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ORIGINAL ARTICLE

Dietary risk factors of physical growth of Filipino school-aged children

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Popular scientific summary

- Adequate nutrition during childhood is essential to promote physical growth.
- This study evaluated the food and nutrient intakes of a total of 6,565 Filipino schoolchildren aged 6–12 years.
- Results demonstrated that consumption of meat, grains and cereal products, sweets, and high-quality protein foods was associated with a lower risk of stunting. Consumption of grains and cereal products, sweets, milk/milk products, high-quality protein foods, calcium, and riboflavin was associated with a lower risk of underweight. Wasting was associated with the consumption of grains and cereal products and dietary intake of riboflavin, thiamin, and fiber. Higher consumption of meat, grains and cereal products, milk/milk products, high-quality protein, and vitamin C and lower consumption of vitamin D and fiber were associated with a higher risk of child obesity.
- Findings could be used as a scientific reference for future product development concepts aimed at recommending healthy foods and balanced menus to help curb the malnutrition status prevailing in the country.

Abstract

Background: Adequate nutrition during childhood is essential to promote child growth and development.
Objective: The study evaluated the relationship of habitual nutrient intake and protein adequacy to the prevalence of child malnutrition.
Methods: Data were derived from a nationally representative sample of children aged 6–12 years. Two nonconsecutive day 24-h dietary recalls (24hR) were collected to estimate the individual food intake. PC-SIDE version 1.0 software (Software for Intake Distribution Estimation) was used to estimate the habitual intake of key nutrients accounting for between- and within-person differences in dietary intake. The 2007 WHO Protein Digestibility Corrected Amino Acid Score (PDCAAS) method was used to measure the protein quality or the utilizable protein intake. The nutritional status of the participants is reflected in the weight-for-age, height-for-age, and body mass index (BMI)-for-age z-scores using the WHO Growth Reference Standard (WHO, 2007).
Results: Undernourished school-aged children were found to have high protein inadequacy. Higher consumption of grains and cereal products, meat, and high-quality protein foods was associated with a lower risk of stunting. Higher intake of milk and milk products, grains and cereal products, high-quality protein foods, calcium, riboflavin, and vitamin C was associated with a lower risk of underweight. Higher consumption of grains and cereal products, riboflavin, thiamine, and fiber was associated with a lower risk of wasting. On the contrary, higher consumption of meat, milk and milk products, grains and cereal products, high-quality protein foods, and vitamin C was associated with a higher risk of obesity. Furthermore, linear growth of children was found to be associated with high-quality protein foods, calcium, vitamin B12, vitamin C, and vitamin D.
Conclusions: Malnutrition among Filipino children is influenced by nutrient intakes. However, the existence of malnutrition among children may be specifically attributed to the quality of protein consumed. Therefore, the study suggests that nutrition interventions and policies focusing on child malnutrition should improve not just the quantity but also the quality of protein sources consumed by children to aid in proper growth and development.

Keywords: *physical growth; nutrient intake; protein adequacy; wasting; underweight; obesity; child malnutrition; school-aged children*

To access the supplementary material, please visit the article landing page

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Malnutrition accounts for at least half (54%) of all childhood deaths worldwide (1). The World Health Organization (WHO) states that malnutrition refers to the insufficient, excessive, or imbalance in the consumption of energy and/or nutrients (2). Malnutrition is also manifested by linear growth failure among children. Globally, an estimated total of 151 million children were affected by growth failure in 2017 (3).

School-aged children are among the most vulnerable to malnutrition due to their high nutritional requirements for growth and development (4). Combating child malnutrition is complex since it is affected by a wide array of factors (5, 6). The primary causes of malnutrition include lack of good quality food and poor child feeding (7). Hence, this translates to a much-needed emphasis on the dietary intake of school-aged children and also its effect on child growth.

In the Philippines, an estimated total of 95 children die from malnutrition every day (8). The Philippines is one of the countries in the world with the largest global burden of malnutrition (9–10). The country has a total of 3.6 million stunted children, which ranks as the 9th country with the highest burden of stunting in the world (11). In terms of wasting, about 769,000 Filipino children suffer from either moderate or severe wasting, which ranks the Philippines as the 10th country in the world with the highest burden of wasting (11). Data from the 2013 National Nutrition Survey (NNS) revealed that 30% of children aged 6–12 years were considered underweight, and it is still considered a public health problem even though it was reduced to 29.1% from 32.0% in 2011 (12). On the contrary, it was also noted that overweight and obesity among children increased by 1.7 percentage points from 2011 (7.4%) to 2013 (9.1%) (12).

Children must be provided with a diet containing adequate quantities of nutrients to allow them to reach their optimal growth (13). Moreover, there is also substantial evidence that a poor dietary intake during childhood can not only affect growth but also could lead to problems that manifest later in life, such as cardiovascular disease, obesity, type 2 diabetes, osteoporosis, and some forms of cancer (14).

Proper child growth indeed requires an adequate intake of the basic nutrients: carbohydrates, protein, and fat (15). Protein, specifically, is gaining interest in nutrition research, especially in its relation to linear growth. Moreover, recent evidence suggests that stunted children might not be receiving adequate dietary intake of essential amino acids and may have low circulating amino acids (16). In particular, dietary protein intake is considered important since it provides the essential amino acids required for protein synthesis which are necessary for child growth (17, 18). Aside from the quantity of dietary protein consumed, protein quality should also be taken into account. A difference in the effect of various types of protein might be due to a different amino acid composition among different protein sources. Furthermore, several previous studies reported that it is not the total amount of dietary protein intake but instead consuming specific protein sources that could affect growth (19, 20). In developing countries such as the Philippines, dietary protein is mainly limited to plant-based sources that are deficient in certain essential amino acids such as lysine and tryptophan, which are both necessary for growth (21, 22). Currently, little is known about the dietary intake of school-aged children, particularly in low- and middle-income countries such as the Philippines (23, 24). This study aims to evaluate the relationship of protein quality, food, and habitual nutrient intake to the prevalence of child malnutrition.

Materials and methods

Study design and populations

The 2013 NNS is a cross-sectional, population-based survey conducted to characterize the health and nutritional status of the Filipino population. The survey used a stratified three-stage sampling system drawn to represent all 17 regions and 80 provinces of the country in both urban and rural areas. A total of 8,592 Filipino households were sampled with a response rate of 87.7%. Data from a total of 6,565 children aged 6–12 years participated in the survey. However, 54 outliers were excluded from the analysis throughout data processing, and as a result, a total of 6,511 children were included in the current analysis. All surveyed households provided signed informed consent prior to participation (25). Ethical consent for the study was obtained from the Food and Nutrition Research Institute Ethics Review Board (FIERC Protocol Code FNRI-2020-019).

Data collection

Demographic and socio-economic data

Demographic and socio-economic data were collected from the 2013 NNS survey participants, including age, gender, and area of residence. The wealth status of participants was defined by proxy indicators including household possession of vehicles, appliances, materials used for housing construction, and sanitation facilities. Scores obtained from principal component analysis were used to define wealth quintiles as poorest, poor, middle, rich, and richest. Detailed methodologies were discussed elsewhere (26).

Anthropometric data

The weight of children was assessed using mechanical Detecto platform beam balance scales (state name of manufacturer and place), while the height was measured using Microtoise—an L-shaped device (SECA 206, Hamburg,

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Germany). Weight and height were measured twice, but when the two measurements were greater than 0.3 kg and 0.5 cm, respectively, a third measurement was made. The mean of the two measurements was correspondingly recorded to the nearest 0.1 kg or cm. Body mass index (BMI) was calculated by dividing weight (in kg) over the square of height (in m).

The nutritional status of children aged 5.08–19.0 years (61–228 months) is reflected in the weight-for-age, height-for-age, and BMI-for-age z-scores using the WHO Growth Reference Standard (27).

Stunting, wasting, underweight, and obese were determined using the World Health Organization-Growth Reference 2007 (WHO-GR) definition: A height-for-age z-score of <−2 SD for stunting; a weight-for-age *z*-score of <−2 SD for underweight; and a BMI-for-age *z*-score of <−2 SD for wasting, while >2 SD for obese. For the weight-for-age *z*-score, the WHO-GR does not cover children aged 121 months and above.

Dietary data

Two nonconsecutive day 24-h dietary recalls (24hR) were collected on-site via face-to-face interview by trained registered nutritionist-dietitians with the parents/caregiver of each child during household visits using structured questionnaires. The first 24-h dietary recall was collected for all children and a second 24-h dietary recall was repeated in 50% of randomly selected households on a nonconsecutive day (once on a weekday and once on a weekend). Food items recalled in most cases were in a cooked state. Quantities were expressed in terms of common household measurements such as cups, tablespoons, or by size and number of pieces. Other food items were consumed raw and therefore recorded in their raw state. Amount of recalled food items consumed were quantified, wherein weights were obtained from a list of compiled Household Food Weights and Measures or through sample or actual weighing. If the food was a meal, the various ingredients in the recipe were recorded and the nutrient contents of each of these composite foods were determined on the basis of the International Network of Food Data Systems (INFOODS) Guidelines.

Food coding and quantity recorded were reviewed to avoid misclassification and under- or overestimation. Energy and nutrient intakes obtained were also scanned to identify implausible values. Estimated energy requirements (EER) were calculated using the equations from the Institute of Medicine considering age, sex, body weight, height, and physical activity level (28). We assumed low physical activity for schoolchildren aged 6–9 years and active physical activity level for schoolchildren aged 10–12 years. For the evaluation of outliers, the ratio of daily energy intake to EER was calculated for each individual and transformed into a logarithmic scale to remove outliers below −3 standard deviation (SD) and above +3 SD (29). After the checking, 54 individuals were excluded from the analysis.

Derivation of utilizable protein

Utilizable protein was estimated based on the 2007 WHO amino acid requirements and the Protein Digestibility Corrected Amino Acid Score (PDCAAS) method (30). The protein value of each food ingredient is multiplied by the digestibility value for that ingredient to calculate the amount of digestible protein present in that food item following the step-by-step process of the computation of utilizable protein presented in a previous study (31). Protein requirement for children is based on the Philippine Dietary Reference Intakes (PDRI)—Estimated Average Requirement (EAR) (32). Prevalence of inadequacy is the proportion of children having less than the given estimated average requirements per day which is 36.5 g. PC-SIDE software was used to calculate the usual nutrient intake including the prevalence of inadequacy.

Statistical analyses

Descriptive statistics were used to summarize the social demographics and characteristics of the participants in the study. Food groups and nutrients used in the analysis are listed in Table 1.

All food items consumed by the children were categorized into 10 food groups consisting of nine major food groups: grains and cereal products, all meat, sweets, vegetables, fats and oils, other foods and beverages, fruits, milk and milk products, and mixed dishes, and one minor food group, beans, nuts, and peas, which was extracted from the all meat, originally meat and protein food group. The food

Table 1. Variables used in the study

Food groups	Nutrients
Grains and cereal products (g)	Utilizable protein (g)
All meat (g)	Total fat (g)
Sweets (g)	Carbohydrates (g)
Fats and oils (g)	Total fiber (g)
Vegetables (g)	Total sugar (g)
Other food and beverages (g)	Calcium (mg)
Fruit and fruit juices (g)	Phosphorus (mg)
Milk/milk products (g)	Iron (mg)
Beans, nuts and peas (g)	Sodium (mg)
Mixed dishes (g)	Vitamin A RE (μg RE)
	Thiamin (mg)
	Riboflavin (mg)
	Niacin (mg)
	Ascorbic acid (mg)
	Vitamin D (mg)
	Zinc (mg)

groups used in the study were used in the NNS Dietary Survey (25). Food group intakes were transformed using the natural logarithm function ln(x). This study examined 16 key nutrients, including utilizable protein, total fat, carbohydrates, total fiber, total sugar, calcium, phosphorus, iron, sodium, vitamin A RE, thiamin, riboflavin, niacin, ascorbic acid, vitamin D, and zinc. Quartiles (Q1, Q2, Q3, and Q4) were generated for the nutrient intake using -xtile- command in Stata to form four groups representing the ordered rank intake. PC-SIDE software (Software for Intake Distribution Estimation for the Windows Operating System) was utilized to estimate the usual intake of nutrients for between- and within-person variation in intake (33) (Iowa State University, Version 1.0). The estimated normal consumption was adjusted for age in years and the first or second day of dietary recalls (all participants had a first-day dietary recall and 50% had a second-day dietary recall). The standard errors for mean usual intake were calculated using a set of jackknife replication weights based on the first-day dietary sample weights. For the association research, we computed the best linear unbiased predictor (BLUP) of usual nutrient intakes (34). The BLUP of habitual intake of key nutrients for growth was estimated for the association study.

Multiple logistic regression

Multiple logistic regression analyses were used to determine the association of food groups and habitual nutrient intakes (as independent variables) to the risks of stunting, underweight, wasting, and obesity among school-aged children (dependent variable) while adjusting for confounders such as age sex, urbanity, and wealth quintile. All dependent variables (underweight, stunting, wasting, and obese) were categorized as dichotomous variables, and odds ratios (ORs) were calculated. Stunting, underweight, wasting, and obesity were used as outcome variables in separate logistic regression models, using the same methods for each. Selected food groups and nutrients were included in the logistic regression analysis. The criterion for selecting the nutrients has a minimum correlation (<0.5 correlation coefficient) to other nutrients to minimize collinearity. All selected independent variables were entered into the regression equation at the same time and were expressed in quartiles. Final models were reached when $P < 0.05$ for all predictors and were evaluated using the Wald test.

Multiple linear regression

Multiple linear regression was conducted to determine the association of food groups and habitual nutrient intakes of children with the anthropometric indices. For the regression models, covariates included were age, sex, urbanity, and wealth quintile. Selected food groups and nutrients were included in the linear regression analysis. The criterion for selecting the nutrients has a minimum correlation (<0.5 correlation coefficient) to other nutrients to minimize collinearity. All selected independent variables were entered into the regression equation at the same time.

All data were analyzed using STATA (version 15; Stata Corp., College Station, TX, USA). The level of significance was set at $P < 0.05$. All analyses were accounted for the complex survey design and sampling weights to reflect nationally representative results.

Results

There are about 6,421 stunted children included in the estimation of the prevalence of stunting, 3,546 children for underweight, 5,906 children for wasting, and 5,360 children for the prevalence of obesity. Children were equally distributed by age group and sex. More than half (58.2%) of the participants were from rural residences, while the others were from urban areas (41.7%). Three out of 10 (30%) participants came from households classified as poorest, while 23% were considered as poor. About 29% and 18% of the children were classified as coming from the wealthy and middle class. Prevalence of stunting, underweight, wasting, and obesity among the children was 30.4, 31.2, 12.9, and 4%, respectively (Table 2).

The prevalence of inadequacy of the utilizable protein by malnutrition status is shown in Fig. 1. Results showed that the prevalence of protein inadequacy for children who are stunted, underweight, wasted, and obese was 42.9, 29.1, 19.4, and 4.9%, respectively.

Table 3 shows the consumption of food groups for nutritional status among school-aged children. Each model presented in Tables 3–6 was adjusted for confounding factors such as age, sex, urbanity, and wealth quintile. Children who consumed more meat and grains and cereal products had a 1% decrease in the odds of stunting compared with those who consumed less from these food groups. Children who consumed more grains and cereal products and sweets had a 1% decrease in the odds of underweight than those who consumed less. However, children who consumed milk and milk products had a 37% decrease in the odds of underweight than those that consumed less. There is a 1% decrease in the odds of wasting for those children who consumed more grains and cereal products than those who consumed less. The odds of children being obese were 1.53 times more likely for those who consumed milk/milk products, about 1.003 times more likely for those who consumed both more grains and cereal products and meat, and about 1.01 times more likely for those who consumed more fats and oils.

Table 4 shows the adjusted OR of nutrients for the risk of malnutrition among school-aged children. The odds of children being stunted were decreased by 31% for children

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Table 2. Demographic, socio-economic, and nutritional status characteristics of children

	n	%
Age groups (years)		
6–9	3,594	54.7
10–12	2,971	45.2
Sex		
Male	3,387	51.6
Female	3,178	48.4
Urbanity		
Rural	3,824	58.2
Urban	2,741	41.7
Wealth quintile		
Poorest	1,906	29.8
Poor	1,487	23.3
Middle	1,168	18.3
Rich	980	15.3
Richest	848	13.3
Nutritional status	***n***	**%**
***Prevalence of stunting*[a]**		
Normal	4,466	69.5
Stunted	1,955	30.4
***Prevalence of underweight*[b]**		
Normal	2,439	68.8
Underweight	1,107	31.2
***Prevalence of wasting*[c]**		
Normal	5,143	87.1
Wasting	763	12.9
***Prevalence of obesity*[d]**		
Normal	5,143	95.9
Obese	217	4.0
Anthropometric	**Mean**	**Standard error**
Weight (kg)	25.9	0.32
Height (cm)	127	0.16
BMI (kg/m^2)	15.64	0.03

[a]Based on the 2007 WHO Growth Reference z-score for height-for-age <−2.
[b]Based on the 2007 WHO Growth Reference z-score for weight-for-age <−2. As WHO's Growth Reference does not cover children aged 121 months and older, 3,019 children categorized under this age group were excluded from the estimation of the prevalence of underweight
[c]Based on the 2007 WHO Growth Reference z-score for BMI-for-age <−2.
[d]Based on the 2007 WHO Growth Reference z-score for BMI-for-age >2.

in the highest quartile (Q4) of utilizable protein intake than the lowest quartile (Q1). The highest quartile (Q4) of utilizable protein and riboflavin intake and the Q2 of calcium intake were significantly associated with a lower risk of underweight.

Quartile 2 (Q2) of thiamin intake and the highest quartile (Q4) of fiber intake were significantly associated with a lower risk of wasting, while the highest quartile (Q4) of riboflavin intake increases the odds of wasting in children.

The highest quartile (Q4) of utilizable protein and vitamin C increases the risk of child obesity, while quartile 2 (Q2) of vitamin D intake and quartile 3 (Q3) of fiber intake decrease the risk of obesity among children.

Results showed that in the linear regression analysis, for every 1-unit increase of the consumption of meat, grains and cereal products, and sweets, children's height significantly increases by 0.01 (95% confidence interval [CI]: 0.004, 0.01), 0.01 (95% CI: 0.01, 0.01), and 0.002 (95% CI: 0.001, 0.004), respectively (Table 5). Also, the height of the children consuming milk and milk products increases by 0.77 (95% CI: 0.02, 1.52) as compared with non-consumers. The body weight of children significantly increases by 0.01 (95% CI: 0.01, 0.01) as the meat consumption increases; by 0.01 (95% CI: 0.01, 0.01) as the grains and cereal products consumption increases; and by 0.003 (95% CI: 0.001, 0.01) as the sweets consumption increases. Also, the BMI increase by 0.004 (95% CI: 0.001, 0.01) for every 1-unit increase of meat; by 0.003 (95% CI: 0.002, 0.004) for every 1-unit increase of grains and cereal products; and by 0.001 (95% CI: 0.0005, 0.002) for every 1-unit increase of sweets consumption.

Table 6 shows that utilizable protein, calcium, vitamin D, and vitamin B12 were significant dietary factors of a child's height after including the confounders in the regression model. Specifically, children's height increases by 0.07 (95% CI: 0.05, 0.09) for every 1-unit increase of dietary utilizable protein intake. Also, increasing the intake of calcium and vitamin D increases the children's height by 0.004 (95% CI: 0.0005, 0.01) and by 0.48 (95% CI: 0.05, 0.9), respectively. In contrast, height decreases by −0.49 (95% CI: −0.84, −0.14) for every 1-unit increase of vitamin B12 intake. It also showed that dietary utilizable protein, vitamin B12, and vitamin C intakes were the significant factors of body weight. Body weight increases by 0.10 (95% CI: 0.07, 0.12) for every 1-unit increase of utilizable protein intake, while body weight decreases by −0.35 (95% CI: −0.67, −0.03) for every 1-unit increase of vitamin B12 intake. Body weight significantly increases by 0.04 (95% CI: 0.002, 0.07) for every 1-unit increase of vitamin C intake. Children's BMI also significantly increases by 0.04 (95% CI: 0.03, 0.05) as utilizable protein intake increases by 1-unit. BMI significantly increases by 0.02 (95% CI: 0.002, 0.03) for every 1-unit increase of vitamin C intake.

Discussion

Stunting

This study had shown that higher consumption of meat and grains and cereal products was associated with a

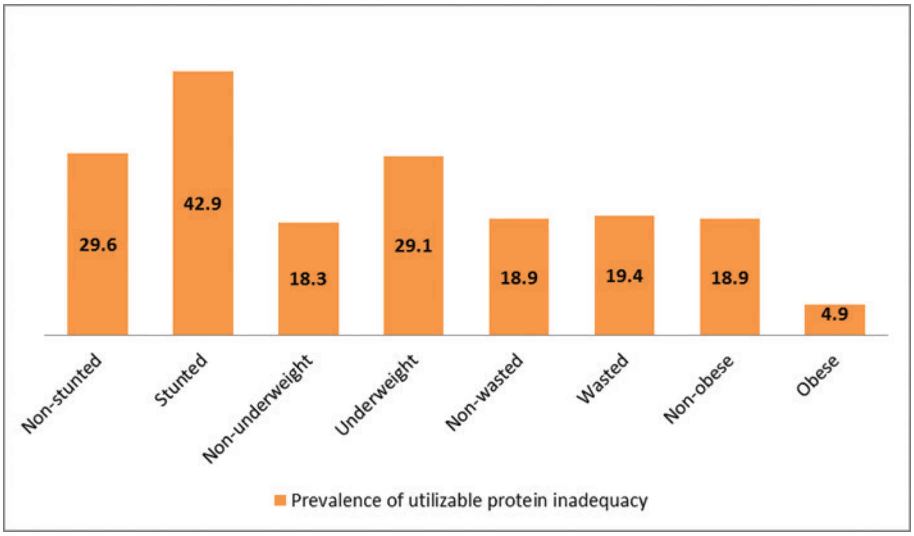

Fig. 1. Prevalence of malnutrition by the prevalence of protein inadequacy represented by utilizable protein intake.

Table 3. Adjusted odds ratio (OR) of food groups for nutritional status among school-aged children

Food groups	Odds ratio (95% CI)			
	Stunting[a]	Underweight[a]	Wasting[a]	Obese[a]
Sample (*n*)	6,421	3,546	5,906	5,360
All meat (g)	0.99 (0.997, 0.999)*	0.99 (0.996, 0.999)	0.99 (0.99, 1)	1.003 (1.001, 1.005)**
All grains (g)	0.99 (0.996, 0.998)**	0.99 (0.996, 0.998)**	0.997 (0.996, 0.998)**	1.003 (1.002, 1.005)**
Sweets (g)	0.99 (0.998,1.001)	0.99 (0.997, 0.999)*	0.999 (0.998, 1)	1.001 (0.999, 1.002)
Fats and oils (g)	1.004 (0.99, 1.01)	1 (0.98, 1.02)	1 (0.99, 1.02)	1.01 (1.003, 1.03)*
All milk				
Non-consumer	ref	ref	ref	ref
Consumer	0.87 (0.67, 1.14)	0.64 (0.45, 0.90)*	1.03 (0.75, 1.43)	1.53 (1.01, 2.34)*
Fruits and fruit juice				
Non-consumer	ref	ref	ref	ref
Consumer	1.15 (0.91, 1.46)	1.05 (0.76, 1.45)	0.96 (0.71, 1.31)	0.91 (0.51, 1.62)
Beans, nuts and peas				
Non-consumer	ref	ref	ref	ref
Consumer	1.26 (0.90, 1.77)	1.45 (0.93, 2.28)	0.87 (0.56, 1.37)	0.70 (0.33, 1.48)

[a]All models were adjusted for age, sex, urbanity, and wealth index.
***P*-value < 0.001, **P*-value < 0.05.

lower risk of stunting. A prior study had stated that meat has been identified as a key food for reducing stunting in children (35). The finding of this study is in line with previous literature which found that meat consumption reduced the likelihood of stunting (36). According to previous research, the consumption of milk and other animal-source foods by undernourished children improves anthropometric indices and reduces the prevalence of nutritional deficiencies (37). Whole grains on the other provide carbohydrates as fuel for children to grow and keep active (38).

Furthermore, a lower risk of stunting was also found to be associated with dietary utilizable protein. Linkages between food groups having high-quality protein and growth are found in previous studies, although these studies had focused on different age groups (39, 40). The findings are similar to the results found that utilizable protein is negatively associated with stunting (41, 42). This indicates that high-quality proteins should be given importance since they are beneficial for child growth, specifically foods rich in amino acids lysine and arginine are both linked to growth hormone release (41).

Table 4. Adjusted odds ratio (OR) of nutrients for the prevalence of malnutrition among school-aged children

Nutrients	Odds ratio (95% CI)			
	Stunting[a]	Underweight[a]	Wasting[a]	Obese[a]
Sample (*n*)	6,421	3,546	5,906	5,360
Utilizable protein				
Q1	Ref			
Q2	0.86 (0.75, 0.98)*	0.94 (0.85, 1.03)	0.99 (0.66, 1.5)	0.97 (0.52, 1.83)
Q3	0.83 (0.68, 1.03)	0.79 (0.65, 0.97)*	0.91 (0.58, 1.42)	1.65 (0.34, 7.95)
Q4	0.69 (0.53, 0.9)*	0.57 (0.35, 0.91)*	0.65 (0.27, 1.55)	5.44 (2.56, 11.5)*
Calcium				
Q1	Ref			
Q2	0.84 (0.59, 1.2)	0.89 (0.84, 0.94)*	0.83 (0.6, 1.17)	0.7 (0.24, 2.07)
Q3	0.73 (0.48, 1.12)	0.78 (0.54, 1.11)	0.79 (0.5, 1.27)	0.71 (0.27, 1.83)
Q4	0.8 (0.46, 1.38)	1.02 (0.83, 1.25)	0.97 (0.79, 1.19)	0.59 (0.31, 1.12)
Vitamin D				
Q1	Ref			
Q2	0.98 (0.83, 1.15)	1.14 (0.89, 1.46)	1.2 (0.96, 1.5)	0.54 (0.33, 0.86)*
Q3	1.09 (0.85, 1.39)	0.99 (0.81, 1.23)	1.15 (0.99, 1.34)	0.77 (0.39, 1.5)
Q4	0.92 (0.71, 1.2)	1.11 (0.67, 1.85)	0.998 (0.69, 1.45)	0.85 (0.55, 1.31)
Vitamin B12				
Q1	Ref			
Q2	0.95 (0.78, 1.15)	0.91 (0.53, 1.58)	0.999 (0.71, 1.41)	1.45 (0.91, 2.33)
Q3	0.86 (0.73, 1.03)	0.85 (0.71, 1.02)	0.87 (0.67, 1.14)	1.07 (0.44, 2.57)
Q4	1.1 (0.76, 1.59)	1.05 (0.75, 1.47)	1.06 (0.68, 1.65)	1.43 (0.79, 2.57)
Riboflavin				
Q1	Ref			
Q2	0.9 (0.69, 1.18)	0.9 (0.69, 1.17)	1.18 (0.8, 1.73)	1.51 (0.38, 6)
Q3	0.87 (0.59, 1.31)	1.01 (0.71, 1.45)	1.42 (1.26, 1.6)*	0.86 (0.16, 4.47)
Q4	0.82 (0.52, 1.29)	0.91 (0.85, 0.98)*	1.44 (1.03, 2.01)*	1.04 (0.17, 6.56)
Thiamin				
Q1	Ref			
Q2	1.09 (0.87, 1.38)	1.08 (0.79, 1.47)	0.86 (0.49, 1.52)	1.16 (0.22, 6.22)
Q3	1.01 (0.82, 1.24)	0.95 (0.73, 1.22)	0.81 (0.66, 0.99)*	1.44 (0.28, 7.56)
Q4	0.85 (0.59, 1.21)	0.81 (0.54, 1.21)	0.77 (0.56, 1.06)	1.84 (0.56, 5.98)
Fiber				
Q1	Ref			
Q2	0.81 (0.63, 1.05)	1.03 (0.87, 1.21)	0.83 (0.72, 0.96)*	0.64 (0.36, 1.14)
Q3	0.92 (0.74, 1.17)	1 (0.63, 1.61)	0.84 (0.63, 1.13)	0.68 (0.52, 0.91)*
Q4	0.98 (0.66, 1.45)	0.89 (0.61, 1.32)	0.69 (0.51, 0.93)*	0.98 (0.76, 1.26)
Vitamin C				
Q1	Ref			
Q2	1.01 (0.87, 1.16)	1.08 (0.89, 1.31)	1 (0.82, 1.23)	1.37 (0.75, 2.52)
Q3	1.02 (0.87, 1.2)	1.08 (0.82, 1.42)	0.95 (0.77, 1.16)	1.13 (0.74, 1.73)
Q4	1.03 (0.82, 1.29)	1.15 (0.92, 1.45)	0.94 (0.61, 1.47)	1.56 (1.02, 2.39)*
Vitamin A				
Q1	Ref			
Q2	1.05 (0.91, 1.22)	0.79 (0.6, 1.02)	0.89 (0.51, 1.56)	1.24 (0.61, 2.53)
Q3	1.07 (0.87, 1.33)	0.94 (0.64, 1.39)	1.04 (0.76, 1.44)	1.26 (0.74, 2.17)
Q4	1.08 (0.9, 1.29)	0.88 (0.69, 1.08)	1.01 (0.75, 1.35)	0.84 (0.34, 2.09)

[a]All models were adjusted for age, sex, urbanity, and wealth index.
**P*-value < 0.05.

Table 5. Linear relationship between children's anthropometric measurements and food group factors

Food groups	B-coefficient (95% CI)		
	Height (m)[a]	Weight (kg)[a]	BMI (kg/m^2)[a]
	B (95% CI)	*B* (95% CI)	*B* (95% CI)
All meat (g)	0.01 (0.004, 0.01)**	0.01 (0.01, 0.01)**	0.004 (0.001, 0.01)**
All milk consumer	0.77 (0.02, 1.52)*	0.58 (−0.22, 1.38)	0.24 (−0.10, 0.58)
Fruits consumer	−0.14 (−0.86, 0.58)	−0.15 (−0.80, 0.50)	−0.03 (−0.29, 0.24)
Beans, nuts, and peas consumer	−0.79 (−1.88, 0.29)	−0.79 (−1.79, 0.21)	−0.29 (−0.67, 0.09)
All grains (g)	0.01 (0.01, 0.01)**	0.01 (0.01, 0.01)**	0.003 (0.002, 0.004)**
Sweets (g)	0.002 (0.001, 0.004)*	0.003 (0.001, 0.01)*	0.001 (0.0005, 0.002)*
Fats and oils (g)	−0.01 (−0.05, 0.03)	−0.004 (−0.03, 0.02)	0.00 (−0.01, 0.02)

[a]All models were adjusted for age, sex, urbanity, and wealth index.
***P*-value < 0.001, **P*-value < 0.05.

Table 6. Linear relationship between children's anthropometric measurements and dietary factors

Nutrients	B-coefficient (95% CI)		
	Height (m)[a]	Weight (kg)[a]	BMI (kg/m^2)[a]
	B (95% CI)	*B* (95% CI)	*B* (95% CI)
Utilizable protein	0.07 (0.05, 0.09)**	0.10 (0.07, 0.12)**	0.04 (0.03, 0.05)**
Calcium	0.004 (0.0005, 0.01)*	0.001 (−0.002, 0.004)	−0.001 (−0.002, 0.001)
Vitamin D	0.48 (0.05, 0.90)*	0.37 (−0.07, 0.81)	0.09 (−0.09, 0.26)
Vitamin B12	−0.49 (−0.84, −0.14)*	−0.35 (−0.67, −0.03)*	−0.10 (−0.24, 0.03)
Riboflavin	−0.17 (−1.53, 1.20)	−1.00 (−2.32, 0.32)	−0.40 (−0.94, 0.15)
Thiamin	0.82 (−0.31, 1.96)	0.71 (−0.37, 1.78)	0.25 (−0.21, 0.71)
Fiber	−0.01 (−0.15, 0.12)	0.05 (−0.09, 0.19)	0.03 (−0.03, 0.08)
Vitamin C	0.01 (−0.02, 0.03)	0.04 (0.002, 0.07)*	0.02 (0.002, 0.03)*
Vitamin A RE	−0.0002 (−0.002, 0.002)	−0.001 (−0.003, 0.0004)	−0.001 (−0.001, 0.0002)

[a]All models were adjusted for age, sex, urbanity, and wealth index.
***P*-value < 0.001, **P*-value < 0.05.

Underweight

This study also revealed that higher consumption of grains and cereal products and sweets was associated with a lower risk of underweight. This could be attributed to the characteristic of grains wherein it is high in fiber and contains more other essential nutrients, including iron, zinc, magnesium, selenium, and B vitamins, necessary for improving the nutritional status (43). Higher consumption of sweets could promote a lower risk of underweight, and the possible explanation could be that sweets or adding sugar to foods increases the energy density. The higher energy density brought by eating sweets would likely have a positive influence on energy intake, especially among children with low energy intake (44). Another aspect that may have influenced this outcome is that the sweets food group is primarily from Filipino traditional desserts, like rice products such as suman, puto, corn puddings, and other sugar-sweetened rice products. The consumption of milk/milk products was also found to be associated with a lower risk of underweight because milk and milk products are the main sources of protein and fat, which are important for the maintenance of appropriate nutritional status (45). This is in line with the findings of a cross-sectional study in India wherein children who consumed dairy milk had lower odds of underweight than those who did not, although this focused on children aged 6–59 months (46). Hence, in the Philippines' Supplementary Feeding Program, which is one of the components of Republic Act 11037, or the Masustansiyang Pagkain para sa Batang Pilipino Act, milk is one of the commodities that is considered to improve the nutritional status of schoolchildren.

In terms of nutrients, dietary utilizable protein, calcium, and riboflavin were found to be associated with a lower risk of underweight. Thus, these findings highlight the value of considering the quality of protein and improving calcium and riboflavin intake when planning a nutrition intervention. In addition, riboflavin could affect the nutritional status because of its role in the metabolism of energy-yielding nutrients (47).

Wasting

The results of this study are in line with the findings of prior research wherein children who did not consume any grains had a higher likelihood of becoming wasted but the analysis was done among 6–23-month-old children (48). Moreover, increased dietary consumption of fiber and thiamine was also associated with a lower risk of wasting. As stated in a previous study, fiber improves overall diet quality as it plays a role in increasing intestinal transport which in turn affects the availability of nutrients absorbed by the body (42), and thiamin plays an important role in carbohydrate and branched-chain amino acid metabolism, making it necessary for energy generation (49).

Obesity

Higher risk of obesity was found to be associated with higher consumption of meat and grains and cereal products. This is confirmed by previous studies that found a higher risk of obesity among subjects who consumed high amounts of grains (50) and meat, especially red and processed meat (51). According to studies, adequate meat consumption is recommended rather than consuming excessive amounts because it is linked to a lower risk of malnutrition and is beneficial for child growth (52–55). Results also showed that consumption of milk and milk products was associated with child obesity. This agrees with previous research wherein dairy consumption appears to influence the study participants' central adiposity and body composition (56). Dairy consumption was also found to be positively associated with waist-to-height ratio (WHtR), fat mass, and fat-free mass. In this study, the consumption of milk and cheese may appear to be responsible for these correlations. In contrast, a prior study reported that there was no significant association between dairy consumption and BMI. However, cheese was found to be positively associated with BMI (57). Another study evaluated the association between milk and dairy consumption and BMI among children aged 2–4 and 5–10 years and discovered that those who consumed the highest amount of milk had a higher BMI than those who consumed the lowest amount (58). According to a study that follows a cohort of 12,829 children aged 9–14 years, it was found that drinking large amounts of milk may provide increased energy and showed increased overall weight in the adolescent population (59).

Lower risk of obesity was also revealed to be associated with higher dietary consumption of fiber and vitamin D. These results are consistent with previous studies which stated that individuals with poor vitamin D and fiber intake were associated with a higher chance of weight gain and greater odds of excess adiposity in childhood (60–62). On the contrary, a higher risk of obesity was found among subjects with an excessive utilizable protein and vitamin C intake. Recent evidence reported that excessive vitamin C can increase reactive oxygen species (ROS) generation which are the by-products of normal cell activity that contributes to an increased risk of obesity (63).

Linear height, weight, and BMI

Higher linear height, weight, and BMI of school-aged children were found to be consistently associated with increased consumption of meat. This is similar to the results of a previous study which reported increased height, body weight, and BMI among children with higher meat intake or animal source foods (64–66). Some of the previous studies have also shown that total meat consumption was associated with weight gain even after controlling for confounding factors (67–69). Aside from meat, consumption of grains and cereal products was also found to be linked with the linear growth of school-aged children. Previous studies that evaluated the association between grain consumption and weight showed either no effect or inverse proportional relationship (70–72). These findings contradict the results of this study. Consequently, the effects of grain consumption on malnutrition may need to be investigated further. Milk/milk products were also found to be linked with higher linear height. Similar results regarding the association of milk/milk products were widely observed (58, 73, 74).

In this study, higher dietary utilizable protein intake was found to be a significant factor affecting height, body weight, and BMI. Several studies supported that an increased dietary protein intake was associated with a greater height, weight, and BMI (40, 75, 76). Height was found to be associated with increased dietary intake of calcium and vitamin D. Several studies have found a positive correlation between calcium intake and height-for-age *z*-score among children aged 6 years and older (77, 78). Vitamin D may have an impact on height as it is essential for achieving optimal linear growth through proper bone development (79). Also, in this study, results have shown a positive correlation of vitamin C with the weight and BMI of children. This contradicts the findings of a previous research that suggested differently indicating that vitamin C deficiency was associated with measures of child obesity and adiposity (80).

Utilizable protein was used in this study as it is more accurate with regard to consumption than the total protein. Values for PDCAAS overestimate the protein quality, specifically for low-quality proteins. Thus, to better meet the protein requirements of humans, the digestible indispensable amino acid scores (DIAAS) should be used to estimate the protein quality of ingredients and diets (81). DIAAS is recommended especially to developing countries like the Philippines because foods typically consumed in many developing countries have lower digestibility of crude protein than foods typically consumed in developed countries (82).

Conclusion

This study provided important evidence into the dietary factors affecting the physical growth of children aged 6–12 years. It was found that undernourished children have a high prevalence of protein inadequacy. Consumption of meat and grains and cereal products, as well as utilizable protein, was identified as the common possible risk factor for stunting, underweight, wasting, obesity, and linear growth, while consumption of milk was identified as a common risk factor for underweight and obesity among schoolchildren aged 6–12 years. Therefore, the study suggests that nutrition interventions and policies focusing on child malnutrition should improve the quality of nutrients in foods consumed by children to aid in proper growth and development. This study suggests more researches on the dietary factors, especially utilizable protein and physical growth.

Ethics approval and consent to participate

Ethical consent for the study was obtained from the Food and Nutrition Research Institute Ethics Review Board (FIERC Protocol Code FNRI-2020-019).

Availability of supporting data

The datasets used and/or analyzed during this study are available from the corresponding author on reasonable request.

Conflict of interest and funding

The authors declare no conflict of interest. N.T. and M. S. are employees of Ajinomoto Inc., Japan. The opinions expressed in this article are those of the authors and do not necessarily reflect the views or recommendations of their affiliations. The research described here was a collaboration of two organizations: The Department of Science and Technology, Food and Nutrition Research Institute (DOST-FNRI), Philippines (data collection and analyses), and Institute of Food Sciences and Technologies (Ajinomoto Inc.), Japan (funding source and study conceptualization).

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