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Contribution of foods to absolute nutrient intake and between-person variations of nutrient intake in Korean preschoolers

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BACKGROUND/OBJECTIVES: The aim of this study was to analyze specific foods influencing absolute nutrient intake and between-person variations of nutrient intake among Korean preschoolers.
SUBJECTS/METHODS: This study included 2,766 participants aged 1-5 years in the 2009-2013 Korea National Health and Nutrition Examination Surveys. Dietary data were obtained from a 24-h dietary recall method. Major food sources of absolute nutrient intake were evaluated based on percent contribution of each food. To assess the contribution of specific foods to between-person variations in nutrient intake, stepwise multiple regressions were performed and cumulative R^2 was used.
RESULTS: White rice and milk were main food sources of energy, protein, carbohydrate, phosphorus, iron, potassium, thiamin, riboflavin, and niacin. The percentage of fat contributed by milk was 21.3% which was the highest, followed by pork, soybean oil, and egg. White rice accounted for 25% and 40% of total variability in total energy and carbohydrate intakes, respectively. About 39% of variation in calcium intake was explained by milk while 40% of variation in phosphorous intake was explained by cheese. The top 10 foods contributing to between-person variations in nutrient intakes were similar with food items that mainly contributed to absolute nutrient intakes. The number of foods explaining 90% of absolute amounts of nutrient intakes varied from 28 for vitamin A to 80 for iron.
CONCLUSIONS: This study identified specific foods that contributed to absolute nutrient intakes and between-person variations in nutrient intakes among Korean preschoolers. Our findings can be used to develop dietary assessment tools and establish food-based dietary guidelines for young children.

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INTRODUCTION

An adequate nutrient intake along with diverse food consumption in preschool children is known to have significant impact on healthy growth and development. In addition, dietary habits formed in this period will persist into adulthood [1]. Therefore, evaluating diets of young children is essential to measure their nutritional health status and improve health in childhood and adulthood. Particularly, identifying foods that contribute to energy and nutrient intakes and their between-person variations could describe the overall dietary practice of the population. In addition, understanding food consumption patterns among preschool children is a prerequisite for the development of dietary assessment tools such as a food frequency questionnaire (FFQ) [2] and the establishment of food-based dietary guidelines for this specific age group.

Several previous studies have reported major food sources contributing to energy and nutrient intakes among preschool children in Western and Asian regions. Regardless of region, milk is the most important contributor to energy and nutrient intake in this age group [3-9]. Dairy products such as cheese, infant formulas, and yogurt additionally contribute to energy and nutrient intake of preschool children [4-7,9]. Bread, meat, sugar-sweetened beverages, cake, and sweet desserts have been frequently observed as contributors to energy and nutrient intakes in Western countries [3-5,7,9] whereas young children in Asian countries obtain large amounts of energy and nutrients from rice, cereals, tubers, and noodles that are main

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staple foods in Asia [6,8,10].

To investigate dietary risk factors for some health outcomes, dietary assessment tools should be prepared to identify dietary difference among subjects. Thus, analysis on specific foods that contribute to between-person variations in nutrient intake has been frequently performed to select food items for inclusion in the FFQ [2,11,12]. To develop food list of FFQ for children aged 3-11 years, a Japanese study [2] has identified food items that contribute to between-person variations in energy, protein, fat, and sodium intakes. They found that steamed white rice explained the highest percentage of between-person variations in energy and protein intakes. Milk and miso soup were also major contributors to between-person variations in nutrient intakes [2]. However, few studies have identified food items that explain differences in energy and nutrient intakes between individuals among young children.

Due to challenges in the assessment of dietary intake among young children, limited information on young children's diets is available compared to information for other age groups. Previous studies have explained that collecting dietary data from young children is demanding since this age group lacks the ability to report their diet. In addition, they tend to eat irregularly and their dietary intake change rapidly as they grow [13,14]. Due to these limitations, little is known about major food sources of nutrients intake and how this contributes to between-person variations in nutrient intake among young children. In Korea, only a few studies have investigated diets of preschool children.

As food consumption patterns vary across gender, age, ethnicity, and country [15,16], determining foods that contribute to nutrient intake and between-person variations in a specific population is necessary to accurately assess diets and tailor effective dietary recommendations. Therefore, the aim of this study was to evaluate the contribution of specific foods to absolute nutrient intake and between-person variations in nutrient intake among Korean preschool children using data from the 2009-2013 Korea National Health and Nutrition Examination Surveys (KNHANES).

SUBJECTS AND METHODS

Data and study subjects

For this study, a total of 2,766 preschool children aged 1-5 years who had 24-h dietary recall data in the 2009-2013 KNHANES were included. The KNHANES is a nationally representative, cross-sectional survey conducted by the Korea Centers for Disease Control and Prevention. It comprised the following three surveys: a health interview survey, a health examination survey, and a nutrition survey. Detailed information on the method and procedures of KNHANES is available elsewhere [17]. The Institutional Review Board (IRB) of the Korea Centers for Disease Control and Prevention approved the KNHANES survey protocol (2009-01CON-03-2C, 2010-02CON-21-C, 2011-02CON-06-C, 2012-01EXP-01-2C, and 2013-07CON-03-4C). Written informed consent was obtained from each child's parents or guardian.

Sociodemographic and dietary variables

Sociodemographic variables were obtained from the health interview survey. Residential areas were divided into rural, city, and metropolitan area. Monthly household income was grouped into five categories: < 1,300,000 won, 1,310,000-2,800,000 won, 2,810,000-3,900,000 won, 3,910,000-5,200,000 won, and ≥ 5,210,000 won. Dietary intake data were obtained by a single 24-h dietary recall of the nutrition survey. Total energy and nutrient intakes were calculated for each subject based on a Korean Food Composition Table [18]. Categorical variables such as sex, residential area, and household income are presented as percentages with standard errors (SE) while continuous variables such as age and nutrient intake are shown as mean ± standard error (SE).

Contributions of specific foods to absolute nutrient intake

Data on specific foods intakes were obtained through 24-h dietary recall. Food intakes were calculated based on the 3rd food code of KNHANES, a reclassification code that integrated with same food sources based on the 1st food code of KNHANES. For example, three kinds of 1st food code such as raw onion, dried onion, and cooked onion were given the same 3rd food code. Amounts of food intakes using the 3rd food code were derived by the KNHANES survey team considering water content of each food. Food codes consumed by less than 0.5% of study subjects were excluded from the analysis.

Contributions of specific foods to absolute nutrient intake were evaluated based on the percentage of total nutrient intake from each food. The top 10 food items contributing to absolute intakes of energy and nutrient were presented by age group. In addition, the number of foods items that accounted for 90% and 80% of absolute intake of each nutrient was suggested, respectively.

Contributions of specific foods to between-person variations in nutrient intake

To assess the contribution of specific foods to between-person variations in nutrient intake, stepwise multiple regressions were performed. In the stepwise multiple regression, total nutrient intake from all foods was included as a dependent variable while nutrient intake provided by each food was included as an independent variable. Cumulative R^2 was used to assess the contribution of foods to variance in nutrient intake. The top 10 food items ranked according to R^2 values were listed by age group. The number of food items with R^2 values up to 0.90 and 0.80 for each nutrient was presented, respectively. Data were analyzed using Statistical Analysis System (SAS) program version 9.3 (SAS Institute, Inc., Cary, NC, USA).

RESULTS

General characteristics of study participants

Characteristics of study participants are presented in Table 1. The mean age of study subjects was 3.0 years and 51.6% of participants were boys. Children living in city and metropolitan area accounted for 40.5% and 42.7% of participants, respectively. Participants' mean energy intake was 1,224 kcal.

Table 1. Characteristics of the study subjects[1)]

	Total (n = 2,766)
Age (yrs, mean ± SE)	3.0 ± 0.03
Sex (% (SE))	
Male	51.6 (1.1)
Female	48.4 (1.1)
Residential area (% (SE))	
Rural	16.7 (1.7)
City	40.5 (2.0)
Metropolitan	42.7 (1.7)
Monthly household income (% (SE))	
≤ 1,300,000 won	7.0 (0.7)
1,310,000-2,800,000 won	34.2 (1.4)
2,810,000-3,900,000 won	23.6 (1.2)
3,910,000-5,200,000 won	18.7 (1.1)
≥ 5,210,000 won	16.5 (1.1)
Energy and nutrient intake (mean ± SE)	
Energy (kcal)	1,224 ± 14.0
Protein (g)	42.2 ± 0.5
Fat (g)	31.2 ± 0.6
Carbohydrate (g)	194.4 ± 2.1
Calcium (mg)	474.5 ± 11.1
Phosphorus (mg)	781.4 ± 12.0
Iron (mg)	7.5 ± 0.2
Sodium (mg)	1,714 ± 30.0
Potassium (mg)	1,648 ± 19.5
Vitamin A (μg RAE)	450.6 ± 10.7
Thiamin (mg)	0.9 ± 0.01
Riboflavin (mg)	1.0 ± 0.01
Niacin (mg)	8.1 ± 0.1
Vitamin C (mg)	69.0 ± 1.9

[1)] All analyses accounted for the complex sampling design effect and appropriate sampling weights.

Contribution of specific foods to absolute nutrient intake

Major food sources of nutrient intakes by age group are shown in Table 2. White rice accounted for 31% of energy intake which was the highest, followed by milk (10.2%), bread (3.5%), cookies and biscuits (2.6%), egg (2.6%), and pork (2.5%). White rice and milk were the main food sources of protein, carbohydrate, phosphorus, iron, potassium, thiamin, riboflavin, and niacin. The percentage of fat contributed by milk was 21.3%, which was the highest, followed by pork (7.4%), soybean oil (6.2%), and egg (5.3%). Milk accounted for 45.9% of calcium intake. Other dairy products including yogurt, cheese, and ice cream also contributed to calcium intake. Regarding sodium intake, salt (17.6%), soy sauce (10.2%), and kimchi (6.6) were major contributors. Foods that provided more than 10% of vitamin A intake included laver (14.3%), milk (14.1%), and carrot (11.1%). Mandarine orange and strawberry provided 17.0% and 11.5% of vitamin C intake, respectively. By age group, milk and modified milk powder were shown as major contributors of nutrients among children aged 1-2 years whereas white rice and milk were main food sources among those aged 3-5 years. Total contribution explained by 10 food items for each nutrient was lower in 3-5 years compared to 1-2 years except for sodium.

Contribution of specific foods to between-person variations in nutrient intake

Table 3 shows top 10 foods contributing to between-person variations in energy and nutrient intakes by age group. The proportion of variability in energy and nutrient intakes explained by 10 food items ranged from 61% for potassium to 93% for calcium. For macronutrient intakes based on the stepwise regression model, the 10 food items accounted for 70-75% of between-person variations. White rice accounted for 25% and 40% of total variability in total energy and carbohydrate intakes, respectively. About 39% of variation for calcium intake was explained by milk while 40% of variation for phosphorous intake was explained by cheese. In younger children aged 1-2 years, modified milk powder also accounted for between-person variations in energy and nutrient intakes. Among children aged 3-5 years, cookies and biscuits were ranked as the major food source of between-person variations for energy and carbohydrate intakes.

Number of foods accounting for absolute nutrient intakes and between-person variations in nutrient intake

Table 4 presents the number of foods needed to explain at least 90% and 80% of absolute nutrient intakes and between-person variations for total energy and selected nutrients. The number of foods explaining 90% of absolute amounts of nutrient intakes varied from 28 items for vitamin A to 80 items for iron. For most nutrients, fewer foods were needed to explain 80% of absolute intakes compared to 90% of intakes. The number of food items required to explain 90% of between-person variations ranged from 8 (calcium) to 37 (potassium) depending on nutrients. The number of food items accounted for 80% of between-person variations was lower than that for 90%. Most nutrients required less than 20 food items to explain 80% of between-person variations except for energy, potassium, and niacin.

DISCUSSION

In this study, we ascertained specific foods that contributed to absolute intakes of energy and nutrients. We also identified foods which explained between-person variations in energy and nutrient intakes among Korean preschoolers. White rice and milk were major contributors to energy and nutrient intakes. The top 10 food items selected accounted for 40-73% of absolute intakes depending on the nutrient. White rice accounted for 25% and 40% of total variability in total energy and carbohydrate intakes, respectively. The top 10 foods contributing to between-person variations in nutrient intake were similar to food items that mainly contributed to absolute nutrient intake. The number of foods explaining 90% of absolute amounts of nutrient intakes varied from 28 for vitamin A to 80 for iron. For potassium, the highest number of foods was needed to explain between-person variations whereas the lowest number of foods was required to explain variations for calcium.

In our study population, two most important food sources of energy and nutrient intakes were white rice and milk. As rice is the main staple food in Asian countries, young children in China [8] also show high rice consumption as the major food

Table 2. Contribution of specific foods to absolute intakes of energy and nutrient by age group[1)]

Rank	Foods	Cum%	Foods	Cum%	Foods	Cum%	Foods	Cum%	Foods	Cum%	Foods	Cum%	Foods	Cum%
1-5 yrs														
	Energy		Protein		Fat		Carbohydrate		Calcium		Phosphorus		Iron	
1	White rice	30.9	White rice	15.8	Milk	21.3	White rice	42.8	Milk	45.9	Milk	23.0	White rice	8.5
2	Milk	41.1	Milk	30.6	Pork	28.7	Milk	48	Modified milk powder	50.7	White rice	40.5	Egg	14.2
3	Bread	44.6	Egg	37.6	Soybean oil	34.9	Bread	51.5	Yoghurt (curd type)	55.5	Egg	45.5	Laver	18.8
4	Cookies and biscuits	47.2	Beef	42.8	Egg	40.2	Rice cake	54	Cheese	60.1	Cheese	49.5	Modified milk powder	23.0
5	Egg	49.8	Chicken	47.8	Cookies and biscuits	44.9	Glutinous rice	56.3	Anchovy	63.3	Pork	52.0	Milk	26.8
6	Pork	52.3	Pork	52.8	Beef	48.6	Apple	58.6	Tofu	65.8	Yoghurt (curd type)	54.5	Beef	30.2
7	Rice cake	54.2	Bread	55.4	Bread	52.2	Cookies and biscuits	60.8	Egg	68.1	Modified milk powder	56.5	Isotonic drink	32.9
8	Glutinous rice	55.9	Tofu	57.6	Modified milk powder	55.2	Mandarin orange	62.5	Ice cream	69.8	Beef	58.5	Bread	35.4
9	Modified milk powder	57.6	Modified milk powder	59.5	Cheese	58.1	Yoghurt (curd type)	64.0	Seaweed	71.4	Anchovy	60.3	Persimmon	37.8
10	Beef	59.1	Cheese	61.2	Cake	60.8	Yoghurt (liquid type)	65.5	Yoghurt (liquid type)	72.9	Tofu	62.0	Tofu	40.1
	Sodium		Potassium		Vitamin A		Thiamin		Riboflavin		Niacin		Vitamin C	
1	Salt	17.6	Milk	18.0	Laver	14.3	White rice	16.0	Milk	29.7	White rice	18.6	Mandarin orange	17.0
2	Soy sauce	27.8	White rice	28.1	Milk	28.4	Milk	26.0	Egg	39.9	Pork	26.0	Strawberry	28.5
3	Kimchi[2)]	34.4	Potato	31.9	Carrot	39.5	Pork	35.1	Laver	45.3	Beef	31.1	Fruit juice	34.4
4	Milk	40.6	Seaweed	34.6	Modified milk powder	46.5	Yoghurt (liquid type)	43.6	White rice	49.2	Milk	35.6	Apple	40.1
5	Fermented soybean paste	45.9	Mandarin orange	37.2	Egg	51.4	Mandarin orange	47.6	Modified milk powder	52.5	Cereals	39.2	Potato	45.7
6	White rice	49.2	Laver	39.5	Persimmon	56.1	Egg	50.2	Yoghurt (curd type)	55.2	Modified milk powder	42.6	Orange	51.2
7	Seaweed	52.3	Sweet potato	41.8	Watermelon	59.7	Cereals	52.7	Pork	57.5	Chicken	45.9	Cereals	54.3
8	Instant noodle	54.8	Egg	43.9	Mandarin orange	63.0	Laver	54.8	Cereals	59.7	Bread	48.3	Sweet potato	57.4
9	Cheese	57.2	Banana	45.9	Spinach	66.3	Modified milk powder	56.8	Mandarin orange	61.8	Glutinous rice	50.3	Modified milk powder	60.4
10	Egg	59.2	Apple	47.9	Cereals	68.7	Potato	58.8	Strawberry	63.7	Mandarin orange	52.3	Milk	63.3
1-2 yrs														
	Energy		Protein		Fat		Carbohydrate		Calcium		Phosphorus		Iron	
1	White rice	31.1	Milk	17.1	Milk	25.3	White rice	43.4	Milk	46.0	Milk	25.6	Modified milk powder	11.2
2	Milk	43.3	White rice	32.6	Modified milk powder	33.6	Milk	49.6	Modified milk powder	57.2	White rice	42.3	White rice	19.6
3	Modified milk powder	47.9	Egg	39.2	Egg	38.6	Modified milk powder	52.8	Cheese	62.7	Cheese	47.6	Egg	24.8
4	Bread	50.7	Beef	44.7	Soybean oil	43.1	Bread	55.6	Yoghurt (curd type)	68.3	Modified milk powder	52.8	Milk	29.3
5	Egg	53.2	Modified milk powder	49.8	Pork	47.2	Apple	57.9	Soy milk	70.9	Egg	57.2	Soy milk	33.5
6	Cookies and biscuits	55.5	Chicken	54.3	Cookies and biscuits	51.2	Rice cake	60.1	Anchovy	73.4	Yoghurt (curd type)	60.4	Laver	37.5
7	Yoghurt (curd type)	57.5	Soy milk	57.3	Cheese	55.2	Glutinous rice	62.2	Tofu	75.6	Soy milk	62.7	Beef	41.0
8	Soy milk	59.6	Pork	60.2	Soy milk	59.2	Yoghurt (curd type)	64.2	Egg	77.5	Beef	64.6	Isotonic drink	43.8
9	Rice cake	61.2	Cheese	62.4	Beef	62.6	Cookies and biscuits	66.2	Yoghurt (liquid type)	79.2	Tofu	66.2	Tofu	46.1
10	Glutinous rice	62.7	Yoghurt (curd type)	64.6	Bread	65.6	Yoghurt (liquid type)	68.1	Seaweed	80.5	Anchovy	67.8	Persimmon	48.2
	Sodium		Potassium		Vitamin A		Thiamin		Riboflavin		Niacin		Vitamin C	
1	Salt	16.4	Milk	20.8	Modified milk powder	17.7	White rice	16.0	Milk	32.6	White rice	18.7	Mandarin orange	15.2
2	Soy sauce	26.0	White rice	30.7	Milk	32.9	Yoghurt (liquid type)	28.0	Egg	41.6	Modified milk powder	28.0	Strawberry	30.3
3	Milk	34.2	Modified milk powder	35.4	Laver	45.0	Milk	39.7	Modified milk powder	49.8	Milk	33.5	Modified milk powder	38.0

Table 2. continued

Rank	Foods	Cum%	Foods	Cum%	Foods	Cum%	Foods	Cum%	Foods	Cum%	Foods	Cum%	Foods	Cum%
4	Fermented soybean paste	39.7	Potato	39.2	Carrot	54.1	Modified milk powder	45.2	Laver	54.3	Beef	38.6	Orange	44.2
5	Kimchi	43.8	Yoghurt (curd type)	41.8	Egg	58.3	Pork	50.5	White rice	57.9	Pork	43.1	Potato	49.7
6	White rice	47.6	Sweet potato	44.3	Persimmon	62.3	Mandarin orange	54.2	Yoghurt (curd type)	61.3	Chicken	46.0	Apple	54.6
7	Cheese	51.2	Seaweed	46.8	Mandarin orange	65.6	Egg	56.6	Soy milk	64.0	Cereals	48.9	Fruit juice	59.2
8	Seaweed	54.5	Mandarin orange	49.2	Cheese	68.4	Soy milk	58.7	Strawberry	66.4	Soy milk	51.3	Yoghurt (liquid type)	63.1
9	Soy milk	56.8	Banana	51.5	Spinach	71.2	Potato	60.7	Mandarin orange	68.4	Mackerel	53.7	Sweet potato	66.5
10	Instant noodle	59.0	Egg	53.5	Watermelon	73.8	Cereals	62.7	Yoghurt (liquid type)	70.4	Mandarin orange	55.5	Milk	69.6
3-5 yrs														
	Energy		Protein		Fat		Carbohydrate		Calcium		Phosphorus		Iron	
1	White rice	30.8	White rice	15.9	Milk	19.0	White rice	42.4	Milk	45.9	Milk	21.4	White rice	8.6
2	Milk	39.9	Milk	29.4	Pork	28.3	Milk	47.1	Yoghurt (curd type)	50.1	White rice	39.5	Egg	14.6
3	Bread	43.7	Egg	36.6	Soybean oil	35.6	Bread	50.9	Cheese	53.9	Egg	44.7	Laver	19.4
4	Pork	46.9	Pork	42.7	Egg	41.1	Rice cake	53.6	Anchovy	57.7	Pork	47.9	Beef	22.9
5	Cookies and biscuits	49.6	Chicken	48.0	Cookies and biscuits	46.1	Glutinous rice	56.1	tofu	60.5	Cheese	51.1	Milk	26.3
6	Egg	52.3	Beef	53.0	Bread	50.0	Cookies and biscuits	58.4	Egg	63.1	Yoghurt (curd type)	53.1	Bread	29.1
7	Rice cake	54.3	Bread	55.9	Beef	54.0	Apple	60.8	Ice cream	65.4	Beef	55.2	Persimmon	31.7
8	Glutinous rice	56.1	Tofu	58.0	Cake	57.0	Mandarin orange	62.5	Bread	67.2	Anchovy	57.2	Isotonic drink	34.2
9	Soybean oil	57.7	Cheese	59.4	Ice cream	59.5	Flour	63.9	Seaweed	69.0	Bread	59.1	Pork	36.6
10	Beef	59.3	Yoghurt (curd type)	60.7	Crackers	62.0	Brown rice	65.3	Kimchi	70.6	Laver	61.0	Tofu	38.9
	Sodium		Potassium		Vitamin A		Thiamin		Riboflavin		Niacin		Vitamin C	
1	Salt	18.1	Milk	16.4	Laver	15.7	White rice	16.1	Milk	27.9	White rice	18.5	Mandarin orange	18.2
2	Soy sauce	28.6	White rice	26.6	Milk	29.1	Pork	27.2	Egg	39.0	Pork	27.4	Strawberry	27.5
3	Kimchi	36.4	Potato	30.4	Carrot	41.4	Milk	36.2	Laver	45.0	Beef	32.6	Fruit juice	34.3
4	Milk	41.7	Seaweed	33.2	Egg	46.7	Yoghurt (liquid type)	42.8	White rice	49.1	Cereals	36.6	Apple	40.4
5	Fermented soybean paste	47.0	Mandarin orange	35.8	Persimmon	52.0	Mandarin orange	47.1	Pork	52.1	Milk	40.6	Potato	46.0
6	White rice	50.1	Laver	38.3	Watermelon	56.2	Cereals	49.9	Cereals	54.8	Chicken	44.0	Orange	51.0
7	Seaweed	53.1	Kimchi	40.6	Spinach	59.8	Egg	52.6	Yoghurt (curd type)	57.1	Bread	46.7	Cereals	54.7
8	Instant noodle	55.7	Egg	42.9	Mandarin orange	63.0	Laver	54.8	Mandarin orange	59.3	Processed meat (pork)	49.0	Sweet potato	57.6
9	Bread	57.8	Sweet potato	45.0	Cereals	65.8	Bread	56.9	Beef	61.4	Glutinous rice	51.1	Persimmon	60.5
10	Laver	59.7	Pork	47.1	Beef	68.5	Chicken	58.9	Chicken	63.4	Mandarin orange	53.2	Milk	63.2

[1] The contributions of specific foods to absolute nutrient intake were evaluated based on the percentages of total nutrient intake from each food.
[2] Traditional fermented cabbage product.

Table 3. Contribution of specific foods to between-person variations of energy and nutrient intakes by age group[1)]

Rank	Foods	Cum R^2	Foods	Cum R^2	Foods	Cum R^2	Foods	Cum R^2	Foods	Cum R^2	Foods	Cum R^2	Foods	Cum R^2
1-5 yrs														
	Energy		Protein		Fat		Carbohydrate		Calcium		Phosphorus		Iron	
1	White rice	0.25	Beef	0.14	Cheese	0.14	White rice	0.40	Milk	0.39	Cheese	0.40	Isotonic drink	0.27
2	Soybean oil	0.33	Chicken	0.28	Pork	0.27	Cookies and biscuits	0.46	Cheese	0.63	Milk	0.57	Modified milk powder	0.34
3	Cookies and biscuits	0.39	White rice	0.37	Milk	0.38	Bread	0.50	Modified milk powder	0.78	White rice	0.68	Persimmon	0.42
4	Milk	0.45	Milk	0.46	Soybean oil	0.46	Rice cake	0.54	Milk powder	0.84	Milk powder	0.71	White rice	0.48
5	Cheese	0.49	Cheese	0.54	Cookies and biscuits	0.54	Apple	0.57	Yoghurt (curd type)	0.87	Egg	0.73	Oriental melon	0.53
6	Bread	0.54	Pork	0.61	Cake	0.60	Instant noodle	0.60	Anchovy	0.89	Modified milk powder	0.76	Radish leaves	0.57
7	Instant noodle	0.57	Egg	0.66	Modified milk powder	0.65	Glutinous rice	0.63	Shrimp	0.90	Garlic	0.78	Onion	0.61
8	Pork	0.60	Modified milk powder	0.69	Beef	0.68	Noodle	0.66	Ice cream	0.91	Yoghurt (curd type)	0.79	Cookies and biscuits	0.63
9	Cake	0.63	Bread	0.71	Instant noodle	0.71	Sweet potato	0.68	Soy milk	0.92	Pork	0.81	Rice cake	0.66
10	Modified milk powder	0.65	Milk powder	0.72	Bread	0.74	Cake	0.70	Tofu	0.93	Anchovy	0.82	Laver	0.69
	Sodium		Potassium		Vitamin A		Thiamin		Riboflavin		Niacin		Vitamin C	
1	Salt	0.22	Milk	0.12	Modified milk powder	0.20	Yoghurt (liquid type)	0.26	Milk	0.33	White rice	0.11	Mandarin orange	0.34
2	Soy sauce	0.33	Oriental melon	0.23	Persimmon	0.36	Pork	0.44	Modified milk powder	0.43	Pork	0.21	Strawberry	0.58
3	Cheese	0.42	Onion	0.32	Beef	0.49	White rice	0.55	Egg	0.54	Modified milk powder	0.30	Apple	0.65
4	Kimchi[2)]	0.49	White rice	0.38	Carrot	0.59	Mandarin orange	0.61	Milk powder	0.58	Chicken	0.37	Fruit juice	0.71
5	Fermented soybean paste	0.55	Sweet potato	0.43	Laver	0.68	Milk	0.64	Laver	0.62	Cereals	0.43	Orange	0.77
6	Seaweed	0.61	Seaweed	0.48	Mandarin orange	0.72	Modified milk powder	0.67	Cheese	0.66	Beef	0.48	Persimmon	0.81
7	Black soybean paste	0.65	Mandarin orange	0.53	Watermelon	0.76	Instant noodle	0.70	Mandarin orange	0.69	Mackerel	0.52	Potato	0.84
8	Whole radish kimchi	0.69	Potato	0.56	Cheese	0.79	Cereals	0.73	Cereals	0.72	Cookies and biscuits	0.56	Cereals	0.86
9	Instant noodle	0.73	Persimmon	0.59	Milk	0.82	Potato	0.75	Strawberry	0.74	Mandarin orange	0.59	Modified milk powder	0.88
10	Mackerel	0.75	Chicken	0.61	Soups	0.85	Chicken	0.77	Garlic	0.77	Tuna	0.61	Kiwi	0.90
1-2 yrs														
	Energy		Protein		Fat		Carbohydrate		Calcium		Phosphorus		Iron	
1	White rice	0.30	Beef	0.14	Milk	0.16	White rice	0.47	Milk	0.39	Milk	0.24	Isotonic drink	0.27
2	Milk	0.38	White rice	0.25	Modified milk powder	0.33	Persimmon	0.51	Modified milk powder	0.78	White rice	0.45	Modified milk powder	0.49
3	Modified milk powder	0.46	Milk	0.36	Soybean oil	0.42	Rice cake	0.55	Cheese	0.83	Cheese	0.56	Persimmon	0.56
4	Soybean oil	0.50	Chicken	0.46	Pork	0.48	Instant noodle	0.58	Yoghurt (curd type)	0.87	Modified milk powder	0.66	White rice	0.62
5	Instant noodle	0.54	Modified milk powder	0.55	Instant noodle	0.52	Bread	0.61	Soymilk	0.89	Garlic	0.69	Oriental melon	0.66
6	Bread	0.57	Egg	0.61	Cookies and biscuits	0.57	Orange	0.63	Shrimp	0.91	Yoghurt (curd type)	0.72	Garlic	0.69
7	Cookies and biscuits	0.60	Pork	0.65	Cake	0.61	Sweet potato	0.66	Anchovy	0.92	Egg	0.74	Soymilk	0.72
8	Rice cake	0.63	Mackerel	0.68	Cheese	0.65	Glutinous rice	0.68	Milk powder	0.93	Soymilk	0.76	Yellow croaker	0.74
9	Rape seed oil	0.65	Soymilk	0.70	Soymilk	0.69	Modified milk powder	0.71	Icefish	0.94	Onion	0.77	Laver	0.76
10	Sweet potato	0.67	Tofu	0.73	Rape seed oil	0.72	Pear	0.73	Tofu	0.95	Soybeans	0.79	Radish leaves	0.78
	Sodium		Potassium		Vitamin A		Thiamin		Riboflavin		Niacin		Vitamin C	
1	Salt	0.25	Milk	0.13	Modified milk powder	0.50	Yoghurt (liquid type)	0.38	Milk	0.33	Modified milk powder	0.21	Strawberry	0.30
2	Soy sauce	0.34	Potato	0.24	Persimmon	0.64	White rice	0.51	Modified milk powder	0.60	White rice	0.37	Mandarin orange	0.59
3	Whole radish kimchi	0.42	Persimmon	0.31	Carrot	0.71	Pork	0.58	Egg	0.68	Pork	0.43	Orange	0.68
4	Black soybean pastes	0.50	Oriental melon	0.38	Laver	0.76	Modified milk powder	0.65	Laver	0.71	Mackerel	0.49	Modified milk powder	0.73

Table 3. continued

Rank	Foods	Cum R^2	Foods	Cum R^2	Foods	Cum R^2	Foods	Cum R^2	Foods	Cum R^2	Foods	Cum R^2	Foods	Cum R^2
5	Kimchi	0.56	White rice	0.43	Mandarin orange	0.80	Milk	0.70	Soymilk	0.75	Chicken	0.54	Fruit juice	0.77
6	Fermented soybean pastes	0.61	Modified milk powder	0.50	Milk	0.83	Mandarin orange	0.75	Strawberry	0.78	Cereal	0.58	Apple	0.82
7	Mackerel	0.65	Sweet potato	0.54	Soups	0.85	Instant noodle	0.77	Mandarin orange	0.81	Yellow croaker	0.61	Potato	0.85
8	Instant noodle	0.70	Garlic	0.59	Watermelon	0.88	Orange	0.80	Yoghurt (curd type)	0.83	Beef	0.64	Persimmon	0.87
9	Seaweed	0.73	Pear	0.63	Soymilk	0.89	Potato	0.82	Garlic	0.85	Duck meat	0.67	Kiwi	0.89
10	Cheonggukjang (fermented soybean)	0.75	Mandarin orange	0.66	Spinach	0.90	Cereal	0.84	Cereal	0.87	Tuna	0.69	Cereal	0.91
3-5 yrs														
	Energy		Protein		Fat		Carbohydrate		Calcium		Phosphorus		Iron	
1	White rice	0.19	Chicken	0.15	Cheese	0.19	White rice	0.34	Milk	0.40	Cheese	0.52	Isotonic drink	0.28
2	Cookies and biscuits	0.28	Beef	0.30	Pork	0.33	Cookies and biscuits	0.41	Cheese	0.76	Milk	0.67	Persimmon	0.35
3	Soybean oil	0.36	Cheese	0.41	Milk	0.42	Bread	0.46	Milk powder	0.84	White rice	0.73	White rice	0.42
4	Cheese	0.43	Milk	0.50	Cookies and biscuits	0.52	Rice cake	0.50	Yoghurt (curd type)	0.87	Milk powder	0.77	Oriental melon	0.47
5	Milk	0.49	White rice	0.58	Soybean oil	0.61	Apple	0.54	Anchovy	0.89	Egg	0.79	Radish leaves	0.52
6	Bread	0.54	Pork	0.65	Cake	0.67	Potato chips	0.57	Ice cream	0.90	Onion	0.81	Cookies and biscuits	0.57
7	Cake	0.57	Egg	0.70	Beef	0.71	Glutinous rice	0.59	Shrimp	0.92	Anchovy	0.82	Rice cake	0.60
8	Pork	0.61	Milk powder	0.72	Potato chips	0.73	Noodle	0.62	Tofu	0.93	Chicken	0.84	Onion	0.64
9	Instant noodle	0.63	Bread	0.74	Ice cream	0.76	Cake	0.64	Seaweed	0.93	Yoghurt (curd type)	0.85	Laver	0.66
10	Rice cake	0.66	Soybeans	0.75	Chicken	0.78	Sweet potato	0.67	Bread	0.94	Pork	0.86	Little neck clam	0.69
	Sodium		Potassium		Vitamin A		Thiamin		Riboflavin		Niacin		Vitamin C	
1	Salt	0.17	Milk	0.12	Beef	0.21	Yoghurt (liquid type)	0.23	Milk	0.34	Pork	0.11	Mandarin orange	0.37
2	Cheese	0.31	Oriental melon	0.25	Persimmon	0.39	Pork	0.44	Egg	0.46	White rice	0.2	Strawberry	0.57
3	Soy sauce	0.42	Onion	0.34	Carrot	0.5	White rice	0.53	Milk powder	0.53	Chicken	0.28	Apple	0.67
4	Seaweed	0.49	Seaweed	0.41	Laver	0.61	Mandarin orange	0.60	Cheese	0.58	Cereal	0.35	Fruit juice	0.74
5	Fermented soybean pastes	0.57	Sweet potato	0.46	Cheese	0.67	Milk	0.64	Mandarin orange	0.62	Beef	0.42	Persimmon	0.78
6	Kimchi	0.63	Mandarin orange	0.50	Mandarin orange	0.72	Fruit juice	0.67	Laver	0.66	Cookies and biscuits	0.48	Orange	0.82
7	Instant noodle	0.66	White rice	0.54	Watermelon	0.76	Instant noodle	0.70	Cereal	0.69	Mandarin orange	0.51	Potato	0.85
8	Black soybean pastes	0.70	Potato	0.57	Soups	0.79	Cereal	0.72	Bread	0.72	Tuna	0.55	Cereal	0.88
9	Whole radish kimchi	0.73	Persimmon	0.60	Milk	0.82	Chicken	0.74	Chicken	0.74	Mackerel	0.58	Oriental melon	0.90
10	Potato chips	0.75	Chicken	0.63	Perilla leaves	0.85	Potato	0.77	Strawberry	0.77	Processed meat (pork)	0.61	Sweet potato	0.91

[1] To assess the contribution of specific foods to between-person variations in nutrient intake, stepwise multiple regressions were performed and cumulative R^2 was used.
[2] Traditional fermented cabbage product.

Table 4. Number of foods accounting for absolute nutrient intakes and between-person variation of nutrient intakes

	Absolute nutrient intake		Between-person variation[1)]	
	90%	80%	90%	80%
Energy	56	30	35	21
Protein	54	30	29	16
Fat	38	21	20	13
Carbohydrate	44	23	30	18
Calcium	40	17	8	4
Phosphorus	54	28	21	9
Iron	80	49	34	18
Sodium	44	27	23	13
Potassium	64	40	37	22
Vitamin A	28	17	13	9
Thiamin	56	31	24	12
Riboflavin	48	24	20	12
Niacin	61	35	33	20
Vitamin C	29	18	11	6

[1)] Data were obtained from the stepwise regression analysis.

contributor to energy and nutrient intakes. Thai National Health Examination Survey has reported that grains and starchy products are major contributors to energy and carbohydrate among 1-5-year-old children [6]. White rice is the main contributor to energy, carbohydrate, protein, phosphorus, potassium, and iron in the entire Korean population according to a report of Korea Health Statistics in 2016 [19]. In preschoolers from Western studies, cereals, bread, and pasta are commonly observed as major food sources of energy and carbohydrate [4,5].

Milk provided large proportion of energy and nutrients in preschoolers in the present study, consistent with other previous studies in Western countries [4,7,9] and Asia [6,8]. Among younger children aged 1-2 years in this study, modified milk powder also contributed to energy and nutrient intakes. Milk has been found to be the most important food source of energy and nutrient intakes until the age of 2 years [4,7,8]. Among US toddlers aged 12-24 months in the 2005-2012 NHANES, milk was ranked as the first food source of energy, protein, fat, carbohydrate, vitamin A, and potassium [7].

In the current study, foods rich in micronutrients were ranked as top 10 food sources. For example, milk and dairy products accounted for more than 60% of calcium intake while fruits were main food contributors to vitamin C intake. Among 696 Flemish preschoolers aged 2.5-6.5 years, milk, sweetened milk drinks, and cheese accounted for 59% of calcium intake [20] while sugared milk drinks, fried potatoes, milk, and fruit juices were main potassium sources [21]. In a sample of Australian preschool children with mean age of 3.5 years, key contributors to potassium intake were milk, yogurt, tropical fruit, and potatoes [22,23]. Fruits and vegetables were main sources of vitamin C intake in young children aged 10-48 months in the Netherlands [5].

Energy-dense but low-nutrient food items such as sugar sweetened beverages, sweet bread, cakes, cookies, biscuits, and sweet desserts also provided substantial amounts of energy and fat among young children [3-5,24]. Based on data from 2010-2011 Irish National Preschool Nutrition Survey, the proportion of energy intake from cakes, biscuits, and sweet desserts increased with age [24]. In addition, this dietary habit was observed in school-aged children and adolescents [25,26]. These findings might be related to increased prevalence of childhood obesity in Western countries [27]. Identifying principal source of energy and nutrient among young children is necessary to provide effective nutritional strategies for the prevention and management of childhood obesity.

One more concern for some young children' diets was higher cheese consumption. Cheese was included in the top 10 food sources for fat and sodium intakes in this study. It was also highly ranked in food lists for fat and sodium variations (the first on fat and the third on sodium food lists). Fat and sodium are major dietary components that are nationally monitored and controlled to prevent non-communicable chronic diseases. On the other hand, cheese together with other dairy products was a major source for calcium of important nutrient for growing children. Caregivers' attention to adequate consumption of cheese is needed to prevent over-nutrition for fat or sodium. Low sodium products or replacement with healthy unsaturated fat sources also need to be considered.

In this study, the top 10 food items explained about 61-93% of between-person variances in energy and nutrient intakes. White rice accounted for a large portion of variability of energy and carbohydrate intake while milk was the major contributor to variation in intakes of calcium, potassium, and riboflavin among Korean young children. The calculation of between-person variation in nutrient intake was used for the selection of foods to be included in the process of developing FFQ [2,11,12]. Similar to our finding, a previous study on the development of FFQ for Japanese children has identified that white rice is the most predictive food of between-person variations in energy and protein intakes and milk is also a major contributor to variation in energy, protein, and fat [2].

We found that for some nutrients, there were differences between major variation foods and major food sources. For example, soybean oil, cheese, instant noodles (ramen), and cake were listed in the top 10 foods of between-person variations in energy intake. However, they were not in the top 10 food sources of energy intake. In terms of carbohydrate, instant noodles, noodles, sweet potato, and cake were observed as between-person variation foods, although these food items were not major food sources. In addition, white rice was relatively a less important food in micronutrients except niacin in explaining between-person variability.

Depending on nutrients, the number of foods required to explain source of energy and nutrients or between-person variations varied. According to our data, 90% of absolute intake was estimated with relatively small number of food items (less than 30 items) for vitamin A and vitamin C while large number of food items were necessary for iron (80 items) and potassium (64 items) due to various food sources. Fewer foods were needed to account for a proportion of between-person variance in intake than those needed to explain the same proportion of study subjects' total intake. Most nutrients required less than 20 food items to account for 80% of between-person variations. In the case of total fat, the top 10 foods in our study explained

much larger proportions of absolute intake and between-person variations compared to the top 10 foods observed in a Korean study on adults [28]. This finding implies that young children show lower levels of dietary diversity than adult population. In addition, this study showed that children aged 1-2 years had lower diversity in terms of food intake compared to those aged 3-5 years.

This study has several limitations. Dietary data obtained from a single 24-h dietary recall may not represent the usual intake of energy and nutrients. In addition, reporting on young children's diets by parents or caregivers could lead to under- or over-estimation of dietary intakes. Our analysis did not consider the consumption of breast milk or dietary supplements due to the lack of database. Despite these limitations, to the best of our knowledge, this is the first study to provide information on food consumption patterns influencing energy and nutrient intakes among preschool aged children in Korea. Our findings could be used to develop dietary assessment tools, including a food list for FFQ and establish food-based dietary guidelines for this specific age group. In addition, the current study might be helpful to suggest effective dietary strategies for the prevention of childhood obesity based on understanding of food intake patterns of preschoolers.

In conclusion, this study reported specific foods associated with energy and nutrient intakes as well as between-person variations in these intakes among young Korean children. As food consumption patterns vary according to age, sex, race/ethnicity, or country, our findings could help identify food items that are important for diets of Korean preschoolers. Understanding current food consumption related energy and nutrients in young children is needed to establish effective dietary guidelines and apply appropriate intervention.

CONFLICT OF INTEREST

The authors declare no potential conflicts of interests.

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