Perspectives in Practice

Association between Unhealthful Eating Patterns and Unfavorable Overall School Performance in Children

MING-LING FU, PhD; LIEYUEH CHENG, PhD; SU-HAO TU, PhD; WEN-HARN PAN, PhD

ABSTRACT

The objective of this article is to evaluate the relationship between children's unhealthful eating patterns and overall school performance. The Nutrition and Health survey in Taiwan Elementary School Children, 2001-2002, was carried out by using a multistaged complex sampling design. A total of 2,222 elementary school children who had complete data on demographics, anthropometrics, diet and lifestyle, and overall school performance were included in the analyses. Differences in characteristics between children with favorable and unfavorable overall performance were compared using t test and χ^2 test. Using factor analysis, food frequency of 22 food groups was grouped into five factors, which were used to construct dietary patterns. The association between dietary patterns and unfavorable overall performance was assessed by multiple logistic regression after adjustment for known risk factors. Prevalence of unfavorable overall performance in Taiwanese elementary school children was 7.1%. Unfavorable overall school performance was positively associated with unhealthful eating patterns, which included high intake of low-quality foods (eg, sweets and fried foods) and low intake of dairy products and highly nutrient-dense foods (eg, vegetables, fruit, meat, fish, and eggs). Children with a greater number of unhealthful eating patterns were more at risk for unfavorable overall performance in school. The study shows that children with unfavorable overall school performance were more likely to eat sweets and fried foods, and were less likely to eat foods rich in protein, vitamins, and minerals. A potential relationship between eating patterns and unfavorable overall school performance is supported by a positive relationship between frequency of food intake and food preferences in our study.

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Taiwan has undergone enormous social and economic change in recent times, leading to adoption of a fast-food culture and development of altered eating patterns. The increased participation of women in the workforce has led to increases in children eating out (1,2). Commercial advertising has pushed heavily the consumption of foods and snacks low in micronutrients and minerals, which has also influenced children's food choices.

Research on the relationship between nutrition and school performance has been carried out in four major areas (3,4):

- the effects of iodine or zinc supplementation in nutrient-deficient children;
- the relationship between anemia, iron supplementation, and learning;
- the effects of insufficient food intake; and
- the importance of breakfast.

With regard to the effects of nutrient deficiencies and supplementation, children with iodine or zinc deficiency were found to have marked improvement in intelligence quotient (IQ) and cognitive ability after they were given iodized oil or zinc and micronutrient supplements (5,6). Children with iron-deficiency anemia can have poorer learning outcomes (7,8), particularly in mathematics (9). If they are given iron supplements, not only do their ferritin stores improve (10), but their IQ and cognitive ability can also increase (11). Giving vitamin and mineral supplements to children without nutritional deficiencies, however, has no effect on their academic achievement (12-14). With regard to malnutrition, insufficient daily intake of meat, fish, eggs, and dairy products (15,16) or long-term starvation (17,18) is positively associated with problems in children's IQ, academic achievement, attendance, concentration span, hyperactivity, and aggression. Children who do not eat breakfast have lower grades in mathematics, shorter attention spans, and worse school

attendance (19-21), particularly in those children who are malnourished (22,23). Protein-energy malnutrition can hinder children's growth and lead to nutritional deficiencies and anemia (24-26). Moreover, nutritional deficiency in childhood can affect later behavioral development and social abilities (27).

Overnutrition has recently become more common in Taiwanese children; however, lower intake of micronutrient-rich foods, such as vegetables, fruit, and milk, have been observed in a large number of children and adolescents (28). The majority of previous research on children's nutrition in relation to cognition and behavior has focused only on extreme nutritional deficiencies. Moreover, the effect of only one specific food or nutritional factor on cognitive and behavioral performance has been investigated. This kind of research is not entirely appropriate for the current nutritional status of elementary school children in Taiwan who have multiple borderline nutritional deficiencies combined with excessive energy intakes (2). The major objective of the study was to examine whether unhealthful eating patterns are associated with unfavorable overall school performance in Taiwanese elementary school students.

METHODS

Participants

The Nutrition and Health Survey in Taiwan Elementary School Children within 2001-2002 was aimed at elementary school children aged from 6 to 13 years. The study sample was selected using stratified, multistaged, clustered sampling. The 359 townships and localities in Taiwan were divided into 13 strata based on ethnicity, geographical location, and population density. In each stratum, eight schools were selected using probability proportional to size sampling. This resulted in a total of 104 schools selected throughout Taiwan. Twenty-four students were randomly selected from each school to give a sample of 2,496 students. A total of 2,419 cases were actually obtained in the designated survey time with a response rate of 78.8%. After excluding subjects with missing data, a total of 2,222 participants were included in our study: 1,206 boys and 1,016 girls. There were 1,187 children from the lower grades (grades 1 to 3) and 1,035 children from the higher grades (grades 4 to 6). Informed consent was given by one of the parents of all school children. The study was approved by reviewers from the Department of Health in Taiwan.

Children's Overall Performance in School

Overall school performance was assessed using a modified version of the Scale for Assessing Emotional Disturbance developed by Epstein and Cullinan in 1998 (29). This scale was translated and adapted for use on 6- to 18-year-olds in Taiwan by Cheng (30). The scale comprises 52 items that encompass seven subscales. One of the subscales is overall performance. This modified subscale has a reliability of 0.92 and validity of 0.76, and includes the following aspects:

- intellectual functioning;
- family support;
- academic functioning;
- motivation for schoolwork;
- peer support;
- personal hygiene and grooming; and
- interest in activities outside of school.

Trained interviewers explained the subscale to the student's teacher, who then gave scores for each of the seven questions. There were five choices for each question: "far above average," "above average," "average," "below average," and "far below average." These five choices were given scores of 4, 3, 2, 1, and 0, respectively.

On the overall performance subscale, lower scores were considered deviant. A substantially deviant overall performance score was indicated by a score that fell below the 9th percentile, ie, Taiwanese Nonemotional Disturbance Norms, which corresponds to standardized scores <6. Therefore, a score of 6 was chosen as the cut point. Children with a score <6 were considered to have unfavorable overall school performance.

Demographic and Socioeconomic Characteristics

Questions pertaining to parental ethnicity, parental education, household income, and parental time spent with child, were jointly answered by both parents. Parental time spent with child was assessed by the number of hours per day that the mother or father spent with their child on activities at home, excluding sleep.

Frequency of Food Intake

There were 22 general food groups included in the questionnaire, with one question for each food group. Frequency of intake was defined as the number of times per week the food group was consumed. The questionnaire was jointly answered by parents and child, based on the child's actual eating patterns in the month prior to the survey.

Food Preferences

Preferences for all of the above 22 food groups were rated by children as "like," "okay," and "dislike."

Statistical Analysis

Prevalence of unfavorable overall school performance in Taiwan children was estimated, through a weighting process, using weights obtained by the sex-age-area–specific group poststratification method (2). Distribution of overall performance was analyzed by percentages and means. Differences in characteristics between children with favorable and unfavorable overall performance were compared using the t test and χ^2 test. Food frequency of the 22 food groups was analyzed using factor analysis. Factors were selected based on principal component analysis and an eigen value of >1.0. Variables with factor-loading scores were >0.37 under Varimax rotation were grouped together in one factor. This resulted in five major dietary factors. Pearson's correlation was used to verify the relationship among each of the factors and between dietary factors and overall performance score. Multivariate analysis was carried out using logistic regression. The association

between unhealthful eating patterns and unfavorable overall performance was assessed after adjustment for known risk factors. The linear trend between food preference and food frequency was evaluated using linear regression. Statistical analyses were carried out using SAS (version 9.1, 2002-2003, SAS Institute, Cary, NC) and values of $P<0.05$ were considered statistically significant.

RESULTS

Children's Characteristics

Prevalence of unfavorable overall school performance in Taiwanese elementary school children was 7.1%. Unfavorable overall performance was more common among boys than girls, and among the higher grades than the lower grades. Prevalence of unfavorable overall performance was also higher in mountain areas compared to other locations. There was no statistically significant difference in mean age, height, weight, and body mass index between children with favorable and unfavorable overall school performance (Table 1).

There was a substantial association between children's overall school performance and family environment. Children were less likely to have unfavorable overall school performance if their parents were Han Chinese, as opposed to Taiwanese aborigines; had higher levels of education; or were better off economically. In addition, children who had higher scores for parental accompanying time had better overall school performance; although only maternal time spent with child achieved statistical significance (Table 1).

Relationship Between Overall School Performance and Dietary Factors Derived from Food Frequency of Different Food Groups

Five dietary factors were chosen based on factor analysis: "highly nutrient-dense foods" (including vegetables, fruit, meat, fish, and eggs), "dairy products," "traditional Taiwanese foods" (including internal organs, seafood, and soy products), "sweets and fried foods," and "icy foods" (Table 2).

Pearson's correlation coefficients demonstrated (Table 3) a substantial positive, but moderate, association between frequency of intake of high-quality foods (highly nutrient–dense foods and dairy products) and overall performance score. There was no statistically significant relationship between frequency of intake of traditional Taiwanese foods or icy foods and overall performance score ($P=0.21$ and 0.98, respectively). There was a significant but weak negative association between the frequency of intake of sweets and fried foods and overall performance score. Moderately weak associations among the first three high-quality food groups were observed ($r=\sim0.2$). There was a significant association between sweets and fried foods and icy foods ($r=\sim0.36$). However, there was either no association, or only a weak association, between sweets and fried foods and high-quality foods (highly nutrient-dense foods and dairy products).

Each of the three dietary factor scores that were substantially associated with overall performance was grouped into tertiles. Cut points were defined to group individuals into low or high intake groups for each dietary factor. Intake frequency at the cut point between tertiles 1 and 2 was taken as the cut point for low intake of highly nutrient–dense foods and dairy products. Intake frequency at the cut point between tertiles 2 and 3 was taken as the cut point for high intake of sweets and fried foods. The relationship between unhealthful eating patterns (low intake of high-quality foods and high intake of low-quality foods) and overall school performance was investigated using logistic regression. Table 4 shows that after adjusting for sex and grade (model 1), children with a single unhealthful eating pattern of either low intake of highly nutrient-dense foods or low intake of dairy products were about 1.9 times more likely to have unfavorable overall performance ($P<0.001$ for both food groups). Similarly, children with high intakes of sweets and fried foods were 1.5 times more likely to have unfavorable overall performance ($P=0.02$). All of these odds ratios achieved statistical significance. However, after adjusting for sex, grade, stratum, parental ethnicity, household income, and parental time spent with child (model 2), only low intake of highly nutrient–dense foods and high intake of sweets and fried foods remained statistically significant (odds ratio$\approx$1.6; $P=0.01$ and 0.02, respectively).

We investigated the relationship between various combinations of the previously mentioned three unhealthful eating patterns and unfavorable overall school performance. Table 5 shows that children who had more unhealthful eating patterns were more at risk for unfavorable overall performance. For students with only one unhealthful eating pattern, only students with low intake of highly nutrient–dense foods achieved a statistically significant increased risk of unfavorable overall performance (1.7 times the risk of students with healthful eating patterns for all three factors). If students had two unhealthful eating patterns, they were 2.3 to 3.1 times more at risk of unfavorable overall performance. Students with unhealthful eating patterns for all three factors were 4.9 times more at risk of unfavorable overall performance. However, after adjusting for sex, grade, stratum, parental ethnicity, household income, and parental time spent with child (model 2), only children with unhealthful eating patterns for all three dietary factors had a statistically significant increased risk of unfavorable overall performance (odds ratio=3.03, $P<0.001$).

Relationship of Children's Food Frequency to Food Preference

Table 6 shows that for each of the food groups in both high-quality foods and low-quality food categories, the level of food intake was substantially and positively associated with children's food preferences. But for several low-quality food groups, a J-shaped curvilinear relationship was shown, indicating that although students who admitted to liking the food ingested more than the other two groups ("okay" and "dislike"), some students who admitted to disliking the food actually ingested slightly more than those who expressed neutrality toward the food.

DISCUSSION

Analysis of data from Nutrition and Health Survey in Taiwan Elementary School Children, 2001-2002, demon-

Table 1. Demographic characteristics of Taiwan elementary school children by overall school performance, Nutrition and Health Survey in Taiwan Elementary School Children, 2001-2002[a]

Characteristics	Overall School Performance		
	Favorable[b]	Unfavorable[c]	*P* value[d]
	← *mean± standard deviation* →		
Age (ys)	9.2±1.4	9.5±1.6	0.08
Height (cm)	134.0±11.0	135.0±12.0	0.50
Weight (kg)	32.5±10.2	33.6±11.1	0.16
Body mass index[e]	17.7±3.3	18.1±3.6	0.15
	← % →		
Sex			
Male	53	69	<0.001
Female	47	31	
Grade			
1st-3rd	54	47	0.05
4th-6th	46	53	
Stratum			
Hakka area	8	6	0.01
Mountainous area	7	13	
East coast area	8	10	
Peng-Hu islands	8	11	
West coast area	69	60	
Paternal ethnicity			
Han Chinese	92	83	<0.001
Aborigines	8	17	
Maternal ethnicity			
Han Chinese	91	80	<0.001
Aborigines	9	20	
Paternal education (y)			
<12	37	66	<0.001
≥12	63	34	
Maternal education (y)			
<12	31	63	<0.001
≥12	69	37	
Household income			
<NT$ 50,000/month[f]	41	60	<0.001
≥NT$ 50,000/month	59	40	
Paternal time spent with child (h/d)			
<1	12	14	0.26
1-3	34	27	
>3	54	59	
Maternal time spent with child (h/d)			
<1	1	4	0.04
1-3	16	18	
>3	83	78	

[a]N=2,222.
[b]Standardized overall school performance score >6.
[c]Standardized overall school performance score ≤6.
[d]*P* values in this column are for *t* test or χ^2 test.
[e]Calculated as kg/m^2.
[f]New Taiwan dollars/month.

strates a potential close relationship between children's unhealthful eating patterns and overall school performance. There was a substantial positive association between unfavorable overall performance and high intake of low-quality foods, such as sweets and fried foods and low intake of high-quality foods, such as highly nutrient-dense foods (vegetables, fruit, meat, fish, and eggs) and dairy products. The greater the number of unhealthful eating patterns, the higher the relative risk for unfavorable overall school performance.

Previous research has found that although high intake of high-fat fast-foods leads to increased calorie and fat consumption, it is also associated with decreased intake of micronutrient-dense foods (31). Our study showed in-

Table 2. Five dietary factors and factor-loading scores for 22 food groups, Nutrition and Health Survey in Taiwan Elementary School Children, 2001-2002[a]

Factor loading scores[b]	Factor 1: Sweets and fried foods	Factor 2: Highly nutrient-dense foods	Factor 3: Icy foods	Factor 4: Dairy products	Factor 5: Traditional Taiwanese foods
High-fat snacks	**0.71**[c]	—	—	—	—
Cookies	**0.66**	—	—	0.16	—
Candy and chocolate	**0.66**	—	—	—	—
Instant noodles	**0.57**	−0.18	0.18	—	0.28
Sugary drinks	**0.54**	—	0.23	−0.29	—
Fried foods	**0.41**	—	0.24	—	0.24
Sugary, high-fat foods	**0.37**	0.28	—	0.25	—
Meat	—	**0.69**	—	−0.15	—
Fish	—	**0.61**	—	—	—
Vegetables	—	**0.55**	—	—	—
Fruit	—	**0.54**	—	0.29	—
Eggs	0.15	**0.40**	—	—	0.35
Ice cream	0.17	—	**0.84**	—	—
Shaved-ice desserts	0.22	—	**0.82**	—	—
Yogurt	—	—	—	**0.68**	0.15
Milk	—	0.31	—	**0.52**	—
Cheese	—	—	—	**0.46**	—
Yogurt milk	0.16	—	—	**0.42**	0.32
Internal organs[d]	—	—	0.16	—	**0.59**
Other seafood	—	0.18	—	0.22	**0.52**
Soy milk	—	—	—	0.19	**0.50**
Other soy products	—	0.25	—	—	**0.39**
Proportion of variability explained (%)	14	10	7	6	5

[a]N=2,222.
[b]Data are not displayed for those with absolute loading values <0.15.
[c]Values in boldface represent factor-loading scores greater than 0.37.
[d]Internal organs includes heart, liver, kidney, and stomach.

Table 3. Pearson's correlation coefficients between overall performance score and five dietary factor scores, Nutrition and Health Survey in Taiwan Elementary School Children, 2001-2002[a]

	Performance score[b]	Highly nutrient-dense foods	Dairy products	Traditional Taiwanese foods	Sweets and fried foods	Icy foods
Performance score	1.00	0.12***	0.14***	0.03	−0.09***	0.01
Highly nutrient–dense foods		1.00	0.22***	0.18***	0.05*	0.02
Dairy products			1.00	0.23***	0.03	0.08***
Traditional Taiwanese foods				1.00	0.12***	0.13***
Sweets and fried foods					1.00	0.36***
Icy foods						1.00

[a]N=2,222.
[b]Performance score: standardized overall school performance score.
*$P<0.05$.
**$P<0.01$.
***$P<0.001$.

ter-correlations among intake of nine low-quality food groups: the higher the intake of one of the nine food groups, the higher the intake of the rest. There was also a negative relationship between the intake of low-quality foods and fruits/vegetables: the higher the intake of the former, the lower the intake of the latter. This indicates that there is some mutual overlap among dietary factors and thus it is not easy to completely isolate the effect of one from another. It is likely that unhealthful eating patterns affect the intake of protein, vitamins, and min-

Table 4. Odds ratios and 95% confidence intervals of relating unfavorable overall school performance and specific dietary factors, Nutrition and Health Survey in Taiwan Elementary School Children, 2001-2002

		Unfavorable Overall School Performance					
		Sample Size		Model 1[a]		Model 2[b]	
Dietary factors	Tertiles[c]	Case	Control	OR[d] (95% CI[e])	*P* value	OR (95% CI)	*P* value
Sweets and fried foods	1 and 2	122	1,536	1.00		1.00	
	3	58	493	1.50 (1.08-2.09)	0.02	1.65 (1.09-2.48)	0.02
Highly nutrient–dense foods	2 and 3	90	1,362	1.00		1.00	
	1	83	642	1.90 (1.39-2.61)	<0.001	1.63 (1.11-2.38)	0.01
Dairy products	2 and 3	92	1,371	1.00		1.00	
	1	85	644	1.94 (1.42-2.65)	<0.001	1.08 (0.73-1.59)	0.72

[a]Model 1: adjusted for sex, grade, and sex*grade (sex and grade interaction).
[b]Model 2: adjusted for sex, grade, sex*grade, stratum, parental ethnicity, parental education, household income and parental time spent with children.
[c]Tertile 1 stands for the lowest tertile, tertile 2 for the middle tertile, and tertile 3 for the top tertile.
[d]OR=odds ratio.
[e]CI=confidence interval.

Table 5. Odds ratios and 95% confidence intervals relating unfavorable overall school performance and dietary pattern defined by levels of three dietary factors, Nutrition and Health Survey in Taiwan Elementary School Children, 2001-2002

Dietary Factors in Tertiles[a]			Unfavorable Overall School Performance					
			Sample Size		Model 1[b]		Model 2[c]	
Sweets and fried foods	Highly nutrient–dense foods	Dairy products	Case	Control	OR[d] (95% CI)[e]	*P* value	OR (95% CI)	*P* value
1 and 2	2 and 3	2 and 3	35	694	1		1	
3[f]	2 and 3	2 and 3	19	232	1.65 (0.92-2.95)	0.09	1.65 (0.87-3.12)	0.12
1 and 2	**1**	2 and 3	25	264	1.72 (1.01-2.93)	0.04	1.66 (0.93-2.97)	0.09
1 and 2	2 and 3	**1**	23	260	1.62 (0.94-2.80)	0.08	1.01 (0.52-1.94)	0.99
3	**1**	2 and 3	9	74	2.32 (1.07-5.05)	0.03	2.22 (0.97-5.11)	0.06
3	2 and 3	**1**	12	72	3.11 (1.54-6.26)	0.002	1.90 (0.83-4.35)	0.13
1 and 2	**1**	**1**	33	172	3.01 (1.81-5.01)	<0.001	1.69 (0.90-3.19)	0.11
3	**1**	**1**	14	45	4.94 (2.49-9.80)	<0.001	3.03 (1.35-6.80)	<0.001

[a]Tertile 1 stands for the lowest tertile, tertile 2 for the middle tertile, and tertile 3 for the top tertile.
[b]Model 1: adjusted for sex, grade and sex*grade (sex and grade interaction).
[c]Model 2: adjusted for sex, grade, sex*grade, stratum, parental ethnicity, parental education, household income, and parental time spent with children.
[d]OR=odds ratio.
[e]CI=confidence interval.
[f]Values in boldface indicate the unhealthful eating tertiles.

erals in both a quantitative and qualitative sense, jointly leading to metabolic consequences, which in turn influence academic and emotional performance and result in unfavorable overall performance.

In an animal study with controlled feeding under specific nutritional conditions, when the ratio of sugar to protein was increased, it was discovered that the activity level of rats also increased (32). In human research, a positive relationship has also been found between an imbalance in the sugar-to-protein ratio and aggressive behavior (33). Our observational research indicates that children who ingest low-quality foods have poor overall performance in school, although it is not easy to ascertain which specific nutrient or nutrients are truly associated with the effect. It is plausible that marginal inadequacy of multiple vitamins, minerals, and protein, together with some nonnutrient dietary components, could compromise children's overall performance level. For example, tryptophan and tyrosine, amino acids derived from protein-rich foods, are known as important substrates for synthesis of neurotransmitters (34). Vitamins B-2, B-6, and B-12, provided primarily by animal products, and folic acid provided by plant products, are essential cofactors in the one-carbon pathway for the production of S-adenosylmethionine, a methyl donor in the formation of serotonin and dopamine (35-38). In addition, other nonnutrient dietary substances, such as betaine (39) and choline (40), are also involved in these pathways. This hypothesis provides a possible explanation for why low intakes of high-quality foods from various sources act together to affect school performance of children.

For high-quality foods, the preference for a food group was substantially associated with higher intake frequency of that specific food group. Children who liked the

Table 6. Mean food frequency from 22 food groups by food preference grouping, Nutrition and Health Survey in Taiwan Elementary School Children, 2001-2002[a]

	Food Preferences			
Food frequency (times/week)	**Dislike**	**Okay**	**Like**	***P* for trend[b]**
High-quality foods	← *mean± standard deviation* →			
Vegetable	5.07±2.24	5.92±1.70	6.31±1.44	<0.001
Fruit	3.32±2.13	4.37±2.07	4.77±2.09	<0.001
Milk	2.14±2.61	3.28±2.58	4.12±2.65	<0.001
Yogurt	0.43±1.03	0.87±1.31	1.41±1.79	<0.001
Yogurt milk	1.22±1.65	1.43±1.59	1.71±1.76	<0.001
Cheese	0.17±0.73	0.50±1.19	0.80±1.46	<0.001
Meat	4.94±2.54	5.61±1.91	6.00±1.73	<0.001
Internal organs[c]	0.17±0.52	0.49±0.84	0.57±0.86	<0.001
Fish	3.00±2.29	3.60±2.19	3.97±2.14	<0.001
Other seafood	0.69±1.05	1.14±1.19	1.39±1.38	<0.001
Soy milk	0.61±1.29	1.03±1.37	1.50±1.77	<0.001
Other soy products	1.29±1.35	1.75±1.41	1.95±1.44	<0.001
Eggs	2.94±2.23	3.39±1.89	4.17±2.10	<0.001
Low-quality foods				
Fried foods	1.07±1.34	0.79±1.11	1.29±1.39	<0.001
Ice cream	0.69±1.24	0.39±0.82	0.89±1.43	<0.001
Sugary, high-fat foods	2.53±2.11	2.12±2.07	2.75±2.15	<0.001
High-fat snacks	1.48±1.60	1.18±1.61	2.12±2.10	<0.001
Instant noodle	0.82±1.20	0.49±0.94	1.32±1.66	<0.001
Cookies	2.30±1.90	1.82±2.05	2.94±2.16	<0.001
Sugary drinks	2.84±2.32	2.38±2.40	3.92±2.49	<0.001
Shaved ice desserts	0.67±1.14	0.31±0.75	0.95±1.56	<0.001
Candy and chocolate	1.74±1.77	1.41±1.77	2.55±2.17	<0.001

[a]N=2,222.
[b]Trend tests were performed, using linear regression.
[c]Internal organs includes heart, liver, kidney, and stomach.

low-quality foods, had a food frequency for these foods that was substantially higher than those children who considered these foods "okay" or "disliked" them. Thus, the association between the frequency of food intake and unfavorable overall school performance is likely to be affected by food preference and food choices. Further research is needed to understand the determinants of food preferences and how they may be changed.

Family characteristics also have an important and positive influence on student's academic achievement and behavior at school (41-43). Our data agreed with the findings that parents are more likely to be concerned about their child's academic and behavioral performance at school if they have more education, mothers spend more time with their children, and family income is greater. The highest prevalence of unfavorable overall performance in our study was in mountain areas, where a large proportion of Taiwanese aborigines live. Parents in this area have lower household income and education. They may not only have less free time to concentrate on their child's academic and behavioral performance at school, but may also lack the nutrition knowledge required to select high-quality foods. In addition, they may be unable to buy high-quality foods, which would, therefore, lead to poor dietary intake in their children.

After adjusting for sex and grade, the majority of unhealthful eating patterns still had a positive effect on unfavorable overall performance in school. However, after adjusting for parental ethnicity, socioeconomic status, and parental time spent with the child, the majority of unhealthful eating patterns no longer had a statistically significant effect. This phenomenon was most pronounced for dairy products. This may be a result of family factors having an influence on both children's eating patterns and overall school performance. Previous research has found that higher parental education levels are associated with lower risk of nutritional deficiencies in children (44). In addition, people with higher levels of education have better eating habits (45). Our study showed that children of parents with higher levels of education were less likely to have unhealthful eating patterns than their counterparts from lower socioeconomic groups. Prevalence of high intake of sweets and fried foods was 20% in the higher-educated parent group compared to 30% in the lower-educated parent group; low intake of highly nutrient-dense foods was 27% compared to 38%; and low intake of dairy products was 24% compared to 42%. It is possible that, when investigating the effect of unhealthful eating patterns on overall performance in school, adjusting for family factors could result in overcorrection and masking of the effect of eating habits on overall performance. However, failure to adjust for such factors could also lead to biased results because of confounding by family socioeconomic status. Nonetheless, our study

showed that after adjusting for risk factors, unhealthful eating patterns of less intake of high-quality foods and more intake of low-quality foods still showed a substantial relationship with unfavorable overall performance in school.

Because previous studies focused mostly on the relationship between academic performance and a single nutrient, there have been no similar studies evaluating the relationship between unhealthful eating patterns and overall school performance. Therefore, it is difficult to compare previous studies with ours.

Our study has the following limitations. Although students with three unhealthful dietary factors had 4.9 times the risk of having unfavorable overall performance, the confidence interval was very wide. This is a result of the large standard error because of the small sample size (46). This is supported by the fact that the group with the widest confidence interval (2.49 to 9.80) had the smallest sample size (n=59). Further study using larger samples and in multiple populations would be beneficial. In addition, as the food frequency and food preference questionnaires were filled out by parents and children and the overall school performance questionnaires were filled out by teachers, there is potential for subjective differences in ratings of food intake quantities and level of food preference. Although our study observed a relationship between dietary pattern and overall performance, as our study is cross-sectional, it is difficult to establish a causal relationship between eating patterns and overall performance. Further prospective or interventional research is needed to fully answer this question. However, associations between food preferences and food frequency supports the hypothesis that liking and disliking low-quality or high-quality foods can affect how children select foods, which in turn determines their nutritional status and school performance. An association between food preference and intake frequency was more consistently found in high-quality foods than in low-quality foods. This may be because a small proportion of children might pretend to not like sweets and high-fat snacks, but, in fact, consume them frequently.

CONCLUSIONS

Our study has found that poor overall school performance in Taiwanese elementary school children may be, in part, explained by their unhealthful eating patterns, reinforcing the importance of a balanced diet. Confirmation of a causal relationship by later prospective research would firmly establish the importance of healthful eating patterns. This study indicates that a balanced diet is crucial not only in maintaining physical health, but also in promoting emotional well-being and psychosocial functioning.

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