03 (0.1)	0.06 (0.3)	0.05 (0.2)	0
Sweetened Tea	0.01 (0.2)	0.007 (0.06)	0.02 (0.1)	0.03 (0.1)	0.04 (0.2)	0.006 (0.05)	0.02 (0.1)	0.01 (0.07)	0.04 (0.2)	0.1 (0.4)
Sweetened fruit drinks	0.13 (0.3)	0.1 (0.3)	0.26 (0.6)	0.12 (0.3)	0.3 (0.5)	0.2 (0.5)	0.4 (0.7)	0.3 (0.6)	0.3 (0.6)	0.3 (0.6)

^aMedian of % energy from drinking containers: at T0 = 51.7%, T1 = 39.8%, T2 = 36.6%, T3 = 34.5% and T4 = 30.1%.

[†]Includes whole, reduced and non-fat, flavoured and unflavoured and non-diary.

[‡]Includes sweetened, artificially sweetened and unsweetened sodas, fruit flavoured, tea and sweetened water.

^aMann-Whitney P -value < 0.05.

Table 5. Food intake in LOW-C vs. HIGH-C (below/above median percent of energy from drinking containers) at 12–24 months of age

Interview (age)	T0 (12.6 months)		T1 (15.6 months)		T2 (18.7 months)		T3 (21.7 months)		T4 (24.8 months)	
	LOW-C <i>n</i> = 148	HIGH-C <i>n</i> = 147	LOW-C <i>n</i> = 103	HIGH-C <i>n</i> = 102	LOW-C <i>n</i> = 83	HIGH-C <i>n</i> = 84	LOW-C <i>n</i> = 67	HIGH-C <i>n</i> = 68	LOW-C <i>n</i> = 52	HIGH-C <i>n</i> = 52
Median of % energy via drinking containers*										
Servings mean (SD)										
Vegetables										
Non-starchy [†]	0.65 (1)	0.42 (0.5)	0.6 (0.7)	0.5 (0.6)	0.56 (0.7)	0.4 (0.5)	0.7 ^a (0.8)	0.3 (0.5)	0.55 (0.7)	0.4 (0.5)
Starchy [‡]	0.5 ^a (0.8)	0.2 (0.4)	0.4 (0.7)	0.4 (0.6)	0.4 (0.6)	0.3 (0.6)	0.3 (0.5)	0.3 (0.6)	0.3 (0.5)	0.2 (0.3)
Fruit										
Any type	0.85 (1.4)	0.66 (0.9)	0.7 (0.9)	0.7 (0.8)	0.75 (1)	0.64 (0.7)	0.72 (0.9)	0.68 (1.2)	0.7 (1.1)	0.4 (0.5)
Grain foods [§]										
Bread, rolls	0.37 (1)	0.21 (0.4)	0.7 ^a (1.1)	0.3 (0.7)	0.8 ^a (1.2)	0.4 (0.6)	0.8 (1.2)	0.6 (0.8)	0.9 (0.9)	0.7 (0.9)
Pasta, rice, oats	2.1 ^a (1.7)	1.2 (1.2)	2.1 ^a (1.6)	1.2 (0.9)	2 ^a (1.7)	1.2 (1)	1.5 (1.2)	1.2 (1)	1.8 ^a (1.5)	1.1 (1)
Baby food grain mixtures	0.03 (0.2)	0.003 (0.04)	0.01 (0.1)	0	0.008 (0.07)	0	0	0	0	0
Cereals ready to eat	0.1 (0.2)	0.1 (0.2)	0.24 (0.5)	0.12 (0.2)	0.3 (0.4)	0.2 (0.3)	0.33 (0.4)	0.22 (0.3)	0.3 (0.4)	0.2 (0.3)
Crackers all types	0.11 (0.3)	0.05 (0.2)	0.09 (0.2)	0.08 (0.2)	0.1 (0.3)	0.1 (0.3)	0.08 (0.2)	0.09 (0.2)	0.18 (0.4)	0.12 (0.2)
Protein source foods										
Meat, fish	1.1 ^a (1.5)	0.4 (0.6)	1.8 ^a (1.7)	0.8 (1.1)	2.2 ^a (2)	1 (1.1)	2.3 ^a (2)	1.5 (1.6)	2.4 ^a (1.8)	1.3 (1.2)
Baby food meat mixtures	0.22 (0.6)	0.23 (0.6)	0.08 (0.3)	0.07 (0.3)	0.011 (0.1)	0.12 (0.4)	0.04 (0.3)	0.05 (0.3)	0	0.02 (0.1)
Eggs and eggs substitute	0.16 (0.38)	0.13 (0.3)	0.2 (0.4)	0.17 (0.3)	0.24 (0.4)	0.15 (0.33)	0.25 (0.4)	0.18 (0.4)	0.36 ^a (0.5)	0.13 (0.3)
Nuts and nut butters	0.04 (0.2)	0.01 (0.08)	0.01 (0.1)	0.02 (0.2)	0.02 (0.2)	0.02 (0.2)	0.04 (0.2)	0.007 (0.06)	0.06 (0.3)	0.03 (0.1)
Legumes [‡]	0.21 (0.4)	0.11 (0.3)	0.18 (0.3)	0.14 (0.2)	0.15 (0.4)	0.16 (0.3)	0.21 (0.5)	0.12 (0.3)	0.14 (0.5)	0.16 (0.3)
Dairy all ^{§§}	0.23 ^a (0.43)	0.09 (0.2)	0.24 ^a (0.3)	0.17 (0.3)	0.37 ^a (0.6)	0.16 (0.3)	0.35 (0.5)	0.2 (0.3)	0.36 (0.4)	0.25 (0.4)
Yogurt all types	0.07 (0.2)	0.05 (0.1)	0.09 (0.2)	0.07 (0.2)	0.09 (0.2)	0.03 (0.1)	0.11 (0.3)	0.07 (0.2)	0.09 (0.2)	0.05 (0.1)
Cheese all types	0.16 ^a (0.4)	0.05 (0.1)	0.15 (0.24)	0.09 (0.2)	0.28 ^a (0.5)	0.13 (0.2)	0.24 (0.4)	0.14 (0.3)	0.27 (0.4)	0.2 (0.4)
Solid fats ^{††}	0.72 ^a (0.9)	0.3 (0.5)	0.7 ^a (0.8)	0.5 (0.9)	0.7 (0.9)	0.45 (0.6)	0.8 (1.4)	0.4 (0.5)	0.7 (1.1)	0.4 (0.7)
Sweets										
Dairy dessert	0.02 (0.1)	0.01 (0.1)	0.03 (1.2)	0.02 (0.08)	0.11 ^a (0.3)	0.02 (0.09)	0.05 (0.2)	0.04 (0.2)	0.14 ^a (0.4)	0.03 (0.1)
Baby food dessert	0.1 (0.4)	0.06 (0.3)	0.08 (0.3)	0.03 (0.2)	0.04 (0.2)	0.04 (0.2)	0.01 (0.1)	0	0	0
Sugar/ Jam/candies/syrups	0.23 ^a (0.8)	0.04 (0.1)	0.5 ^a (1.4)	0.1 (0.5)	0.2 (0.8)	0.4 (2.3)	0.3 (1)	0.4 (1.8)	0.4 (0.9)	0.3 (1.3)
Cakes/cookies, snack bars, miscellaneous desserts	0.38 ^a (0.65)	0.22 (0.5)	0.38 ^a (0.6)	0.24 (0.6)	0.55 ^a (1.2)	0.46 (1.6)	0.5 ^a (0.8)	0.15 (0.3)	0.33 (0.7)	0.37 (0.9)
Salty snacks	0.08 ^a (0.3)	0.006 (0.03)	0.08 (0.3)	0.04 (0.2)	0.3 ^a (0.8)	0.03 (0.2)	0.2 (0.5)	0.06 (0.2)	0.15 (0.4)	0.06 (0.2)

*Median of % energy from bottles and sippys: at baseline = 51.7%, T1 = 39.8%, T2 = 36.6%, T3 = 34.5% and T4 = 30.1%.

[†]Dark green, yellow, tomatoes etc.[‡]Potatoes, corn, cassava etc. [§]Whole and refined grain combined, ^{§§}cooked dried beans.^{††}cheese and yogurt combined.^{‡‡}Butter, margarine, shortening etc.^aMann-Whitney *P*-value < 0.05.

Table 6. Comparison of selected nutrient intake with the Dietary Guidelines for Americans 2010 (age 1–3 years) in LOW-C and HIGH-C (below/above median percent of energy from drinking containers) at 12–24 months of age

Median of energy via drinking containers*	Dietary Guidelines for Americans	T0 (12.6 months)		T1 (15.6 months)		T2 (18.7 months)		T3 (21.7 months)		T4 (24.8 months)	
		LOW-C	HIGH-C	LOW-C	HIGH-C	LOW-C	HIGH-C	LOW-C	HIGH-C	LOW-C	HIGH-C
		n = 148	n = 147	n = 103	n = 102	n = 83	n = 84	n = 67	n = 68	n = 52	n = 52
% of Recommendations / ✓ within limits x –outside of limits											
Total energy	900–1000 kcal day ^{-1†}	136	113	128	115	130	103	122	109	122	107
Fat % of energy	30–40%	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Carbohydrates % of energy	45–65%	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Protein % of energy	5–20%	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Dietary fibres	14 g day ⁻¹	66	44	61	49	62	51	60	50	59	47
Vitamin D	15 mcg day ⁻¹	63	79	45	65	47	61	43	57	41	50
Calcium	700 mg day ⁻¹	149	150	119	147	123	139	115	136	115	129
Sodium	UL 1500 mg day ⁻¹	✓	✓	X	✓	X	✓	X	✓	X	✓
Iron	7 mg day ⁻¹	190	188	147	97	138	110	129	107	127	94

*Median of % energy from drinking containers: at T0 = 51.7%, T1 = 39.8%, T2 = 36.6%, T3 = 34.5% and T4 = 30.1%.
[†]900 kcal day⁻¹ for 1 year olds, 1000 kcal day⁻¹ for 2 year olds.

intake by 58 kcal day⁻¹ (≈5% reduction of total daily energy). When testing absolute container energy intake in a similar model, it was associated with increased total energy ($\beta = 0.97$, P -value < 0.001, 95% CI: 0.57, 1.37); every additional 100 kcal consumed through drinking containers were associated with an addition of 97 kcal day⁻¹ in total energy intake.

When testing bottle percentage energy and sippy cup percentage energy separately, no significant association was found [$\beta = -4.25$, $P = 0.067$, 95% CI (–8.8, 0.3) for bottles and $\beta = -2.2$, $P = 0.6$ 95% CI: –10.3, 5.9, for sippy cups]. A significant interaction between gender and age was found in all four models predicting total energy, indicating girls' gains in overall consumption increased at a faster rate over time than boys' ($\beta = 18.7$, $\beta = 11.9$, $\beta = 20$, $\beta = 18.2$, $P < 0.01$ for all).

We also tested the association between PEDC and nutrient density (standardized intake per 1000 kcal) of vitamin D, calcium, sodium and iron. In models controlling for age and gender, PEDC was positively associated with vitamin D and iron intake per 1000 kcal ($\beta = 0.16$, $\beta = 0.2$, respectively) and inversely associated with sodium intake per 1000 kcal ($\beta = -19.8$), P -value ≤ 0.001 for all. For every 10% increase in percent of energy consumed via drinking containers, iron intake would increase 2 mg per 1000 kcal and vitamin D would increase 1.6 mcg per 1000 kcal, sodium intake would decrease 198 mg per 1000 kcal. We did not identify a significant association with calcium intake.

Discussion

This is the first study to analyse longitudinal associations between proportional intake of energy from bottles and sippy cups (PEDC), and toddlers' dietary and energy intake. This observational study was nested within a randomized trial of a bottle-weaning intervention among 1 year olds consuming ≥ 2 bottles per day at baseline. In these trial data, the intervention was associated with reduced bottle use, but not with our weight outcome, ≥85% weight-for-length. In both groups, reduced bottle use was paralleled by increased use of sippy cups (Bonuck *et al.* 2013b). Therefore, we set out to explore their

Table 7. Linear mixed models for energy intake (kcal day⁻¹), vitamin D, calcium, sodium and iron density (mg per 1000 kcal)

Model description				
Outcome variable	Variables in the model	Effect size estimate	95% CI	P-value
Energy intake (kcal day ⁻¹)	Containers % of energy	-5.8	-10.96-(-0.6)	0.029
	age, months	-12.4	-26.8-1.96	0.09
	Baseline weight-for-length	22.4	-40.6-85.5	0.5
	gender (boy = 0, girl = 1)	-398.1	-667.3-(-128.8)	0.004
	Age*gender	18.7	6.8-30.7	0.002
	Containers total energy (kcal)	0.97	0.57-1.37	<0.001
	age, months	14.8	2.05-27.5	0.023
	Baseline weight-for-length	-46.3	-103.4-10.9	0.112
	gender (boy = 0, girl = 1)	-144.1	-381.6-93.4	0.23
	Age*gender	11.9	0.85-22.9	0.035
	Bottle percent of energy	-4.25	-8.8-0.3	0.067
	age, months	-16.4	-28.7-(-4.2)	0.009
	Baseline weight-for-length	-18.9	-138.4-100.5	0.76
	gender (boy = 0, girl = 1)	-397.6	-681.1-(-114.2)	0.006
	Age*gender	20	6.1-33.9	0.005
Vitamin D mcg per 1000 kcal	Sippy cup percent of energy	-2.2	-10.3-5.9	0.6
	age, months	0.96	-9.5-11.4	0.86
	Baseline weight-for-length	-41.4	-129.4-46.5	0.35
	gender (boy = 0, girl = 1)	-334.1	-530.8-(-137.4)	0.001
	Age*gender	18.2	5.4-30.9	0.005
Calcium mg per 1000 kcal	Containers % of energy	0.16	0.09-0.22	<0.001
	age, months	-0.02	-0.15-0.11	0.78
	gender (boy = 0, girl = 1)	-0.2	-1.4-0.96	0.74
Sodium mg per 1000 kcal	Containers % of energy	4.02	-0.68-8.73	0.094
	age, months	-12.24	-21.8-(-2.7)	0.012
	gender (boy = 0, girl = 1)	-51.1	-146.5-44.2	0.29
Iron mg per 1000 kcal	Containers % of energy	-19.8	-27.4-(-12.2)	<0.001
	age, months	-4.6	-20.1-10.9	0.56
	gender (boy = 0, girl = 1)	-25.1	-176.9-126.7	0.75
	container % energy * age, months	0.64	0.3-1	<0.001
	Containers % of energy	0.2	0.08-0.32	0.001
	age, months	0.03	-0.21-0.27	0.82
	gender (boy = 0, girl = 1)	-0.54	-2.8-1.8	0.64
	container % energy * age, months	-0.01	-0.02-(-0.005)	<0.001

*Covariance type autoregressive 1 for all models.

combined association with dietary measures. In the observational data (i.e. ignoring randomization) reported here, PEDC between 1 and 2 years of age had mixed associations with dietary quality. For example, low PEDC was associated with both favourable (e.g. less total sugars; more fibre and iron) and unfavourable (more solid fats, sodium, and sweets) dietary outcomes. Regarding energy intake, every 10% increase from drinking containers (i.e. higher PEDC) was associated with ≈5% decrease in total daily energy intake.

Comparable studies of drinking containers and dietary intake are scant; observations on sippy cup use typically do not describe its association with dietary outcomes (Behrendt *et al.* 2001; Sealy *et al.* 2011). Here, PEDC decreased from 52% at 12 months of age to 33% at 24 months, this finding is slightly higher at 12 months but similar to the beverage proportion of energy in FITS at 24 months (43% at 12–14 months and 36% at 19–24 months) (Skinner *et al.* 2004). In NHANES (National Health and Nutrition Examination Survey) 2001–2006, beverages

(milk, 100% fruit juice, fruit drink and soft drinks) contributed 663 kcal day⁻¹ (43% of total energy) to the diet of children from birth to 5 years old (Fulgoni & Quann 2012). Our relatively high PEDC at 12 months is likely due to the sample being selected for high (≥ 2 day⁻¹) bottle use.

Children consuming a lower daily PEDC had higher total energy intake until approximately 18 months of age, despite comparable total weight (grams) of food consumed. In linear mixed models, there was an inverse association between PEDC and total energy. Our sample's daily energy intake (ranging from 1094 kcal day⁻¹ to 1163 kcal day⁻¹) was comparable with the mean energy intake of 1140 kcal day⁻¹ in FITS toddlers (12 to 23 months old) in 2008 (Butte *et al.* 2010). In FITS, as in our FYCS, intakes of energy and most nutrients increased with age and with percent of energy from table foods. Yet, FITS toddlers (19–24 months old) with the lowest intake of table foods consumed more grams of food and about the same calories as those with the highest intake of table foods (Briefel *et al.* 2004). Absolute energy consumed in drinking containers was associated with increased total energy in adjusted models. In NHANES 1999–2002, children 2 to 5 years old who drank more milk, 100% fruit juice, fruit drinks and soda had increased total energy intake (O'Connor *et al.* 2006). In NHANES 2003–2006, higher orange juice consumption was associated with higher daily energy intake in children 4–18 years of age (Wang *et al.* 2012).

Our data suggest association of drinking container use with diet quality. As expected, the LOW-C group consumed less vitamin D and calcium in association with lower milk intake from 15 months onwards as well as higher intakes of bread, meat, dairy products, solid fats, sweets and sweet baked goods. The lower intakes of calcium, vitamin D and saturated fatty acids correspond to findings from FITS where milk was the leading source of those nutrients in toddlers 12 to 24 months of age. The LOW-C group's higher intakes of dietary fibres, iron and sodium are comparable with the FITS findings where the leading sources of those nutrients were solid foods (Fox *et al.* 2006).

Strengths of our study include the use of a detailed multiple-pass dietary intake interview that incorporated a measure of drinking container type. To our

knowledge, former studies failed to combine data on drinking container use and dietary intake. Additionally, because of the relatively short gaps between interviews, our study adds to the limited body of knowledge on the dietary transitions during the second year of life. Nevertheless, FYCS was not designed as a representative sample and our findings reflect dietary intakes and feeding practices of low-income, predominantly Hispanic urban families. Moreover, children were recruited only if their (non-water) bottle intake was higher than recommended. Some limitations in data collection warrant consideration; the use of a single 24-hour dietary recall and possible inconsistency in the caregiver interviewed throughout follow-ups may have incorporated error into our dietary intake estimation. Another limitation to consider is our low retention rate. Our study follow-up relied upon WIC scheduled visits which were frequently changed and thus resulted in missed interviews; additional efforts to obtain data were not as effective, however, we could not detect any differences between those lost to follow-up and those retained. Some potential bias may have affected our results since sippy cups were given to intervention group participants; yet, in all but the first follow-up sippy cup use was comparable in the intervention and control groups (Bonuck *et al.* 2013b).

Our finding of an inverse association between PEDC and total energy challenges a premise of the parent trial, i.e. that calories consumed as liquids are not as well regulated and could lead to excess intake of energy. A recent review did not support the premise that liquid calories are processed differently than calories from solids (Slavin 2012), while an earlier review cited conflicting data (Almiron-Roig *et al.* 2003), neither analysed data for children. The difference in energy intake together with the similar amounts of food consumed suggests that the HIGH-C group's diet was characterized by lower energy density (amount of energy per unit of food weight, typically kcal per gram) (Rolls 2009). Studies in children (2 to 6 years old) found consistency in the weight of food consumed despite varying energy density both in a single meal (Leahy *et al.* 2008a,b) and when tested over the course of a day (Leahy *et al.* 2008c), thus resulting in a decrease in total energy intake

when energy density was reduced (Rolls 2009). FITS found that toddlers consuming less table foods compensated by eating larger amounts to maintain a similar caloric intake (Briefel *et al.* 2004).

One possible mechanism to explain this finding may be the ability of food volume to alter a young child's feeling of hunger and satiety. In older infants' excessive intake of fruit juice, insufficient or diluted formula and difficulties transitioning to solid foods are among the causes for failure to thrive (Cole & Lanham 2011). A case-control study in children with failure to thrive found cases consumed a slightly lower total energy and more cases were using bottles than controls (Wright *et al.* 2000). We suggest that this may appear within the spectrum of normal weight and normal energy intake as well.

Conclusions

Our findings shed new light on the extensive use of both sippy cups and bottles during the second year of life and suggest the need for nationally representative data on drinking container practices, and their associations with diet and health consequences. Drinking in container during the second year of life is clearly associated with food and nutrient intake. In our sample, the influence on diet quality was mixed with those consuming less energy via drinking container also having higher intakes of iron and dietary fibres together with lower calcium, vitamin D and higher sodium intake.

Future research with more ample data should facilitate clear guidelines as to what can be considered as appropriate vs. excessive or prolonged use and should include the type of beverage to be consumed in drinking containers (bottles and the various sippy cups types) as well as the type of complimentary foods to be presented.

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Conflict of interest

The authors declare that they have no conflicts of interest.

Contributions

KB and CH conceptualized and designed the study. SBA prepared and analyzed the data and wrote the paper. JF advised on data analysis. KB, CH, JF and SBA were involved in data interpretation and critical revision of manuscript. All authors read and approved the final manuscript.

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