

# Relationship between adhering to dietary guidelines and the risk of obesity in Korean children

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**BACKGROUND/OBJECTIVES:** Dietary guidelines for Korean children were released in 2009. The goal of the present study was to examine diet quality in terms of adherence to these dietary guidelines as well as explore the association between guideline adherence and risk of obesity in Korean children.

**SUBJECTS/METHODS:** Children aged 5-11 years (mean age = 8.9 years old, n = 191, 80.6% girls) were recruited from a university hospital in Seoul, Korea. Adherence to dietary guidelines for Korean children was calculated using the Likert scale (1-5), and children were then categorized into low, moderate, and high groups based on adherence scores. Obesity or being overweight was determined based on an age- and gender- specific percentile for body mass index (BMI) of the 2007 Korean National Growth Charts. Diet quality was evaluated from 3 days of dietary intake data.

**RESULTS:** Children in the high adherence group were characterized by significantly lower BMI percentiles and paternal BMIs as well as higher percentages of fathers with a high level of education and higher household incomes compared to those in the low or moderate group. Children in the high adherence group consumed significantly higher amounts of milk and dairy products, were less likely to consume lower than the EAR of phosphorus and iron, and had higher NARs for calcium, phosphorus, iron, zinc, and MAR than those in low groups. The ORs for obesity (BMI  $\geq$  95<sup>th</sup> percentile) or being overweight including obesity (BMI  $\geq$  85<sup>th</sup> percentile) were significantly lower in the high adherence group compared to the low adherence group (OR: 0.33, 95% CI = 0.13-0.82, *P* for trend = 0.019; OR: 0.26, 95% CI: 0.11-0.61 *P* for trend = 0.002).

**CONCLUSIONS:** Korean children who adhered to dietary guidelines displayed better diet quality and a reduced risk of obesity.

Nutrition Research and Practice 2014;8(6):705-712; doi:10.4162/nrp.2014.8.6.705; pISSN 1976-1457 eISSN 2005-6168

**Keywords:** Children, obesity, adherence, dietary guidelines, Korean

## INTRODUCTION

The number of overweight and obese children has increased worldwide in recent years and is now a significant public health problem. According to the 2013 Korea School Health Examination, the prevalence of obesity in children and adolescents increased from 13.2% in 2009 to 15.3% in 2013 in South Korea [1]. Overweight and obese children may suffer psychological and social problems and are more likely to be diagnosed with metabolic diseases such as metabolic syndrome [2,3], diabetes [4, 5] and chronic diseases in adulthood [6].

Even though there are many contributing factors associated with childhood obesity, the key modifiable factors are diet and physical activity. As with many other countries, Korea has experienced rapid economic development, Westernization of diets, and an increasingly sedentary lifestyle. Several studies on

Korean children have demonstrated imbalanced nutrient intake [7,8] and poor dietary behaviors such as skipping breakfast [7-10], frequent unhealthy snacking [11], excessive dieting among girls [12-13], and reduced physical activity [7,14].

In 2009, the Ministry of Health and Welfare in Korea released dietary guidelines for Korean children aged 3-11 years, with a focus on improving overall diet quality and thus preventing childhood obesity. The guidelines were developed to satisfy the goals of the 2010 Health Plan of Korea using an evidence-based approach based on data from the Korea National Health and Nutrition Examination Survey (KNHANES). After professional review, dietary guidelines for Korean children were finalized into five categories and 19 specific statements with emphasis on adequate micronutrient intake, maintenance of proper body weight, reduction of sodium intake, and healthy dietary behaviors (Table 2) [15].

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Received: January 21, 2014, Revised: August 5, 2014, Accepted: August 6, 2014

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**Table 1.** General characteristics of Korean children by adherence level to dietary guidelines

	Adherence level								P value <sup>1)</sup>
	Total (45-88) (n = 191)		Low (45-64) (n = 60)		Moderate (65-72) (n = 68)		High (73-88) (n = 63)		
	n	%	n	%	n	%	n	%	
Age									
5-6 yrs	8	4.2	3	5.0	3	4.4	2	3.2	0.864
7-8 yrs	100	52.4	28	46.7	37	54.4	35	55.6	
9-11 yrs	83	43.5	29	48.3	28	41.2	26	41.3	
Gender									
Girls	154	80.6	48	80.0	57	83.8	49	77.8	0.675
Height (cm) <sup>2)</sup>	135	0.6	136.6	1.0 <sup>a</sup>	133.5	0.9 <sup>b</sup>	135.2	1.5 <sup>ab</sup>	0.085
Weight (kg) <sup>2)</sup>	36.1	0.7	38.8	1.3 <sup>a</sup>	35.4	0.9 <sup>b</sup>	34.2	1.1 <sup>b</sup>	0.007
BMI percentiles									
5 <sup>th</sup> -84 <sup>th</sup>	93	48.7	18	30.0	34	50.0	41	65.1	0.003
85 <sup>th</sup> -94 <sup>th</sup>	37	19.4	15	25.0	12	17.7	10	15.9	
≥ 95 <sup>th</sup>	61	31.9	27	45.0	22	32.4	12	19.0	
Parental BMI (kg/m <sup>2</sup> ) <sup>2)</sup>									
Father	24.8	0.2	25.2	0.4 <sup>a</sup>	25.3	0.4 <sup>a</sup>	24.0	0.4 <sup>a</sup>	0.040
Mother	22.6	0.2	23.4	0.5 <sup>a</sup>	22.4	0.4 <sup>a</sup>	22.1	0.4 <sup>a</sup>	0.088
Physical activity <sup>3)</sup>									
Low	16	8.8	8	13.8	5	7.7	3	5.2	0.334
Moderate	113	62.4	36	62.1	43	66.2	34	58.6	
Vigorous	52	28.7	14	24.1	17	26.2	21	36.2	
Parental education level									
Father (≥ college)	140	74.5	42	72.4	43	64.2	55	87.3	0.010
Mother (≥ college)	122	63.9	37	61.7	41	60.3	44	69.8	0.478
Parental employment									
Father (Yes)	186	99.5	56	98.3	67	100.0	63	100.0	0.318
Mother (Yes)	73	38.6	25	42.4	26	38.2	22	35.5	0.736
Household income (1,000 KRW/month)									
< 3,000	27	14.1	10	16.7	11	16.2	6	9.5	0.022
3,000-5,999	121	63.4	39	65.0	48	70.6	34	54.0	
≥ 6,000	43	22.5	11	18.3	9	13.2	23	36.5	

<sup>1)</sup> Continuous variables were tested using General Linear Model (GLM) adjusted for age and sex. Tukey's multiple comparison test was used as the post-hoc test; Categorical variables were tested by chi-square test.

<sup>2)</sup> Mean ± SE.

<sup>3)</sup> Low activity: < 600 (MET-min/week), Moderate: 600-2999 (MET-min/week), and Vigorous: 3,000 ≤ (MET-min/week); International Physical Activity Questionnaires (IPAQ) [19].

**Table 2.** 2009 dietary guidelines for Korean children

Components
Category 1: Eat a variety of foods
Eat a balanced diet
Eat a variety of vegetables at every meal
Eat protein foods (fish, lean meat, beans, eggs, and so on) once or more per day
Drink two cups of milk every day
Category 2: Be active and consume appropriate amounts of food
Perform physical activity one or more hours per day
Know and maintain proper age-specific height and weight
Limit television watching or playing computer games to less than two hours per day
Eat appropriate amount of snacks and meals regularly
Category 3: Keep regular mealtimes and eat less salt
Eat breakfast every day
Eat slowly and chew foods well
Eat less salty, sugary, and fatty foods
Category 4: Choose snacks safely and wisely
Eat fresh fruits and drink milk for snacking
Avoid frequent consumption of confectioneries, soda, and fast food
Be able to recognize and avoid unhealthy foods
Select foods after checking nutrition labels and expiration dates
Category 5: Eat meals with your family and have good table manners
Try to eat meals with your family
Wash hands before eating
Sit properly on your chair while eating to show gratitude
Only take the amount of food you will actually eat and avoid wasting food

However, very few studies have evaluated the relationship between adhering to these dietary guidelines and obesity in Korean children. Thus, the aim of this study was to evaluate how adherence to dietary guidelines is related with diet quality, which includes food, energy, and nutrient intakes, as well as the relationship between guideline adherence and risk of obesity in Korean children.

## SUBJECTS AND METHODS

### Subjects

From March to September 2011, 256 children aged 5-11 years who visited a growth clinic at Inje University Sanggye Paik Hospital for general growth evaluation in Seoul, Korea were recruited. Of these 256 children, those with incomplete anthropometric measurements, questionnaires, or 3-day dietary intake data were excluded. After applying the exclusion criteria, 191 children were enrolled in the study. This study was performed according to the Declaration of Helsinki, and the Institutional Review Board at Inje University Sanggye Paik Hospital approved all study procedures. Before study participation, all children and their parents provided written informed consent.

### *Adherence to dietary guidelines*

Adherence to dietary guidelines for Korean children was evaluated using a five-point Likert scale ranging from strongly disagree (1) to strongly agree (5). Children were grouped into tertiles according to adherence scores, but due to tie scores, subjects were classified as 45-64 ( $n = 60$ ), 65-72 ( $n = 68$ ), and 73-88 ( $n = 63$ ). Children in the lowest tertile were considered to be in the low adherence group, those in the second tertile were moderate, and those in the highest tertile were in the high adherence group. A parent or caregiver assisted in responding to the interviewer's questions regarding dietary guidelines depending on the child's age.

### *Dietary assessment*

Dietary intake was obtained from 1- and 2-day 24 hr recall food records, which included 2 weekdays and 1 weekend day. Food records included questions about food ingredients, brand name, portion size, as well as food and drink names. During the first visit, trained interviewers provided detailed verbal and written instructions to the parent or caregiver present with the child. Parents were instructed to record the child's food records with the child using food models and pictures in the provided journal. Moreover, 1-day 24 hr recall was carried out at the hospital on the first visit and recorded at home an additional 2 days out of the week. During the second visit, trained interviewers reviewed all food records of the children brought by the parents or caregivers through a face-to-face interview in order to obtain any missing information.

Dietary data were coded, and food and nutrient intakes were calculated using the CAN-Pro 3.0 (The Korean Nutrition Society, 2003). The 3-day dietary data were used to calculate average daily nutrient and energy intakes. Recipes in the Can-Pro 3.0 were revised based on children's 3-day dietary intake data. Foods were categorized as one of the following 17 groups: grains & grain products, potatoes, sugars & sweets, legumes, nuts & seeds, vegetables, mushrooms, fruits, meat & meat products, eggs, fish & shellfish, seaweed, milk & dairy products, beverages, seasonings, oil, and animal fat. Macronutrient intakes as percentages of total energy intake were also calculated. Age- and sex-specific Estimated Energy Requirement (EER) or Estimated Average Requirement (EAR) of Dietary Reference Intakes for Koreans (KDRIs) was used to evaluate energy or nutrient intake in children [16]. To evaluate overall diet quality of children, the Mean Adequacy Ratio (MAR) was determined as a mean of the Nutrient Adequacy Ratios (NARs) for the 11 nutrients (protein, calcium, phosphorus, iron, zinc, vitamin A, thiamin, riboflavin, niacin, vitamin C, and folate). NARs for each nutrient were calculated as the ratio of personal daily nutrient intakes to Recommended Nutrient Intake (RNIs) for Koreans [16] and truncated at 1.

### *Anthropometric measurements and definition of childhood obesity*

Height and weight were measured using a JENIX stadiometer, after which BMI ( $\text{kg}/\text{m}^2$ ) was calculated. Children wore light clothes and no shoes when measured. Children were classified as obese if they were at or above the 95<sup>th</sup> percentile for age- and gender- specific BMI, and children were considered overweight if  $85^{\text{th}} \leq \text{BMI percentile} < 95^{\text{th}}$  on the Korean National Growth Charts (2007) [17]. Children in the 5<sup>th</sup>-84<sup>th</sup> percentiles

of BMI were classified as normal. There were no children below the 5<sup>th</sup> percentile of BMI.

### *Potential confounders*

General characteristics, including age and sex, were collected. In addition, parents' self-reported heights and weights were considered to control for genetic factors. Parents' BMIs ( $\text{kg}/\text{m}^2$ ) were calculated, and parental obesity was defined as a BMI of 25 or over according to the Korean definition of adult obesity [18]. Due to the impact of socio-economic status on children's weight [8], relevant variables such as parental employment, parental education level, and monthly household income were collected. Parental employment was categorized as either "yes" or "no" (If parents' primary responsibility was care of the child and/or household, employment status was considered "no"). Parental education level was categorized as either (1) college level or higher; (2) secondary education or lower. Monthly household income was classified as: (1)  $< 3,000,000$  KRW; (2)  $3,000,000$ - $5,999,999$  KRW; or (3)  $\geq 6,000,000$  KRW, where 1,100 Korean won was considered equal to approximately one US dollar. To assess children's health behaviors as they relate to weight, physical activity levels were classified as low, moderate, and vigorous based on the International Physical Activity Questionnaire (IPAQ) [19].

Trained interviewers collected information, and all information in this study was provided by children with parent or caregiver assistance.

### *Statistical analysis*

All statistical analyses were performed using SAS version 9.3 (SAS Institute Inc., Cary, NC, USA). Continuous variables were tested across tertiles of adherence scores using Generalized Linear Model (GLM) adjusted for potential confounding variables. Categorical variables were tested by  $\chi^2$ -test. Multivariate logistic regression analysis was performed to estimate odds ratios and 95% Confidence Intervals (CI) to assess risk of obesity or being overweight including obesity across tertiles of adherence scores after adjusting for age, sex, paternal BMI, paternal education level, and monthly household income. Statistical significance was defined as  $P < 0.05$  (two sided).

## **RESULTS**

### *General characteristics by level of adherence*

As shown in Table 1, there was no difference in age or gender across the groups. Children in the high adherence group had a significantly lower body weight and BMI percentiles than those in the low or moderate adherence group ( $P = 0.007$  and  $0.003$ ). Fathers with children in the high adherence group were more likely to have a lower BMI and higher level of education compared to fathers with children in the low or moderate group ( $P = 0.040$  and  $0.010$ ). Children in the high adherence group also had a higher household income compared to those in the low or moderate group ( $P = 0.022$ ). Children in the high adherence group showed significantly higher scores for all dietary guidelines compared to those in lower adherence groups ( $P$  for trend =  $0.001$ ; Table 3).

**Table 3.** Comparison of adherence to each item by adherence level to dietary guidelines in Korean children

	Adherence level								P for trend <sup>1)</sup>
	Total (45-88) (n = 191)		Low (45-64) (n = 60)		Moderate (65-72) (n = 68)		High (73-88) (n = 63)		
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	
Total mean score	68.8	0.6	59.3	0.6 <sup>c</sup>	68.4	0.3 <sup>b</sup>	78.2	0.5 <sup>a</sup>	0.001
Eat a variety of foods	13.7	0.2	11.6	0.3 <sup>c</sup>	13.8	0.3 <sup>b</sup>	15.8	0.3 <sup>a</sup>	0.001
Eat a balanced diet	3.2	0.1	2.3	0.1 <sup>b</sup>	3.3	0.1 <sup>a</sup>	3.8	0.1 <sup>a</sup>	0.001
Eat a variety of vegetables at every meal	2.8	0.1	2.2	0.1 <sup>b</sup>	2.9	0.1 <sup>b</sup>	3.2	0.1 <sup>a</sup>	0.001
Eat protein foods (fish, lean meat, beans, eggs, and so on) once or more per day	4.1	0.1	3.8	0.1 <sup>b</sup>	4.1	0.1 <sup>b</sup>	4.5	0.1 <sup>a</sup>	0.001
Drink two cups of milk every day	3.6	0.1	3.2	0.2 <sup>b</sup>	3.4	0.1 <sup>b</sup>	4.2	0.1 <sup>a</sup>	0.001
Be active and consume appropriate amounts of food	12.9	0.2	10.8	0.3 <sup>c</sup>	12.8	0.3 <sup>b</sup>	15.1	0.3 <sup>a</sup>	0.001
Perform physical activity one or more hours per day	3.4	0.1	3.0	0.2 <sup>b</sup>	3.4	0.2 <sup>ab</sup>	3.7	0.2 <sup>a</sup>	0.001
Know and maintain proper age-specific height and weight	2.5	0.1	2.1	0.1 <sup>b</sup>	2.4	0.1 <sup>b</sup>	3.0	0.1 <sup>a</sup>	0.001
Limit television watching or playing computer games to less than two hours per day	3.6	0.1	2.9	0.2 <sup>c</sup>	3.6	0.1 <sup>b</sup>	4.4	0.1 <sup>a</sup>	0.001
Eat appropriate amount of snacks and meals regularly	3.5	0.1	2.9	0.1 <sup>c</sup>	3.5	0.1 <sup>b</sup>	3.9	0.1 <sup>a</sup>	0.001
Keep regular mealtimes and eat less salt	10.5	0.2	8.9	0.2 <sup>c</sup>	10.4	0.2 <sup>b</sup>	12.1	0.2 <sup>a</sup>	0.001
Eat breakfast every day	4.4	0.1	3.9	0.2 <sup>b</sup>	4.5	0.1 <sup>a</sup>	4.7	0.1 <sup>a</sup>	0.001
Eat slowly and chew foods well	3.1	0.1	2.6	0.1 <sup>b</sup>	3.0	0.1 <sup>b</sup>	3.7	0.2 <sup>a</sup>	0.001
Eat less salty, sugary, and fatty foods	3.0	0.1	2.3	0.1 <sup>c</sup>	2.9	0.1 <sup>b</sup>	3.7	0.1 <sup>a</sup>	0.001
Choose snacks safely and wisely	15.4	0.2	13.7	0.3 <sup>c</sup>	14.9	0.2 <sup>b</sup>	17.5	0.3 <sup>a</sup>	0.001
Eat fresh fruits and drink milk for snacking	3.6	0.1	3.0	0.1 <sup>c</sup>	3.5	0.1 <sup>b</sup>	4.2	0.1 <sup>a</sup>	0.001
Avoid frequent consumption of confectioneries, soda, and fast food	3.4	0.1	3.0	0.1 <sup>b</sup>	3.2	0.1 <sup>b</sup>	4.1	0.1 <sup>a</sup>	0.001
Be able to recognize and avoid unhealthy foods	4.0	0.1	3.7	0.1 <sup>b</sup>	3.9	0.1 <sup>b</sup>	4.5	0.1 <sup>a</sup>	0.001
Select foods after checking nutrition labels and expiration dates	4.3	0.1	4.0	0.1 <sup>b</sup>	4.3	0.1 <sup>ab</sup>	4.6	0.1 <sup>a</sup>	0.001
Eat meals with your family and have good table manners	16.3	0.2	14.4	0.3 <sup>c</sup>	16.5	0.2 <sup>b</sup>	17.8	0.2 <sup>a</sup>	0.001
Try to eat meals with your family	4.3	0.1	3.9	0.1 <sup>b</sup>	4.2	0.1 <sup>b</sup>	4.7	0.1 <sup>a</sup>	0.001
Wash hands before eating	4.1	0.1	3.4	0.1 <sup>b</sup>	4.4	0.1 <sup>a</sup>	4.6	0.1 <sup>a</sup>	0.001
Sit properly on your chair while eating to show gratitude	3.8	0.1	3.4	0.1 <sup>b</sup>	3.9	0.1 <sup>a</sup>	4.3	0.2 <sup>a</sup>	0.001
Only take the amount of food you will actually eat and avoid wasting food	4.0	0.1	3.7	0.1 <sup>b</sup>	4.1	0.1 <sup>a</sup>	4.3	0.1 <sup>a</sup>	0.001

<sup>1)</sup> P for trend was tested using General Linear Model (GLM) adjusted for age, sex, children's BMI percentiles, paternal BMI, paternal education level, and household income. Tukey's multiple comparison test was used as the post-hoc test.

**Table 4.** Daily food, energy intakes, and percent of energy by adherence level to dietary guidelines in Korean children

	Adherence level								P for trend <sup>1)</sup>
	Total (45-88) (n = 191)		Low (54-64) (n = 60)		Moderate (65-72) (n = 68)		High (73-88) (n = 63)		
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	
Food groups (g)									
Grains & grain products	240.2	4.6	244.4	8.8 <sup>a</sup>	232.1	6.8 <sup>a</sup>	244.9	8.4 <sup>a</sup>	0.844
Potatoes	21.5	1.9	17.8	2.3 <sup>a</sup>	24.3	3.3 <sup>a</sup>	22.1	3.9 <sup>a</sup>	0.401
Sugars & sweets	8.9	0.6	7.4	0.6 <sup>a</sup>	9.1	1.0 <sup>a</sup>	10.3	1.1 <sup>a</sup>	0.054
Legumes	23.2	2.1	17.7	2.5 <sup>a</sup>	25.0	4.0 <sup>a</sup>	26.5	4.1 <sup>a</sup>	0.050
Nuts & seeds	3.7	0.5	2.9	0.8 <sup>a</sup>	4.7	1.0 <sup>a</sup>	3.3	0.8 <sup>a</sup>	0.366
Vegetables	166.8	7.9	150.7	9.6 <sup>a</sup>	173.1	13.6 <sup>a</sup>	175.1	16.4 <sup>a</sup>	0.307
Mushrooms	4.5	0.5	4.7	0.9 <sup>a</sup>	4.3	0.8 <sup>a</sup>	4.5	0.8 <sup>a</sup>	0.934
Fruits	132.5	8.2	115.5	17.1 <sup>a</sup>	141.4	11.1 <sup>a</sup>	139.1	14.6 <sup>a</sup>	0.359
Meat & meat products	87.6	4.4	97.6	8.9 <sup>a</sup>	79.3	5.8 <sup>a</sup>	87.2	8.2 <sup>a</sup>	0.307
Eggs	29.1	1.6	26.5	2.6 <sup>a</sup>	28.7	2.7 <sup>a</sup>	32.1	2.8 <sup>a</sup>	0.278
Fish & shellfish	39.2	2.1	35.1	3.3 <sup>a</sup>	41.0	3.5 <sup>a</sup>	41.1	4.1 <sup>a</sup>	0.190
Seaweed	2.3	0.2	2.8	0.5 <sup>a</sup>	2.3	0.4 <sup>a</sup>	1.8	0.3 <sup>a</sup>	0.041
Milk & dairy products	255.4	11.7	205.9	15.6 <sup>b</sup>	259.6	18.9 <sup>ab</sup>	298.0	23.7 <sup>a</sup>	0.010
Beverages	34.6	4.4	24.8	5.5 <sup>a</sup>	41.2	8.7 <sup>a</sup>	36.9	7.9 <sup>a</sup>	0.220
Seasonings	25.1	0.8	24.6	1.5 <sup>a</sup>	26.0	1.4 <sup>a</sup>	24.6	1.3 <sup>a</sup>	0.792
Oil	7.3	0.3	7.6	0.4 <sup>a</sup>	7.3	0.4 <sup>a</sup>	6.9	0.5 <sup>a</sup>	0.335
Animal Fat	0.3	0.1	0.2	0.1 <sup>a</sup>	0.2	0.1 <sup>a</sup>	0.4	0.1 <sup>a</sup>	0.189

**Table 4.** continued

	Adherence level								P for trend <sup>1)</sup>
	Total (45-88) (n = 191)		Low (54-64) (n = 60)		Moderate (65-72) (n = 68)		High (73-88) (n = 63)		
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	
Energy (kcal)	1,615.2	24.1	1,590.9	46.2 <sup>a</sup>	1,590.9	36.1 <sup>a</sup>	1,664.5	43.4 <sup>a</sup>	0.254
Percent of energy (%)									
Carbohydrate	57.0	0.4	56.9	6.5 <sup>a</sup>	57.3	5.2 <sup>a</sup>	56.8	6.7 <sup>a</sup>	0.896
Protein	15.9	0.2	15.7	2.1 <sup>a</sup>	15.8	2.3 <sup>a</sup>	16.0	2.6 <sup>a</sup>	0.594
Fat	27.1	0.4	27.4	5.9 <sup>a</sup>	26.9	4.4 <sup>a</sup>	27.2	5.0 <sup>a</sup>	0.689

<sup>1)</sup> P for trend was tested using General Linear Model (GLM) adjusted for age, sex, children's BMI percentiles, paternal BMI, paternal education level, and household income. Tukey's multiple comparison test was used as the post-hoc test.

**Table 5.** Percentages of children that did not meet the Estimated Energy Requirement (EER) (< 75%) or the Estimated Average Requirement (EAR) by adherence level to dietary guidelines in Korean children

	Adherence level								P for trend <sup>1)</sup>
	Total (45-88) (n = 191)		Low (45-62) (n = 60)		Moderate (65-72) (n = 68)		High (73-88) (n = 63)		
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	
Energy <sup>2)</sup>	12.0	2.4	13.3	4.4 <sup>a</sup>	11.8	3.9 <sup>a</sup>	11.1	4.0 <sup>a</sup>	0.639
Protein	0.0	0.0	0.0	0.0 <sup>a</sup>	0.0	0.0 <sup>a</sup>	0.0	0.0 <sup>a</sup>	
Calcium	60.7	3.5	71.7	5.9 <sup>a</sup>	54.4	6.1 <sup>a</sup>	57.1	6.3 <sup>a</sup>	0.114
Phosphorus	5.8	1.7	11.7	4.2 <sup>a</sup>	4.4	2.5 <sup>ab</sup>	1.6	1.6 <sup>b</sup>	0.024
Iron	7.9	2.0	16.7	4.9 <sup>a</sup>	4.4	2.5 <sup>b</sup>	3.2	2.2 <sup>b</sup>	0.006
Zinc	9.4	2.1	13.3	4.4 <sup>a</sup>	10.3	3.7 <sup>a</sup>	4.8	2.7 <sup>a</sup>	0.079
Vitamin A	15.2	2.6	21.7	5.4 <sup>a</sup>	14.7	4.3 <sup>a</sup>	9.5	3.7 <sup>a</sup>	0.113
Thiamin	6.8	1.8	13.3	4.4 <sup>a</sup>	2.9	2.1 <sup>b</sup>	4.8	2.7 <sup>ab</sup>	0.053
Riboflavin	9.4	2.1	15.0	4.6 <sup>a</sup>	8.8	3.5 <sup>a</sup>	4.8	2.7 <sup>a</sup>	0.080
Niacin	2.6	1.2	3.3	2.3 <sup>a</sup>	0.0	0.0 <sup>a</sup>	4.8	2.7 <sup>a</sup>	0.630
Vitamin C	40.8	3.6	48.3	6.5 <sup>a</sup>	30.9	5.6 <sup>b</sup>	44.4	6.3 <sup>ab</sup>	0.490
Folate	74.9	3.1	78.3	5.4 <sup>a</sup>	70.6	5.6 <sup>a</sup>	76.2	5.4 <sup>a</sup>	0.240

<sup>1)</sup> P for trend was tested using General Linear Model (GLM) adjusted for age, sex, children's BMI percentiles, paternal BMI, paternal education level, and household income. Tukey's multiple comparison test was used as the post-hoc test.

<sup>2)</sup> The percentage of children consumed under 75% of the EER.

**Table 6.** Nutrition Adequacy Ratios (NARs) and Mean Adequacy Ratio (MAR) by adherence level to dietary guidelines in Korean children

	Adherence level								P for trend <sup>1)</sup>
	Total (45-88) (n = 191)		Low (45-64) (n = 60)		Moderate (65-72) (n = 68)		High (73-88) (n = 63)		
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	
Protein	1.00	0.00	1.00	0.00 <sup>a</sup>	1.00	0.00 <sup>a</sup>	1.00	0.00 <sup>a</sup>	
Calcium	0.73	0.02	0.67	0.03 <sup>b</sup>	0.75	0.03 <sup>ab</sup>	0.77	0.02 <sup>a</sup>	0.021
Phosphorus	0.97	0.01	0.95	0.01 <sup>b</sup>	0.96	0.01 <sup>ab</sup>	0.99	0.01 <sup>a</sup>	0.010
Iron	0.96	0.01	0.93	0.01 <sup>b</sup>	0.97	0.01 <sup>a</sup>	0.98	0.01 <sup>a</sup>	0.001
Zinc	0.97	0.01	0.95	0.01 <sup>b</sup>	0.96	0.01 <sup>ab</sup>	0.99	0.01 <sup>a</sup>	0.021
Vitamin A	0.91	0.01	0.88	0.02 <sup>a</sup>	0.91	0.02 <sup>a</sup>	0.93	0.02 <sup>a</sup>	0.157
Thiamin	0.97	0.01	0.95	0.01 <sup>a</sup>	0.98	0.01 <sup>a</sup>	0.98	0.01 <sup>a</sup>	0.065
Riboflavin	0.97	0.01	0.95	0.01 <sup>a</sup>	0.97	0.01 <sup>a</sup>	0.98	0.01 <sup>a</sup>	0.080
Niacin	0.98	0.00	0.98	0.01 <sup>a</sup>	0.99	0.00 <sup>a</sup>	0.98	0.01 <sup>a</sup>	0.990
Vitamin C	0.81	0.02	0.77	0.03 <sup>b</sup>	0.86	0.02 <sup>a</sup>	0.79	0.03 <sup>ab</sup>	0.343
Folate	0.73	0.02	0.69	0.03 <sup>a</sup>	0.75	0.03 <sup>a</sup>	0.74	0.03 <sup>a</sup>	0.075
MAR	0.91	0.01	0.88	0.01 <sup>b</sup>	0.92	0.01 <sup>a</sup>	0.92	0.01 <sup>a</sup>	0.008

<sup>1)</sup> P for trend was tested using General Linear Model (GLM) adjusted for age, sex, children's BMI percentiles, paternal BMI, paternal education level, and household income. Tukey's multiple comparison test was used as the post-hoc test.

*Dietary intake by level of adherence*

In terms of children's food consumption, children in the highest tertile of adherence scores consumed significantly more

milk & dairy products and less seaweed than those in lower adherence groups (P for trend = 0.010, and 0.041; Table 4). Furthermore, a significantly lower percentage of children in the

**Table 7.** Odds ratios (95% confidence intervals) for obesity (BMI  $\geq$  95<sup>th</sup> percentile) or being overweight including obesity (BMI  $\geq$  85<sup>th</sup> percentile) by adherence level in Korean children

	Adherence level			<i>P</i> for trend <sup>1)</sup>
	Low	Moderate	High	
BMI $\geq$ 95 <sup>th</sup> percentile	1.00	0.57 (0.26-1.26)	0.33 (0.13-0.82)	0.019
BMI $\geq$ 85 <sup>th</sup> percentile	1.00	0.45 (0.20-1.00)	0.26 (0.11-0.61)	0.002

<sup>1)</sup> *P* for trend was tested using General Linear Model (GLM) adjusted for age, sex, paternal BMI, paternal education level, and household income.

high adherence group consumed less than the EAR of phosphorus and iron compared to those in lower adherence groups (*P* for trend = 0.024 and 0.006; Table 5). Children in the high adherence group showed higher NARs for calcium, phosphorus, iron, zinc, and MAR compared to those in lower adherence groups (*P* for trend = 0.021, 0.010, 0.001, 0.021 and 0.008; Table 6).

#### Adherence to dietary guidelines and obesity

Risk of obesity (BMI  $\geq$  95<sup>th</sup> percentile) or being overweight including obesity (BMI  $\geq$  85<sup>th</sup> percentile) decreased significantly in the high adherence group compared to the low adherence group after adjusting for age, sex, paternal BMI, paternal education level, and monthly household income (OR: 0.33, 95% CI = 0.13-0.82, *P* for trend = 0.019; OR: 0.26, 95% CI: 0.11-0.61, *P* for trend = 0.002; Table 7).

## DISCUSSION

This study found that adherence to dietary guidelines for Korean children was positively related with reduced risk of obesity. Children in the high adherence group were associated with improved diet quality compared to those in lower adherence groups. Children in the high adherence group also showed higher consumption of milk and dairy products compared to children in lower adherence groups. Furthermore, a significantly lower percentage of children in the high adherence group consumed less than the EAR of phosphorus and iron, whereas they had higher NARs for calcium, phosphorus, iron, zinc, and MAR compared to those in lower adherence groups. In addition, high adherence was related with lower paternal BMI, higher paternal education level, and higher monthly household income.

Analysis of adherence to dietary guidelines revealed that children who closely adhered to dietary guidelines were more likely to have a normal body weight and BMI percentiles for their age and sex. These findings are in agreement with previous studies carried out in other countries demonstrating the effectiveness of dietary guidelines on weight management in children [20-21]. A prospective study on adolescent girls in the US showed that higher adherence to a Diet Approaches to Stop Hypertension (DASH) style diet was associated with lower BMIs over a 10-year follow-up [20]. Another study on Canadian children reported that higher adherence to DASH diet was significantly associated with reduced measures of adiposity [21]. However, in the Australian study, dietary guideline index scores showed no or weak association with BMI and waist circumference Z-scores in children depending on their age [22].

Previous studies have recommended dietary guidelines for adequate consumption of nutrients, similar to those for Korean children [20-22]. In our study, children in all groups did not consume enough energy and nutrients, except for protein based on the EER or the EAR of KDRIs [16]. In terms of calcium, vitamin C, and folate, percentages of children that did not meet the EAR were relatively higher compared with other nutrients in Table 5 (60.7%, 40.8%, and 74.9%, respectively). According to the 2012 KNHANES, energy and nutrient intakes of children aged 6-11 years were lower than the EER or the EAR. Particularly, percentages of children that did not meet the EAR were 77.3% and 46.8% for calcium and vitamin C, respectively [8]. Furthermore, average daily energy intake of children in our study was lower than that of children aged 6-11 years in the 2012 KNHANES (1,615.2 kcal versus 1,806.8 kcal) [8].

Our study also found that children in the highest tertile of adherence scores consumed more milk and dairy products. Furthermore, a significantly lower percentage of children in the high adherence group consumed less than the EAR of phosphorus and iron compared to those in lower tertiles. In terms of NARs and MAR, children in the highest adherence group had significantly better NARs for calcium, phosphorus, iron, zinc, and MAR. This result was similar to a previous Korean study in which primary school children with high adherence to 2003 Korean dietary guidelines showed higher intake of several nutrients [23]. In a study on Korean adolescents, adherence to dietary guidelines was shown to be positively correlated with dietary fiber intake [24]. In addition, two studies on Australian [22] and Brazilian children [25] observed that compliance to dietary guidelines was associated with better food and nutrient consumption.

In terms of the association between dietary behaviors and weight status in Korean children, several studies reported that eating foods derived from animals [26], a high percentage of one's energy intake from fat, Western dietary patterns [27], frequent snacking [28], and parent-reported high appetites [29] are positively associated with being overweight or obese. These results also indicate that a balanced diet might help prevent excessive weight gain in children.

The present study found that adherence to dietary guidelines in children was associated with parental socio-economic variables. This finding was in agreement with a study that people at the highest household income level are more likely to exhibit healthy behaviors compared to those at lower income levels [8]. Other studies reported that family income or parental socio-economic status affects nutritional intake in children [30, 31]. Based on the inverse relationship between paternal BMI and adherence to dietary guidelines, parental healthy behaviors likely determine those of children. Hence, family environment should be considered when trying to improve adherence to dietary guidelines.

However, this study has several limitations. First, external validity of the results could be limited since the subjects were recruited from a hospital. Secondly, adherence to dietary recommendations was measured using the Likert scale, which is limited in its ability to accurately classify adherence in all components. In addition, participants' adherence to dietary guidelines was based on how they conceived of dietary guidelines

rather than what they actually did. This gap between perception and performance could be another limitation. Lastly, this study was a cross-sectional study, which means it is not possible to determine a causal relationship between adherence to dietary guidelines and risk of obesity in Korean children.

On the other hand, this study has several strengths. To the best of the author's knowledge, this is the first study to evaluate risk of obesity and diet quality by degree of adherence to dietary guidelines for Korean children, which were developed with a focus on creating a balanced diet and preventing pediatric obesity. Availability of detailed dietary information allows this study to predict typical dietary intake relatively accurately.

In conclusion, adherence to dietary guidelines may be related to improved diet quality, high levels of parental education, lower parental BMIs, and higher household income, resulting in prevention of childhood obesity. These findings support the broader use of dietary guidelines for weight management as a means of establishing healthy eating habits during childhood, which could help prevent metabolic disease later in life.

## ACKNOWLEDGEMENT

The authors appreciate all interviewers and Inje University Sanggye Paik Hospital staffs who assisted in implementation of the survey. This research was supported by a grant from the Korea Food and Drug Administration (KFDA) (11162KFDA 701). The KFDA had no role in the design, analysis, or writing of this article. None of the authors have any conflicts of interest to declare. All authors reviewed and approved the final manuscript. The Institutional Review Board at Inje University Sanggye Paik Hospital approved this study.

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