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ABSTRACT

Background: U.S. preschool children consume inadequate amounts of key nutrients. Understanding the contents of lunches packed by parents and consumed by their children can help identify areas of opportunity for the development of healthy food preferences.

Objective: To evaluate the nutrient adequacy of lunches packed by parents and consumed by children attending early care and education (ECE) centers.

Methods: Baseline data from 607 parent–child dyads in the "Lunch Is in the Bag" cluster-randomized controlled trial in Central Texas were examined. Foods packed by parents and consumed by children in sack lunches were observed at 30 ECE centers on 2 nonconsecutive days. Mean levels of energy, macronutrients, vitamins, and minerals were estimated with covariate-adjusted multilevel regression models that accounted for center-level clustering and repeated within-child measures.

Results: Energy (kilocalories) was 602.48 for packed lunches compared to 374.40 for consumed lunches. In packed lunches, percentage of energy as macronutrients for protein (14.8%), carbohydrate (55.9%), and total fat (31.2%) were within the acceptable macronutrient distribution range (AMDR) for the children's ages. Sugar (28.9% of energy) was above the AMDR recommendation. Only a quarter of parents packed 33% or more of the child's dietary reference intake (DRI) for dietary fiber. Over half the parents packed 33% or more of the DRI for vitamin A and calcium, and less than one in 8 packed 33% of the DRI for potassium. Children consistently consumed between 60 and 80% of the nutrients that were packed.

Conclusions: Preschool children rely on parents to present them with healthy food choices, but lunches packed by parents for their preschool children do not consistently provide adequate nutrients. These data and the relationships between the dietary quality of packed and consumed lunches can be useful information to guide nutrition behavior change through targeted interventions.

Abbreviations: ECE, early care and education; AND, Academy of Nutrition and Dietetics; DRI, dietary reference intake; USDA, U.S. Department of Agriculture; DGA, Dietary Guidelines for Americans; LIITB, Lunch Is in the Bag; BMI, body mass index; FIAS, Food Intake and Analysis System; CSFII, Continuing Survey of Food Intakes by Individuals; AMDR, acceptable macronutrient distributions ranges; IOM, Institute of Medicine

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Introduction

The typical U.S. child's diet has a preponderance of foods and beverages that are energy dense but nutrient poor and promote both obesity and undernutrition. U.S. preschool children's diets have been shown to lack vitamins A, D, E, folate, and calcium [1] and to provide excessive amounts of zinc [1], solid fats, and added sugars [2,3]. Both the Academy of Nutrition and Dietetics and the Dietary Guidelines for Americans 2015 (DGA) have stated that calcium, dietary fiber, potassium, and vitamin D are nutrients of public health concern [4,5]. Efforts to increase the dietary quality of children's diets should focus both on preventing obesity and providing sufficient amounts of essential nutrients.

Current estimates suggest that as many as 12 million U.S. children (61%) under the age of 6 are in care outside the home [6–11]. Preschool children spend an average of 33 hours per week in early care and education (ECE) centers [12] where they consume 2 or more meals and snacks per day and consequently receive 50–67% of their daily energy recommendations [6,11,12]. Therefore, the ECE center is a major contributor of nutrition for many 3- to 5-year-old children and is an ideal setting to both study and promote healthy eating habits and food preferences [12].

Licensed ECE centers must comply with state level regulations regarding the foods offered to assure that children receive adequate nutrients for growth and development [13]. For example, the Child and Adult Care Food Program (CACFP) offers guidelines on how often and how much each food group should be offered to children. The latest revision of CACFP meal patterns (that are yet to be implemented) requires a

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greater variety of vegetables and fruits, increased amounts of whole grains, and decreased amounts of added sugars and saturated fats in the meals served. CACFP meal patterns are based on the DGAs [14].

In a substantial proportion of ECE centers, parents are responsible for sending food from home, and there are no specific federal or state guidelines to follow. Legislative changes in Texas allowed for ECE centers to close their kitchens in 2003, and some ECE centers relinquished the responsibility of providing healthy meals to the children in their care, leaving the responsibility of packing healthy lunches to the parents of these children [15,16]. Given the high prevalence of childhood obesity and low-quality diets, there is a need to evaluate the quality of preschool-aged children's diets [17,18]. It is not clear whether parents are aware of the nutrient recommendations that are appropriate for their preschool children. For example, Bruening and colleagues found that the mean daily intakes of vitamin A ($p < 0.01$), riboflavin ($p < 0.01$), and calcium ($p < 0.001$) were higher in a group of children receiving CACFP ($n = 20$) compared to those who brought their lunch from home ($n = 20$) [19].

Parents are exposed to the obesogenic food environment described in the DGAs 2010 [20]. Parents of preschool children may encounter an overwhelming array of less healthy foods at the grocery store, pressure from older kids to purchase products that they might not otherwise buy for their preschooler, and convenience might drive parent's packing behaviors as well as the availability of refrigeration and or microwaves at the ECE center. Researchers have studied the barriers and motives for parents to choose the type of foods offered to children (6–12 years). Nepper and Chai found that convenience of prepackaged foods that tend to be less healthy, perceptions of higher cost of healthy foods, preference for the taste of energy-dense foods, presence of picky eaters in the family, and lack of support from partners were the most frequent barriers that parents perceived for feeding healthy foods to their child [21]. Conversely, Roos and colleagues established the relationships between parental choice motives (e.g., health and natural content, sensory appeal) and children's consumption of healthy foods [22]. More research is needed to establish the barriers and motives that parents of younger children have for offering healthy foods.

In a 2006 study, Sweitzer et al. using data from 74 preschoolers' packed sack lunches, found that parents were not including sufficient energy, carbohydrate, vitamin A, calcium, iron, and zinc and that the lunches had more than the recommended amount of sodium; however, no consumption data were observed in that study [23]. The Lunch Is in the Bag (LIITB) efficacy trial conducted at 30 ECE centers in Texas (2010–2014) utilized a detailed observation methodology that provides an opportunity to evaluate the dietary quality of foods packed by parents for their preschool children as sack lunches, as well as of foods consumed by children [24–26].

The aim of this study was to evaluate the nutrient adequacy of lunches packed by parents of preschool children attending ECE centers, as well as the nutrient adequacy of the packed food consumed by the children. Nutrient adequacy was evaluated against the dietary reference intakes (DRIs); the recommended dietary allowances (RDAs), adequate intakes (AI), and acceptable macronutrient distribution ranges (AMDRs) were used as appropriate for each nutrient [27].

Methods

Subjects

Baseline data from the LIITB cluster randomized trial were used for this study. Additional details on the LIITB trial have been previously published [24–26]. A total of 1396 ECE centers that were licensed by the Texas Department of Family and Protective Services were contacted via telephone survey. Eligible ECE centers ($n = 104$) that cared for a minimum of 15 preschool-aged children and required parents to provide food from home were invited to participate in the study. Of the 104 invited ECE centers, 87% indicated interest in participating, but only 28% followed through with a letter of intent, resulting in a sample of 30 ECE centers. Parent–child dyads ($n = 607$) included (1) the parent primarily responsible for packing the food for lunch and (2) the 3- to 5-year-old child who regularly ate lunch at a participating ECE center. Parents received a gift card as incentive for returning self-reported surveys with demographic data, but no incentive was provided for letting our staff observe their child's lunch. All ECE centers included in this study were in Central and Southeast Texas and all measurements and procedures were approved by the Institutional Review Boards at the University of Texas–Austin and the University of Texas Health Science Center Houston.

Observation methodology and training

The observation methodology has been developed and validated by Sweitzer et al. [24] and is briefly described below. Observers were trained to recognize foods commonly found in preschoolers' lunches and to first visually estimate portion sizes of 41 foods [24] and then check their visual estimates as follows: Standard portions of individual ingredients (e.g., tablespoons, cups, ounces, or fluid ounces) were measured out and assembled into mixed dishes commonly found in preschoolers' sack lunches (e.g., 1 cup of cereal or 1 peanut butter and jelly sandwich with different amounts of fillings). This measured amount was then compared with their visually estimated portion size [23,24]. At the end of training, researchers measured and assembled 10 test lunches, including 5 lunch items each, to test the accuracy of their visual estimations. Across observers and for each of the 10 lunches tested, no statistical differences were found between the amounts measured by the researchers and the mean portion sizes visually estimated by the observers. The authors concluded that the visual estimation measurement method has high validity (intraclass correlation = 0.951–1.0; 95% confidence interval, 0.91–0.97) and reliability (intraclass correlation = 0.979; 95% confidence interval, 0.957–0.993) [24]. More details on the observation methodology and training can be found elsewhere [24]. Other research has shown the validity and reliability of visual techniques compared to weighted methods to measure school lunches or hospital meals [28–30].

Measures and data collection

Trained staff measured height and weight of participating children the week prior to the baseline period of lunch box observations, using standardized methods and equipment [31]. Body mass index (BMI) was calculated as height (m)/weight^2 (kg). The parent of each dyad completed a self-reported survey for demographic data. Types and amounts of foods and beverages in lunches packed by parents ($n = 607$; lunchbox observations) and consumed by their preschool child (child lunch observations) were recorded in the field on 2 nonconsecutive weekdays by trained observers using validated methodology. Lunchbox observation records included a detailed, nominal description of foods and beverages found inside each sack lunch. First, the amounts of food observed in lunchboxes were documented in standard measuring units (e.g., cups, pieces, or ounces). Trained observers recorded individual food items and individual ingredients of "mixed dishes" and documented the estimated amounts for each ingredient and for the total dish in standard serving sizes. For example, a dish with rice, chicken, and vegetables could be recorded as 1 cup total, $^1/_2$ cup rice, $^1/_4$ cup chicken, 2 tablespoons carrots, 2 tablespoons peas; or 1 cup total, 50% rice, 25% chicken, 12.5% carrots, 12.5% peas. Quality control checks were completed for 10% of all lunchbox observation records in the field, including food records. After the lunchbox observation, during lunch time, observers used visual cues to determine and record the amount of each item consumed by the child. The amount consumed was reported in the same units as the amount packed. Observers were trained to annotate in the food records if any food was spilled, dropped, shared, or taken away. Observers in the field could log the content of multiple lunchboxes, but each observer would log consumption of 6 children at the most.

Data management

Trained staff reviewed each lunch observation record to be coded and entered into the Food Intake and Analysis System (FIAS, Millenium, University of Texas–Houston School of Public Health). FIAS utilizes the Food and Nutrient Databases published by the U.S. Department of Agriculture to provide standardized energy and nutrient content of foods entered [32], as well as conversion to weight units (e.g., grams), when amounts of foods are entered. For example, a trained observer could have recorded cheese in ounces, cups, slices, or pieces. FIAS provides options to enter "Cheese, natural, Cheddar or American type" in (a) cups (diced, melted, grated), (b) cubic inch, (c) slice, (d) stick, (e) ounce, (f) specific measurements in inches, etc. Consequently 1 slice of cheese = 1 ounce or 28.35 g.

A registered dietitian reviewed the data for all lunchbox observations and child lunch observations at baseline to ensure that types and amounts of foods were accurately coded before data entry. After data were entered into FIAS, a registered dietitian reviewed the resulting database to certify that all food items were entered into FIAS with appropriate coding standards.

Data analysis

Data were analyzed using SAS software (Version 9.4, SAS Institute, Inc., Cary, NC). Descriptive and central tendency statistics were computed to determine demographic characteristics of the sample. A random-effects regression model with random intercepts at the ECE center level and repeated effects at the child level was used to analyze the nutrient data for the packed lunches and for the food consumed by the children and controlled for child age, sex, and BMI. This modeling strategy was required to account for potential clustering of outcomes at the center level and nonindependence of observations within children [33]. To calculate the energy distribution of each meal, the energy (kilocalories) provided by protein (4 kcal/g), carbohydrate (4 kcal/g), sugar (4 kcal/g), total fat (9 kcal/g), and saturated fat (9 kcal/g) was computed. AMDRs were used to evaluate the amount of energy provided by macronutrients [27]. Regressed means for nutrients from lunchbox observations and child lunch observations were estimated and compared to DRIs; the RDAs, AIs, and AMDRs were used as appropriate for each nutrient [27]. Preschool-aged children in this study fell into 2 different age categories of DRI, 1- to 3-year-old and 4- to 8-year-old children. Two separate models were designed to determine (a) differences between amounts packed and consumed and (b) differences between age groups. In addition, all models were adjusted for child age, sex, and BMI. Percentage of meal consumed was calculated as follows: $\%\ \text{Consumed} = 100 - \left[\frac{(\text{Packed} - \text{Consumed})}{\text{Packed}}\right] * 100$. Children in part-time programs should receive foods and beverages that provide at least one third of the daily nutrient recommendations. To determine nutrient adequacy of lunches in this study, the cutoff point established by the benchmarks for nutrition in child care [34] was utilized; that is, the lunch of a preschool child should contain 33% of the DRIs for each nutrient. Accordingly, absolute nutrient values were used and data were not adjusted for energy (kilocalories).

Results

Baseline lunchbox observation data were collected for 607 parent–child dyads at 30 ECE centers in central Texas. Demographic data for the sample are reported in Table 1. Participating children had a mean age of 3.5 years with sex equally represented (52–48%). Over 22% of the children measured were overweight or obese. Parents had a mean age of 36.5 years and over 37% were overweight or obese. The family members who were primarily responsible for packing the child's lunch were mostly female. More than half of the sample had an annual family income greater than $100,000 and over 80% of the sample had at least an associate or bachelor's degree. Additional demographic and sample descriptive data for the LIITB study are available in previous publications [25]. Due to the nature of the study, this sample was skewed toward higher income and higher education than the Texas population. ECE centers that cater toward lower income populations usually received governmental assistance to provide food for the children in their care and were not eligible for this study

Lunchbox observations were analyzed with FIAS to determine the nutrient content of 1196 parent packed lunches from 607 preschoolers. Table 2 includes regressed means of energy, macronutrients, and micronutrients, both packed and consumed. The average meal packed by parents had 6.5 food items and an estimated weight of 504.7 g. Lunches packed had a mean of 602.48 kcals, about 66% of which were consumed by the children (Fig. 1). Children consistently consumed between 61 and 79% of the nutrients packed, for each of the macronutrients and micronutrients.

Mean energy of packed lunches (Table 3) was distributed as 55% carbohydrate, 15% protein, and 31% total fat. These

Table 1. Parent and child demographics[a] from the lunch Is in the bag trial (2011–2013).

Child		n	%
Age (mean, SD)		3.51	(0.69)
Calculated BMI percentile (mean, SD)		56.79	(29.99)
Child BMI categories			
	Underweight[b]	32	(5.54)
	Healthy weight[c]	416	(71.97)
	Overweight[d]	75	(12.98)
	Obese[e]	55	(9.52)
Race			
	Caucasian	367	(66.01)
	Hispanic	105	(18.88)
	Other	84	(15.11)
Gender			
	Boy	315	(52.33)
Parent		n	%
Age (mean, SD)		36.51	(5.42)
Calculated BMI (mean, SD)		24.76	(5.07)
Parent BMI categories			
	Underweight[f]	15	(2.75)
	Healthy weight[g]	327	(60.00)
	Overweight[h]	127	(23.30)
	Obese[i]	76	(13.94)
Gender			
	Female	499	(89.75)
Race			
	Caucasian	396	(71.74)
	Hispanic	98	(17.75)
	Other	58	(10.51)
Annual family income			
	Less than $59,999	92	(17.43)
	$60,000–$79,999	52	(9.85)
	$80,000–$99,999	83	(15.72)
	Greater than $100,000	301	(57.01)
Highest level of education			
	Some college or less	96	(13.30)
	Associate or bachelor's degree	274	(49.37)
	Master's or doctorate degree	185	(33.33)
Marital status			
	With partner	503	(91.12)

BMI = body mass index.
[a]Numbers for different outcome measures may vary due to missing values.
[b]<5th BMI percentile.
[c]≥5th to <85th BMI percentile.
[d]≥85th to <95th BMI percentile.
[e]≥95th BMI percentile.
[g]BMI 18.5–24.9.
[h]BMI 25–29.9.
[i]BMI ≥ 30.

Table 2. Nutrient composition of lunches from lunch is in the bag trial that were packed by parents and consumed by their preschool child ($n = 607$)[a].

	Packed		Consumed		% Consumed[b]	
	Mean	SE	Mean	SE	Mean	SE
Total grams of food[c]	504.67 ±	9.45	302.87 ±	9.45	64 ±	4.90
Energy (kcal)[c]	602.48 ±	11.70	374.40 ±	11.70	66 ±	4.93
Macronutrients						
Protein (g)[c]	21.87 ±	0.54	14.26 ±	0.54	69 ±	5.30
Carbohydrate (g)[c]	83.55 ±	1.78	51.07 ±	1.78	66 ±	4.92
Dietary fiber (g)[c]	5.59 ±	0.15	3.33 ±	0.15	61 ±	5.52
Sugar (g)[c]	43.25 ±	1.21	26.96 ±	1.21	66 ±	5.41
Total fat (g)[c]	21.36 ±	0.51	13.30 ±	0.51	64 ±	5.76
Saturated fat (g)[c]	7.55 ±	0.19	4.68 ±	0.19	67 ±	5.89
Monounsaturated fat (g)[c]	7.82 ±	0.20	4.87 ±	0.20	63 ±	5.92
Polyunsaturated fat (g)[c]	4.11 ±	0.12	2.56 ±	0.12	62 ±	5.96
Cholesterol (mg)[c]	48.34 ±	2.23	31.00 ±	2.23	79 ±	5.98
Vitamins						
Vitamin A (mcg RAE)[c]	187.03 ±	7.52	104.96 ±	7.52	68 ±	6.35
Vitamin C (mg)[c]	50.14 ±	2.15	30.81 ±	2.15	67 ±	5.21
Thiamin (mg)[c]	0.45 ±	0.01	0.27 ±	0.01	67 ±	5.33
Riboflavin (mg)[c]	0.56 ±	0.01	0.34 ±	0.01	71 ±	5.14
Niacin (mg)[c]	5.76 ±	0.16	3.67 ±	0.16	62 ±	5.65
Minerals						
Calcium (mg)[c]	338.05 ±	9.34	215.19 ±	9.34	71 ±	5.43
Iron (mg)[c]	3.57 ±	0.10	2.14 ±	0.10	66 ±	5.38
Zinc (mg)[c]	2.94 ±	0.08	1.89 ±	0.08	68 ±	5.31
Sodium (mg)[c]	989.40 ±	30.04	628.66 ±	30.04	69 ±	5.54
Potassium (mg)[c]	715.14 ±	14.50	445.36 ±	14.50	62 ±	4.93

RAE = Retinol activity equivalents.
[a]Regressed mean and standard error adjusted to control for cluster effect at the school and child levels as well as child age, gender, and body mass index.
[b]%Consumed = {[(Amount consumed − Amount Packed)/Amount Packed] * 100}.
[c]Consumed significantly different from packed at the <0.001 level.

AMDR values were within those recommended by the Institute of Medicine for young children [35]. Percentage of energy from total sugar (29%) exceeded the recommended <25%, and energy contributed by saturated fat (11%) exceeded the recommended 10%. Mean energy of meals consumed was distributed as 56% carbohydrates, 15% protein, and 30% total fat, which were also within age-appropriate AMDRs. Percentage of energy consumed from sugar (30%) exceeded the recommended level of 25%, and energy consumed from saturated fat (11%) was slightly over the recommendation. Although percentage of energy from protein and sugar was significantly higher ($p < 0.05$) and percentage of total fat was significantly lower ($p < .05$) for meals consumed compared to meals packed, most of these differences were small.

Table 4 indicates the DRIs for 3-year-olds and 4- to 5-year-olds, respectively. The mean percentages of each DRI for lunches that were packed and consumed are illustrated in Figs. 2 and 3. According to the U.S. Department of Agriculture in the Early Childhood and Child Care Study, the lunch of a preschool child should contain 33% of the DRI for each nutrient [34,36]. The amount of energy packed exceeded the recommendation for both groups, but the amount consumed was under the cutoff point. The amount of dietary fiber and potassium packed and consumed in both 3-year-old and 4- to 5-year-old lunches fell short of the dietary recommendation. Iron and calcium packed were adequate (i.e., at least 33% of the recommendation). Preschoolers ate less than the recommended amounts of iron and calcium. The amount of sodium packed per meal was nearly 3 times (85–98% of DRI) the recommended amount for both 3-year-olds and 4- to 5-year-olds. The amount of sodium consumed was also high, at over half of the day's recommendations (56.6% for 3-year-olds and 57.9% for 4- to 5-year-olds). For all nutrients, the percentage of DRI packed was significantly different from the percentage of DRI consumed; the percentage of DRI packed for and consumed by 3-year-olds was also significantly different ($p < 0.05$) from the percentage of DRI packed for and consumed by 4- to 5-year-olds. A significant ($p < 0.05$) interaction between packed/consumed and age group was found for all nutrients, indicating that the difference between percentage of DRI packed and consumed varies depending on age group.

Discussion

The purpose of this study was to determine the nutrient composition and evaluate the dietary quality of preschoolers' packed lunches using age-appropriate DRIs. Overall, the macronutrient distribution of lunches packed and consumed was

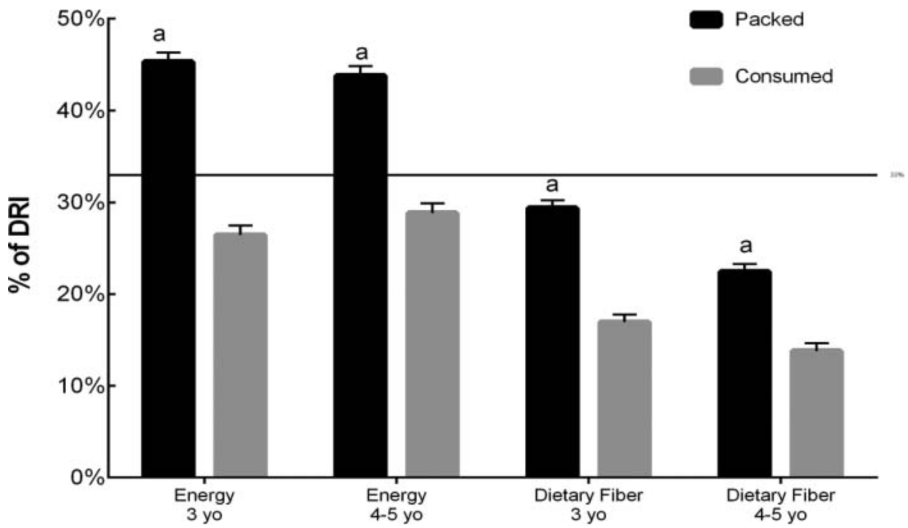

Figure 1. Percentage of age-appropriate DRI (expressed in Estimated Energy Requirement (EER) for energy and AI for dietary fiber) content of lunches from in the Lunch Is in the Bag trial that were packed by parents and consumed by their preschool children ($n = 607$). Regressed mean and SE adjusted to control for cluster effect at the school and child level. Energy expressed in EER. [a]Packed consumed/age interaction significant at the $p < 0.001$ level.

broadly in line with the AMDRs. However, levels of energy, fiber, and several key minerals and micronutrients did not meet standards established by the DRI guidelines. The average lunch packed by parents of both 3-year-olds and 4- to 5-year-olds did not provide sufficient dietary fiber and potassium to meet the recommendations. Sodium (>33%), sugar (>25%), and saturated fat (>10%) all exceeded the recommended amounts for 3-year-old and 4- to 5-year-old preschoolers. As a consequence, the amount of food consumed by 3-year-olds and 4- to 5-year-olds provided less than the recommended (<33% DRI) amounts of energy, dietary fiber, calcium, potassium, and iron; in addition, excessive amounts of sodium (>33% DRI), sugar (>25% energy), and saturated fat (>10% energy) were consumed. The excessive amounts of sodium, sugar, and saturated fat suggest that there is a need for comprehensive environmental interventions to help parents who pack lunches offer adequate foods to their preschool children [5,20].

Furthermore, preschoolers only consumed 64% of the grams of food packed; consequently, preschoolers consumed between 60 and 70% of the nutrients available (Table 2). Some of the highest consumption percentages included protein (69%) and cholesterol (79%), suggesting that children might be choosing to consume a higher amount of animal protein foods compared to other foods offered at lunch. Preschoolers consumed, on average, more kilocalories (0.5% increase) from protein compared to the proportion of kilocalories of protein packed, as shown in Table 3. The lowest consumption percentages included dietary fiber (61%) and potassium (62%), which were also below 33% for amount packed. There is a need to address the factors that influence the food choices of parents of preschool children; for example, the marketing of highly palatable and convenient products targeted at parents of preschool-aged children [21,22]. Caretakers and nutrition educators can help parents find healthy alternatives for lunch. Research from Robson and colleagues suggests that preschool children attending ECE centers are not receiving adequate diets at home [37]. Consequently, improving what children receive at the ECE centers can be an effective way of improving their overall diets.

Energy distribution of each meal (Table 3) represents the kilocalories provided by protein, carbohydrates, and total fat. The typical lunch that parents packed for their preschool child had a correct proportion of energy derived from protein, carbohydrate, and fat as measured by the AMDR [27]. The energy distribution of the meals consumed showed that preschoolers consumed more of their energy from protein ($p < 0.001$) and sugar ($p < 0.001$). Therefore, children appear to readily consume protein and high-sugar foods (both naturally occurring and added sugar) offered at lunch. The increase in relative

Table 3. AMDR for macronutrients of lunches from lunch is in the bag trial that were packed by parents and consumed by their preschool child ($n = 607$)[a].

	Packed			Consumed			AMDR[b]	
	Mean		SE	Mean		SE	3-Year-Olds	4- to 5-Year-Olds
	Macronutrients as % of Energy							
Protein[c]	14.8	±	0.28	15.3	±	0.28	5–20	10–30
Carbohydrate	55.9	±	0.79	56.2	±	0.79	45–65	
Sugar[c]	28.9	±	0.85	30.4	±	0.85	<25	
Total fat[c]	31.2	±	0.55	30.4	±	0.55	30–40	25–35
Saturated fat	10.94	±	0.23	10.6	±	0.23	<10[d]	

AMDR = acceptable macronutrient distribution range.
[a]Regressed mean and standard error adjusted to control for cluster effect at the school and child levels as well as child age, sex, and body mass index.
[b]Institute of Medicine [35].
[c]Consumed significantly different from packed at the <0.001 level.
[d]Established by the Dietary Guidelines for Americans 2015 [5].

Table 4. Age-appropriate dietary reference intakes expressed in recommended dietary allowances and adequate intakes.

	3-Year-Olds ($n = 316$)		4- to 5-Year-Olds ($n = 296$)	
Energy[a]	1300	kcal/d	1400–1500	kcal/d
Dietary fiber[b]	19	g/d	25	g/d
Vitamins:				
Vitamin A[b]	300	mcg/d	400	μg/d
Vitamin C[b]	15	mg/d	25	mg/d
Thiamin[b]	0.5	mg/d	0.6	mg/d
Riboflavin[b]	0.5	mg/d	0.6	mg/d
Niacin[b]	6	mg/d	8	mg/d
Minerals:				
Calcium[b]	700	mg/d	1000	mg/d
Iron[b]	7	mg/d	10	mg/d
Zinc[b]	3	mg/d	5	mg/d
Sodium[c]	1000	mg/d	3800	mg/d
Potassium[c]	3000	mg/d	1200	mg/d

[a]Estimated energy requirement.
[b]Recommended dietary allowance.
[c]Adequate intake.

energy coming from sugar consumed represents another area of opportunity to educate parents, because they are packing and children are consuming more than the recommended amounts of sugar [27].

The DRI recommendations differ by age group and preschoolers fall under 2 different age categories. Parents do not seem to be aware that there is a significant increase in the dietary needs of 4- to 5-year-olds compared to 3-year-old children. The percentage of DRI packed for nutrients is consistently and significantly lower in the 4- to 5-year-old group (Figures 1–3). Calcium recommendations, for example, increase from 700 mg/day for 3-year-olds to 1000 mg/day for 4- to 5-year-olds. The difference in DRI can be translated into 1 cup of 1% cow's milk, which contains 305 mg of calcium [38]. More information about the appropriate serving sizes to meet the nutrient needs of children and how to increase them relative to age should be emphasized so that parents can offer enough food to meet the dietary guidelines for their children as they grow older. The interaction between packed/consumed and age groups in terms of percentage of DRI indicates that children are consuming higher percentages of food packed as they get older.

Parents from the LIITB study packed lunches that were inadequate (<33% DRI) in dietary fiber, calcium, and potassium with excess (>33% DRI) amounts of sodium. Knowing that children consume approximately 65% of the grams of food packed at lunch, it can be assumed that packed lunches that seem to contain enough nutrients might not translate into an adequate consumption. For example, with calcium, parents of 3-year-olds are packing 49% of the DRI for calcium but children are consuming only 30%; parents of 4- to 5-year-olds are packing 33% of the DRI for calcium and children are consuming 22%. If parents do not recognize the increased nutrient needs of their 4-year-old child and continue to pack the same serving size that they used when the child was 3, then the older child will not meet his or her need even if he or she consumed 100% of what was packed.

The aim of this study was to find specific nutrients of concern in this sample of packed lunches that could be used for future interventions. For example, the results from this study can be used to find specific foods and beverages that could be encouraged or discouraged for preschoolers' lunches. The most common main entrees found in this sample (defined as major distinct protein source) included foods high in sodium, sugar, and saturated fat. Additionally, not many of these foods are sources of dietary fiber, calcium, potassium, and iron. Main entrees included peanut butter and jelly sandwiches (20.5%), ham and cheese sandwiches (16.7%), nuggets or breaded chicken (7.9%), cheese and/or yogurt (7.9%), pasta with meat or hot dog (7.5%), deli meats with or without cheese (7.3%), pizza or tacos (5.5%), prepackaged lunch combinations (5.4%), hot dog with or without buns (4.7%), macaroni and cheese (3.2%), and eggs and beans (1.6%). Additionally, 4.7% of

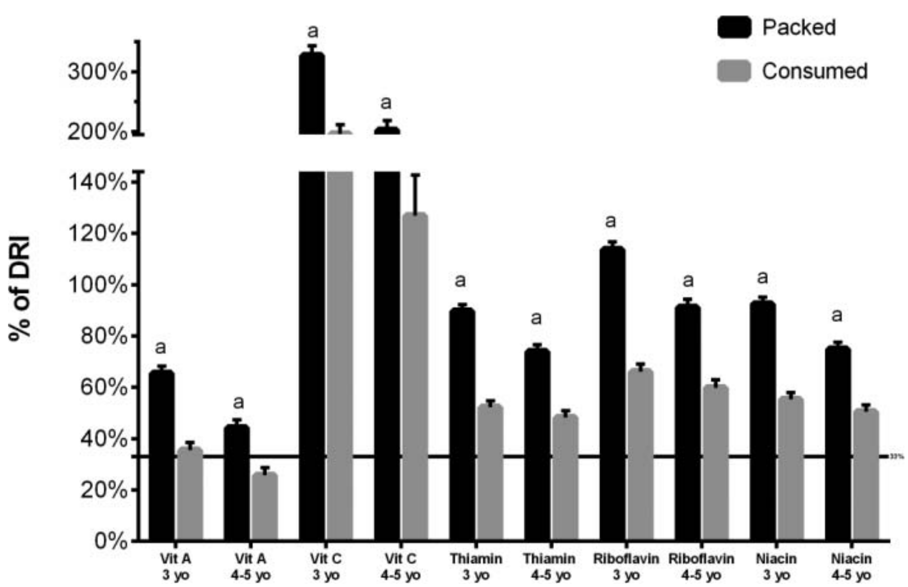

Figure 2. Percentage of age-appropriate vitamin DRI (expressed in RDA for vitamins A and C, thiamin, riboflavin, and niacin) content of lunches from the Lunch Is in the Bag trial that were packed by parents and consumed by their preschool children ($n = 607$). Regressed mean and SE adjusted to control for cluster effect at the school and child levels. [a]Packed consumed/age interaction significant at the $p < 0.001$ level.

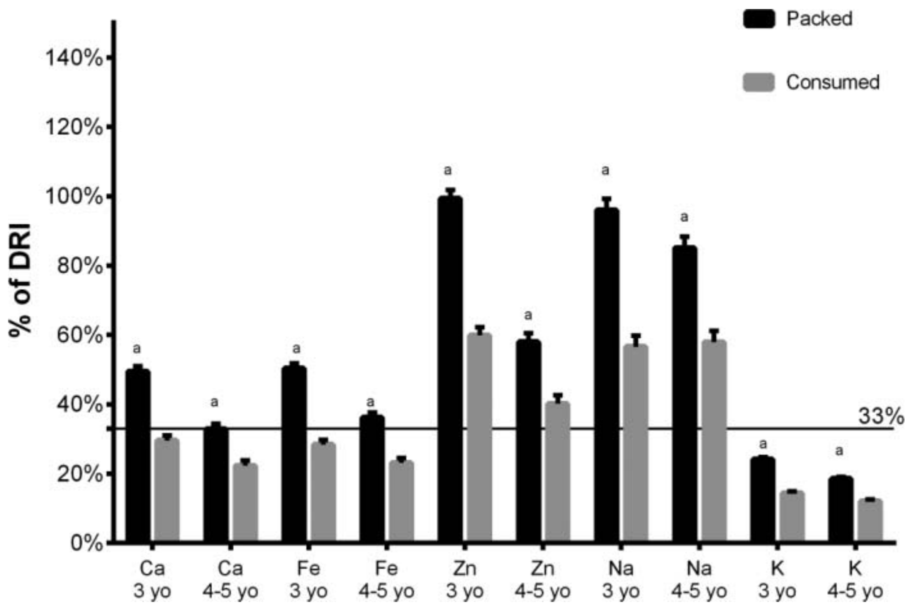

Figure 3. Percentage of age-appropriate mineral DRI (expressed in RDA for calcium and iron and AI for sodium and potassium) content of lunches from the Lunch Is in the Bag trial that were packed by parents and consumed by their preschool children ($n = 607$). Regressed mean and SE adjusted to control for cluster effect at the school and child level. Energy expressed in EER. [a]Packed consumed/age interaction significant at the $p < 0.001$ level.

lunches did not include a distinct protein source and 7.1% of lunches included more than 1 distinct protein source. The most common beverage found was sugar-sweetened beverages (25%), followed by 100% fruit juice (14%), milk (14%), and flavored milk (4%). Some lunches included more than 1 beverage (5%) or did not have a beverage at all (38%) [26]. Healthy Eating Index–2010 scores reveal that 49.2% of lunches did not include any vegetables but 93.3% packed at least some fruit, 52.2% had some whole grains, 82.2% included at least some dairy, and 86.5% included at least some protein. More information on the content found in this sample of lunches has been published previously [24,25]. Combining the knowledge of specific nutrient shortages in preschoolers' lunches with the foods and beverages typically packed can provide insight into potential intervention efforts or policy advocacy.

Understanding the difference between foods offered and foods consumed can be beneficial when analyzing nutrients that are usually consumed in excess. The amount of sodium that parents packed is well over the recommendations; parents of 3-year-olds packed 96% of the DRI for sodium, therefore supplying almost an entire day's worth of the nutrient in one meal. Parents of 4- to 5-year-olds packed 85% of the DRI for sodium. If parents are taught to maintain the serving size of foods that are high in sodium, saturated fat, and sugar as their child gets older, then older children might receive lunches that do not exceed the recommendations. Children in both age categories consumed 60% of the DRI for sodium for lunch, which is almost double the recommended 33%.

This study has some limitations. The nature of the study resulted in a highly educated sample with high income; nevertheless, the dietary quality of lunches is subpar. A limitation of using DRIs for children to evaluate diets is the fact that they have been extrapolated from adult nutrient needs; however, comparing nutrient intakes to the DRIs provides useful information about the nutrients of concern in children's diets. Time and data collection burden did not allow for differentiation of food items that were packed with the intention of being offered as snacks or as part of lunch. Because lunch guidelines varied, we had some teachers who offered all of the foods packed to the child, and others would present only certain items to the children. Therefore, we could not measure accurately which items were intended for snack by the parents. Strengths for this study include the use of an observation methodology with high validity and reliability to provide detailed observations of food packed by parents and consumed by preschool children. Data collectors went through extensive training and quality controls were conducted to ensure consistency and accuracy of data. Furthermore, sample size allowed for complex regression models that controlled for ECE center and repeated measure variances as well as controlling for child age, sex, and BMI.

Conclusions

Lunches packed by parents of preschool children do not meet the dietary recommendations for dietary fiber and potassium and exceed the recommended amounts of sodium, sugar, and saturated fat. Parents need to understand the impact of each food item they choose to put in or leave out of their child's lunchbox: the nutrient density of the lunchbox is directly reflected in what their child will consume. These findings corroborate the areas of concern identified by the DGA [5]. These data and the relationships that exist between amounts parents pack and what children consume can be useful information to guide nutrition behavior change, through either individual or environmental interventions.

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Author contributions

M.J.R.-P., N.R., S.J.S., C.R.-G., C.E.B.-W., M.E.B., and D.M.H. designed the research. M.J.R-P. and S.J.S. conducted the research. M.J.R.-P. and N.R. analyzed the data or performed statistical analysis. M.J.R.-P. and N.R. wrote the article. M.J.R.-P. had primary responsibility for the final content. All authors read and approved the final article.

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