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ORIGINAL ARTICLE

Dietary sources of energy and nutrient intake among children and adolescents with chronic kidney disease

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Abstract
Background Our purpose was to identify the main food contributors to energy and nutrient intake in children with chronic kidney disease (CKD).
Methods In this cross-sectional study of dietary intake assessed using Food Frequency Questionnaires (FFQ) in the Chronic Kidney Disease in Children (CKiD) cohort study, we estimated energy and nutrient intake and identified the primary contributing foods within this population.
Results Completed FFQs were available for 658 children. Of those, 69.9% were boys, median age 12 (interquartile range (IQR) 8–15 years). The average daily energy intake was 1968 kcal (IQR 1523–2574 kcal). Milk was the largest contributor to total energy, protein, potassium, and phosphorus intake. Fast foods were the largest contributors to fat and sodium intake, the second largest contributors to energy intake, and the third largest contributors to potassium and phosphorus intake. Fruit contributed 12.0%, 8.7%, and 6.7% to potassium intake for children aged 2–5, 6–13, and 14–18 years old, respectively.
Conclusions Children with CKD consumed more sodium, protein, and calories but less potassium than recommended by the National Kidney Foundation (NKF) guidelines for pediatric CKD. Energy, protein, and sodium intake is heavily driven by consumption of milk and fast foods. Limiting contribution of fast foods in patients with good appetite may be particularly important for maintaining recommended energy and sodium intake, as overconsumption can increase the risk of obesity and cardiovascular complications in that population.

Keywords Nutrient intake · Food · Children · Adolescents · Chronic kidney disease

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Abbreviations

AI	Adequate intake
CKiD	Chronic Kidney Disease in Children
CKD	Chronic kidney disease
DSN	Dietary sources of nutrients
eGFR	Estimated glomerular filtration rate
EER	Estimated energy requirement
FFQ	Food Frequency Questionnaire
IQR	Interquartile range
NHANES	National Health and Nutrition Examination Survey
NKF	National Kidney Foundation
RDA	Recommended dietary allowance

Introduction

Optimizing nutritional intake to improve nutritional status is an essential aspect of pediatric chronic kidney disease (CKD) clinical management [1, 2]. Dietary guidance is frequently provided in clinical practice to optimize growth and achieve favorable serum chemistry profiles. Dietary guidelines for children with CKD are available [3], with target intakes for protein, sodium, potassium, phosphorus, and total calories, as well as recommended dietary adjustments based on laboratory monitoring. Studies of children with CKD indicate that diet quality and nutrient intake decrease as kidney function declines [4]. Anorexia and poor appetite are common in children with CKD and contribute to inadequate nutrient and caloric intake [5, 6]. Any nutritional intervention to address inadequate intake or abnormal nutritional indexes must focus on dietary composition. However, little is known about dietary composition in these children, and there is little guidance for clinicians on how best to aid a patient achieve the recommended dietary intake.

We evaluated dietary intake of children with CKD and identified the main food contributors to energy and nutrient intake with the aim of providing information to care providers for tailoring nutritional advice to these children. We contextualize findings by comparing them with data from the general population.

Methods

Study design

The Chronic Kidney Disease in Children (CKiD) study is an ongoing, multicenter, prospective cohort study of children with mild-to-moderate CKD from 57 clinical sites in the United States and Canada. Eligibility criteria for enrollment into the study comprised children with glomerular and nonglomerular disease age 1–16 years, estimated glomerular filtration rate (eGFR) [7] 30–90 ml/1.73 m^2, and no previous organ transplantation. The primary glomerular diagnoses were focal segmental glomerulosclerosis (FSG) and hemolytic uremic syndrome (HUS), while primary nonglomerular diagnoses included obstructive uropathy, aplastic/hypoplastic/dysplastic kidneys, and reflux nephropathy. A detailed description of the CKiD study population and design was previously reported [7, 8]. The study protocol was approved by the Institutional Review Boards of each participating center, and informed consent was obtained from all participants.

Dietary assessment

The Child Harvard Service Food Frequency Questionnaire (HSFFQ) was used to assess dietary intake in the CKiD study. This tool was adapted from the Food Frequency Questionnaire (FFQ) developed and evaluated by Willett et al. [9] and designed to be self-administered. However, unlike the original, which focused mainly on intake during the last year, the child HSFFQ was designed to reflect usual eating habits in the prior 28 days and is validated in Native American and Caucasian children aged 1–5 years and in pregnant women [10, 11]. Three similar age-specific versions (2–5, 6–13, and 14–18 years) were adopted in the CKiD study targeting children aged 1–18 years and assessing dietary information on a total of 86 or 87 food items (depending upon age group). The FFQ was completed by the study coordinator through interview or was self-administered by children or their guardian(s). Self-reported intake frequencies (ranging from never in the past 28 days to >6 times per day) were converted to times per day, and estimated portion sizes were derived from the general population and applied to estimate daily total consumption for each item [12, 13]. Daily nutrient and caloric intake was then extracted from overall item consumption using the Nutrition Data System for Research (NDSR, version 2013). Total energy and nutrient intake (including protein, fat, carbohydrate, sodium, potassium, and phosphorus) for every child was computed as the sum of all food items. The analysis was restricted to participants who had completed at least 75% of the questionnaire at the baseline visit, with total energy intake in the range of 500–5000 kcal and percent estimated energy requirement (%EER) between the 2.5th and the 97.5th percentile.

Food grouping

Individual food items were aggregated into 36 mutually exclusive groups based on the USDA Dietary Sources of Nutrients (DSN) database [14], National Health and Nutrition Examination Survey (NHANES) classifications of food groups [15], and input from clinical dietitians. Food mixtures were not disaggregated. Fast foods were amalgamated into one composite group that included hamburgers, hotdogs, tacos, burritos, and French fries. Food groups were further subdivided when appropriate to enable better discernment of specific nutrient intake. For example, fruit was assessed as a single group contributing to energy intake, but bananas (given their high potassium content) were treated as a distinct food group when quantifying potassium intake. Food classifications are presented in Supplemental Table 1.

Patient demographic and clinical data

Height and weight were determined as the mean of two independent measurements using a stadiometer and a standing scale, respectively. Age- and sex-specific height, weight and body mass index (BMI) z-scores were calculated using US Centers for Disease Control and Prevention (CDC) growth charts from normative data [16]. Family income, race, and maternal education information were collected at the baseline visit. Disappearance of plasma iohexol was used to assess glomerular filtration rate (GFR). When GFR could not be directly measured, estimated GFR (eGFR) from published equations derived from the CKiD population was substituted [7].

Serum potassium, phosphate, and albumin were centrally measured enzymatically, as were total protein and urine creatinine concentrations, using a Bayer Advia 2400 analyzer (Siemns Diagnosis, Tarrytown, NY, USA). Hypoalbuminemia was defined as serum albumin <3.8 g/dl as was elevated phosphate (>6.5 mg/dl for children <13 years and >4.5 mg/dl for children >13 years). Elevated serum potassium was defined as >5.2 mEq/L.

Statistical analyses

Continuous variables are expressed as median and interquartile range (IQR) and categorical variables as frequencies and proportions. Energy, nutrient intake, and %EER are described by age category. The mean proportion of each food group/item was calculated as described by Krebs-Smith et al. [17]. Proportional contributions of each food group to energy and nutrient (carbohydrate, fat, protein, sodium, potassium, and phosphorus) intakes were calculated by summing the nutrient content across items within a food group (e.g., cheese) and dividing by the total nutrient intake across all food items for an individual. Food groups were then ranked in terms of their contribution to energy and nutrient totals. The five top food contributors to sodium, potassium, and phosphorus for each age group were compared. When quantitative comparison was appropriate, Wilcoxon signed-rank tests were used to compare mean contribution of food categories with children in the general population. Statistical analyses were performed using SAS version 9.4 (SAS Institute, Cary, NC, USA). All tests were two-sided, and a P value of <0.05 was considered statistically significant.

Results

Baseline data and dietary intake

Of the 732 children who provided dietary intake information, 658 completed >75% of the FFQ at baseline. Compared with the excluded group, children in the analysis were more likely to be Caucasian (68% vs. 54%, $P < 0.01$), have higher family income (33% vs. 12%, $P < 0.01$) and higher maternal educational attainment (college, 63% vs. 42%, $P < 0.01$). Characteristics of the 658 children are presented in Table 1; 59.9% were boys, median age was 12 (IQR 8–15) years, and median eGFR 53.5 (IQR 38.9—73.5) ml/min/1.73 m^2. More than two thirds had not received dietary counseling in clinics (Table 2).

Table 1 Patient baseline characteristics

Variables	Median (IQR) or *n* (%)
Male	394 (59.9)
Age (years)	12 (8, 15)
Weight z-score	0.1 (-0.8, 1.0)
Height z-score	−0.5 (−1.3, 0.3)
BMI z-score	0.5 (-0.3, 1.4)
BMI z-score ≤ -2	15 (2.3)
BMI z-score ≥ 2	62 (9.6)
Glomerular disease	203 (30.9)
GFR (ml/min/1.73 m^2)	53.5 (38.9, 73.5)
Maternal education	
High school	244 (37.9)
College and more	400 (62.1)
Race	
Caucasian	447 (67.9)
African American	97 (14.7)
Other	114 (17.4)
Annual family income	
< $36000	256 (38.9)
$36000–$75000	182 (27.7)
>$75000	220 (33.4)
Hypoalbuminemia	51 (7.8)
Hyperkalemia	45 (7.0)
Hyperphosphatemia	84 (13.1)

BMI body mass index, *GFR* glomerular filtration rate, *IQR* interquartile range

Contributions to energy and macronutrients

Dietary sources of energy and protein are presented in Tables 3 and 4, respectively; macronutrients are presented in greater detail in Supplemental Tables 2-5.

Energy intake Twenty food groups/items each contributed at least 2% to energy intake, representing 84% of total energy intake. Median energy intake was 52 (IQR 34–80) kcal/kg/day (Table 2), and median EER was 100% (IQR 75–135%). Milk was the top contributor, providing 7.7% of total energy intake, which was not significantly different from the general population (7.7% vs. 7.0%, $P = 0.27$) [15]. Other major contributors were fast foods (6.8%), bread and rolls (6.6%), fruit (6.1%), chips, crackers, popcorn, pretzels (5.6%), poultry products (5.3%), and pasta (5.1%).

Protein intake Median protein intake of the overall cohort was 1.8 (IQR 1.2–2.7) g/kg/day (Table 2), and protein intake in all age groups was higher than the recommended daily

Table 2 Dietary intake of energy and nutrients in children with chronic kidney disease (CKD) by age at baseline

	2–3 years old $n = 39$	4–8 years old $n = 164$	9–13 years old $n = 235$	14–18 years old $n = 220$	Overall $n = 658$
Energy					
Kcal/kg/day	101 (85, 137)	86 (63, 109)	46 (32, 65)	37 (27, 51)	52 (34, 80)
EER%	114 (98, 163)	119 (93, 156)	91 (66, 125)	92 (70, 125)	
Carbohydrate					
G/kg/day	14.3 (11.1, 18.8)	11.6 (8.2, 15.0)	5.8 (4.1, 8.5)	5.0 (3.5, 7.2)	6.8 (4.4, 10.6)
Energy%*	53 (50, 60)	53 (49, 58)	52 (47, 56)	54 (49, 59)	
Fat					
G/kg/day	3.8 (3.2, 5.3)	3.1 (2.4, 4.3)	1.8 (1.2, 2.4)	1.4 (1.0, 2.0)	2.0 (1.3, 3.1)
Energy%*	34 (30, 38)	35 (32, 38)	35 (31, 39)	34 (30, 37)	
Protein					
G/kg/day	3.4 (3.0,4.8)	2.8 (2.1, 3.8)	1.6 (1.1, 2.2)	1.3 (1.0, 2.0)	1.8 (1.2, 2.7)
Energy%*	13 (12, 15)	14 (12, 15)	14 (12, 16)	14 (12, 15)	
RDA%	456 ± 168	365 ± 172	209 ± 119	168 ± 85	
Sodium					
Mg/day/kg	154 (126, 208)	122 (95, 183)	74 (49, 99)	62 (42, 84)	83 (55, 122)
AI%	238 ± 95	265 ± 117	207 ± 84	274 ± 115	
Potassium					
Mg/kg/day	146 (125, 202)	108 (79, 135)	58 (40, 79)	49 (33, 66)	66 (42, 102)
AI%	46 ± 15	54 ± 25	53 ± 22	69 ± 31	
Phosphorus					
Mg/kg/day	72 (57, 92)	52 (36, 67)	28 (20, 38)	21(15, 32)	31 (20, 49)
RDA%	81 ± 25	98 ± 45	96 ± 38	116 ± 49	

EER estimated energy requirements, *AI* adequate intake, *RDA* recommended dietary allowance, *CKD* chronic kidney disease

* Percentage of energy derived from macronutrients

allowance (RDA) in healthy children (range 100–140%). Milk was also the largest food source for protein, contributing 13.8% of total protein intake on average, which was similar to that reported in the general population (13.2%, $P = 0.17$) [15]. Other important contributors included poultry products (12.0%), fast foods (8.4%), pork products (7.4%), and bread and rolls (5.4%). Restricting to animal protein intake, the highest contributors were milk (19.9%), poultry products (17.4%), pork products (10.8%), and fast foods (10.4%). Restricting to vegetable protein intake, the highest contributors were bread and rolls (14.9%) and pasta (14.0%).

Carbohydrate intake The main sources of carbohydrates were fruit (11.4%), bread and rolls (8.6%), beverages (8.3%), pasta (6.7%), and ready-to-eat cereals (6.6%). The contribution of fruit to carbohydrate intake was significantly higher than in the general population (11.4% vs. 3.9%, $P < 0.01$) [15].

Fat intake The main food sources for fat intake were fast foods (10.5%), poultry products (8.6%), chips, crackers, popcorn, pretzels (8.2%), milk (7.3%), and cheese (5.8%).

Contribution to sodium, potassium, and phosphorus

Dietary sources for sodium and potassium are presented in Tables 5 and 6 and for phosphorus in Supplemental Table 6.

Sodium intake Median sodium intake was 83 (IQR 55–122) mg/kg/day, which is higher than the recommended level [range 100% adequate intake (AI) in all age groups] (Table 2). Fast foods were the largest single source of sodium, contributing 9.4% of the total. Other major sources for sodium intake included cheese (7.1%), poultry products (6.0%), bread and rolls (5.7%), and chips, crackers, popcorn, and pretzels (5.6%). Stratifying by age group, cheese (10.0%) was the top contributor to sodium intake in children aged 2–5 years, while fast foods were the main source for children aged 6–13 (8.8%) and 14–18 (10.2%) years (Fig. 1a).

Potassium and phosphorus intake Medium potassium intake was 66 (IQR 42–102) mg/kg/day, while median phosphorus intake was 31 (IQR 20–49) mg/kg/day (Table 2). Milk was the largest single contributor to both potassium (15.9%) and phosphorus (20.3%) intake. Compared with percentage

Table 3 Food/food group energy sources in children with chronic kidney disease between 2 and 18 years old [a]

Ranking	Food groups/items[a]	Mean (%)	Cumulative (%)
1	Milk	7.7	7.7
2	Fast foods	6.8	14.5
3	Bread and rolls	6.6	21.1
4	Fruit	6.1	27.2
5	Crackers, popcorn, pretzels, chips	5.6	32.8
6	Poultry products	5.3	38.1
7	Pasta	5.1	43.2
8	Beverages	4.5	47.7
9	Ready-to-eat cereals	4.2	51.9
10	Candy, chocolate, and sugary foods	4.2	56.1
11	Fruit juice	3.4	59.5
12	Pork products	3.2	62.7
13	Milk products	3.1	65.8
14	Cake, cookies, pie	3.0	68.8
15	Biscuit, corn bread, pancakes	2.8	71.6
16	Cheese	2.6	74.2
17	Nuts and seeds	2.6	76.8
18	Yogurt	2.4	79.2
19	Pizza	2.3	81.5
20	Mayonnaise and salad dressing	2.2	83.7

[a] Food groups ($n = 11$) contributing at least 1%, in descending order: eggs, potatoes, beef, rice, other vegetables, coffee and tea, butter and margarine, vegetable and other soup, fish and fish products, sausage and luncheon meats, legumes

contribution (18.8%) in the general population, the contribution of milk to potassium intake was significantly lower ($P < 0.01$). Other important dietary sources of potassium were fruit (excluding bananas 8.5%), fast foods (7.4%), fruit juice (7.0%), and potatoes (4.9%) and of phosphorus were cheese (7.2%), fast foods (6.3%), poultry products (5.2%), and

Table 4 Food/food group sources of protein in children with chronic kidney disease etween 2 and 18 years old[a]

Ranking	Food groups/items[a]	Mean (%)	Cumulative (%)
1	Milk	13.8	13.8
2	Poultry products	12.0	25.8
3	Fast foods	8.4	34.2
4	Pork products	7.3	41.5
5	Bread and rolls	5.4	46.9
6	Pasta	5.1	52.0
7	Cheese	3.7	55.7
8	Fish and fish products	3.7	59.4
9	Beef	3.5	62.9
10	Eggs	3.4	66.3
11	Pizza	3.4	69.7
12	Nuts and seeds	3.2	72.9
13	Yogurt	3.0	75.9
14	Ready-to-eat cereals	2.6	78.5
15	Chips, crackers, popcorn, pretzels	2.2	80.7
16	Biscuit, corn bread, pancakes	2.1	82.8

[a] Food groups ($n = 10$) contributing at least 1% in descending order: sausage and luncheon meats, fruit, legume, candy, chocolate, sugary foods, milk products, vegetable and other soup, corn and peas, other vegetables, potatoes, rice

Table 5 Food/food group sources of sodium in children with chronic kidney disease children 2 and 18 years old [a]

Ranking	Food groups/items	Mean (%)	Cumulative (%)
1	Fast foods	9.4	9.4
2	Cheese	7.1	16.5
3	Poultry products	6.0	22.5
4	Bread and rolls	5.7	28.2
5	Chips, crackers, popcorn, pretzels	5.6	33.8
6	Ready-to-eat cereals	5.0	38.8
7	Pork products	4.9	43.7
8	Tomato and tomato sauce	4.8	48.5
9	Milk	4.6	53.1
10	Vegetable and other soup	4.5	57.6
11	Eggs	4.1	61.7
12	Biscuit, corn bread, pancakes	3.9	65.6
13	Pasta	3.6	69.2
14	Pizza	3.1	72.4
15	Rice	3.0	75.4
16	Sausage and luncheon meats	2.8	78.2
17	Broccoli, spinach, greens	2.5	80.6
18	Mayonnaise and salad dressing	2.4	83.0
19	Legume (beans)	2.1	85.1
20	Fish and fish products	2.0	87.1

[a] Food groups ($n = 5$) contributing at least 1% in descending order: corn and peas, beverages, other vegetables, milk products, nuts and seeds

Table 6 Food/food group sources of potassium in chronic kidney disease children between 2-18 years old[a]

Ranking	Food groups/items	Mean (%)	Cumulative (%)
1	Milk	15.9	15.9
2	Fruit	8.5	24.4
3	Fast foods	7.4	31.8
4	Fruit juice	7.0	38.8
5	Potatoes	4.9	43.8
6	Tomato and tomato sauce	3.9	47.7
7	Yogurt	3.4	51.1
8	Banana	3.3	54.4
9	Pork products	3.1	57.5
10	Vegetable and other soup	3.0	60.6
11	Ready-to-eat cereals	3.0	63.5
12	Poultry products	3.0	66.5
13	Milk products	3.0	69.4
14	Carrot, sweet potatoes, squash	2.9	72.3
15	Nuts and seeds	2.3	74.6
16	Other vegetables	2.3	76.9
17	Legume (beans)	2.2	79.1

[a] Food groups ($n = 12$) contributing at least 1% in descending order: chips, crackers, popcorn, pretzels, bread and rolls, pasta, pizza, corn and peas, broccoli, spinach and greens, beverage, beef, candy, chocolate and sugary foods, eggs, fish and fish products, biscuit, cornbread, pancakes

biscuits, corn bread, pancakes, and tortillas (4.5%). By age group, milk was the main potassium and phosphorus source across all ages (Fig. 1b, c); fruit contribution for children 2–5, 6–13, and 14–18 years were 12.0%, 8.7%, and 6.7%, respectively.

Differences in nutrient intake and food contributors by eGFR

Nutrient and energy intake and food contributors were compared across strata of eGFR (<60 ml/min/1.73 m^2 vs. ≥60 ml/min/1.73 m^2); no significant differences were found. In addition, food contributors to energy, sodium, potassium, and phosphorus intake were very similar between groups (data not shown).

Discussion

Malnutrition has been reported in children with CKD and can affect growth [2, 18]. Nutritional counseling and intervention is regarded as an effective method for optimizing growth and biochemical balance in children with CKD. However, dietary adherence is poor [19]. This study aimed to identify the main food contributors to energy and nutrient intake in children

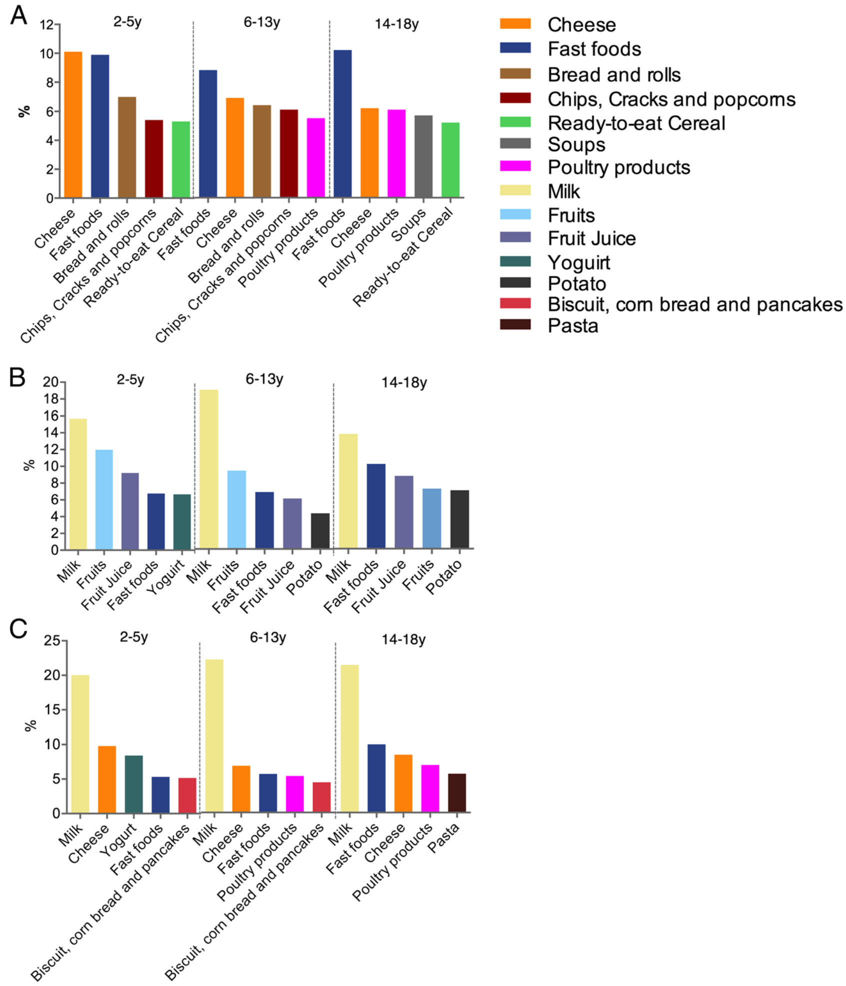

Fig. 1 Top five food sources for sodium, potassium, and phosphorus by age: **a** sodium, **b** potassium, **c** phosphorus

with CKD and compare them with data from the general population [15, 20] to help determine dietary intervention and counseling strategies.

As noted in healthy children, milk was the top contributor to energy intake. Milk and dairy products are the primary dietary sources of energy, high-quality protein, and other nutrients for children in many countries [21]. However, fast foods were the second largest food source of energy, contributing 6.8% to total energy intake. Three food groups (chips/crackers/popcorn/pretzels; beverages; candy/chocolate/sugary foods) contributed calories but added minimal nutritional value. This suggests that children in our cohort overconsume energy-dense, nutrient-poor foods, as has been reported for the general population [22]. Dietary guidelines recommend that children with CKD consume 100% of the age-specific EER individually adjusted for physical activity. Maintaining normal energy intake is particularly important for growth in children with CKD. However, overconsumption of energy foods may lead to the further complication of obesity [1, 23], which is associated with faster progression of CKD and higher mortality rates in the adult population [24]. Our results suggest that a large percentage of children in the CKiD cohort achieve energy intake levels consistent with and sometimes greater than the EER. A decrease of 50% in the intake of fast food, beverages, chips/crackers/popcorn/pretzels, and candy/chocolate/sugary foods could reduce average energy intake in our cohort by 11%, which would eliminate overconsumption in 20% of children in the CKiD cohort who have excess energy intake.

Protein-energy malnutrition is a known complication in children with CKD [18]. Dietary protein intake often decreases as kidney function declines [25, 26]. Within this study, however, dietary protein intake in all age groups was higher than the recommended level (range 100–140% RDA). Excessive protein intake has been reported to impact renal function in adult patients with CKD [27]. A low-protein intake in children with CKD has not been shown to delay CKD progression, though it is widely recommended for adult patients [28]. Protein restriction in children with CKD must be cautiously used due to the very important role protein plays in growth. In terms of sources of protein, animal sources (milk, poultry products, fast foods, and pork products) contributed 41.5% of overall protein intake. Although there is no recommendation for the relative contribution of animal- and plant-based sources of protein, a primary recommendation of the 2010 dietary guidelines for Americans is to shift food intake patterns toward a plant-based diet.

Sodium intake was much higher within this cohort than recommended but similar to the trend observed in the general US population [29]. Fast foods contributed 9.4% of total sodium intake and was higher in the older age group, consistent with a general population trend toward increased processed meat consumption and decreased fruit and dairy consumption as children age [30–32]. High sodium intake is associated with elevated blood pressure and risk of hypertension in children [33]. A randomized trial in adult CKD patients indicated that the CKD population might be more salt sensitive, and a low-sodium diet could effectively reduce blood pressure and the incidence of cardiovascular complications [34, 35].

Milk was the main source for potassium within this cohort, contributing 15.9%. Fruit was the second largest contributor at 8.5%, indicating that children in our study had a relatively high frequency of fruit consumption. However, overall potassium intake was still lower than recommended, which is similar to trends in the general population [36]. Only 7% of children in the CKD cohort had hyperkalemia—a clinical indicator that could motivate a reduction in potassium intake—suggesting that low potassium intake in the cohort is not the result of clinical factors. The 2010 dietary guidelines for the general population urged increasing dietary intake of fruit, as US children and adolescents intakes have consistently failed to meet recommended levels [22, 37, 38] and most children with CKD would similarly benefit from increased fruit consumption and potassium intake.

There are notable limitations in our study. Although FFQs are useful for evaluating long-term dietary habits of children, they are often subject to poor recall, low response rates, and intake overestimation [39]. Portion sizes from the general US population were applied to estimate daily energy and nutrient intake, which simplified the questionnaire but underrepresents the variability in portion sizes across the CKiD cohort. In addition, dietary intake may be overestimated in the 4.9% of CKiD participants who reported poor appetite at baseline. Finally, we were unable to accurately estimate absolute intake. However, our findings are useful as an epidemiologic and clinical guide to understanding relative nutritional intake in children with CKD and important food contributors.

Conclusion

Characterizing the major contributors to energy and nutrients intake in children with CKD is an important part of understanding dietary intake and improving nutritional counseling. Our findings suggest that children with CKD overconsume sodium, protein, and calories relative to recommendations by the National Kidney Foundation. These dietary intake trends were similar to that of the general pediatric population. Higher fruit and vegetable intake has been recommended for children in general and may be particularly important in this vulnerable population at risk of acidosis and other blood chemistry imbalances. Limiting intake of fast foods, salty snacks, candies, and sugared beverages in patients with good appetite may help children with CKD avoid obesity and hypertension, which can result from overconsumption of these calorie-dense, high-sodium foods.

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Compliance with ethical standards

Ethical statement The study design and conduct were approved by an external study monitoring board appointed by the National Institute of Diabetes and Digestive and Kidney Diseases and by the institutional review boards of each participating center.

Conflict of interest None of the authors declare a conflict of interest.

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