Dietary Risk Factors of Physical Growth of Filipino School-aged Children

Imelda Angeles Agdeppa (iangelesagdeppa@yahoo.com.ph)
Department of Science and Technology, Food and Nutrition Research Institute https://orcid.org/0000-0001-9132-7399
Taro Nakamura
Institute of Food Sciences and Technologies, Ajinomoto Co., Inc.
Mayu Sugita
Institute of Food Sciences and Technologies, Ajinomoto Co., Inc.
Marvin Bangan Toledo
Department of Science and Technology, Food and Nutrition Research Institute
Pamela Castillo Sampaga
Department of Science and Technology, Food and Nutrition Research Institute
Jezreel Ann Taruc Zamora
Department of Science and Technology, Food and Nutrition Research Institute

Research

Keywords: Child Malnutrition, Stunting, Underweight, Wasting, Obesity, Protein Adequacy, Utilizable Protein

Posted Date: April 30th, 2021

DOI: https://doi.org/10.21203/rs.3.rs-442943/v1

Abstract

Background: The study evaluated the relationship of the usual nutrient intake and protein adequacy to the prevalence of child malnutrition.

Methods: Data were derived from the 2013 Philippine National Nutrition Survey. A total of 6,565 children aged 6-12 years across all the 17 regions that participated in the survey were analyzed. Two (2) non-consecutive day 24-hour 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 usual intake of energy and 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.

Results: School-aged children were found to have lower dietary intake of utilizable protein than total protein. Higher consumption of grains and meat decreased the prevalence of stunting. Furthermore, linear growth of children was found to be associated with the dietary intake of several nutrients including utilizable protein, calcium, vitamin B12, vitamin C and vitamin D. The prevalence of stunting and underweight significantly decreased with a higher consumption of utilizable protein. Milk consumption decreased the prevalence of underweight. The prevalence of underweight also decreases with a higher dietary consumption of calcium, riboflavin and vitamin C. Higher consumption of grains also decreased the prevalence of underweight and wasting. A decreased prevalence of wasting was also found with higher dietary consumption of riboflavin, thiamine and fiber. On the contrary, higher consumption of meat, milk and grains increased the prevalence of obesity. In particular, higher dietary consumption of utilizable protein and vitamin C increased the prevalence of obesity.

Conclusions: Even though the dietary total protein intake of school-aged children is considered adequate, the existence of malnutrition among children may be specifically attributed to quality of protein consumed. Therefore, the study suggests that nutrition interventions and policies focusing on child malnutrition should improve not just the quantity, but the quality of protein sources consumed by children to aid in proper growth and development.

Background

Malnutrition accounts for at least half (54%) of all the 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]. Combatting child malnutrition is complex since it is affected by a wide array of factors. 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]. 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 [10]. In terms of wasting, about 769,000 Filipino children suffers from either moderate or severe wasting which ranks the Philippines as the 10th country in the world with the highest burden of wasting [10]. Data from the 2013 National Nutrition Survey (NNS) revealed that 30% of children aged 6–12 years were considered underweight and is still considered a public health problem even though it was reduced to 29.1% from 32.0% in 2011 [11–12]. On the other hand, 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].

It is important that children are provided with a diet containing adequate quantities of nutrients to allow them to reach their optimal growth [13]. Moreover, there is also a substantial evidence that a poor dietary intake during childhood can not only affect growth but could also 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 on its relation with 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 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 be also 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 consuming specific protein sources that could affect growth [19–20]. In developing countries such as the Philippines, however, dietary protein is mainly limited to plant-based sources, which 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 present study aims to evaluate the relationship of protein quality, food and usual nutrient intake to the prevalence of child malnutrition.

Materials And Methods

Study Design and Populations

The 2013 National Nutrition Survey (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 8592 Filipino households were sampled with a response rate 87.7%. Hence, data from a total of 6,565 children aged 6 to 12 years participated in the survey were analyzed for this study. 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 information were collected from the 2013 NNS survey participants, including age, gender and area of residence. 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 height was measured using Microtoise – an L-shaped device (SECA 206, Hamburg, Germany). Weight and height were measured twice, but when two measurements were greater than 0.3 kg and 0.5 cm respectively, a third measurement was made. The mean of the 2 measurements were correspondingly recorded to the nearest 0.1 kg or cm. Body mass index was calculated by dividing weight (in kg) over the square of height (in meters).

For the nutritional status of children 5.08 to 19.0 years old (61–228 months), the WHO Growth Reference 2007 was used.

Dietary data

Two (2) non-consecutive day 24-hour dietary recalls (24hR) were collected on site via face-to face interview by trained registered nutritionist-dietitians using structured questionnaires. All members of the sampled households were interviewed for the first 24 hours of food intake. The second day recall was obtained from the 50% of randomly chosen households with first 24hR. Food items recalled in most cases were in 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.

Derivation of utilizable protein

Utilizable protein was estimated using the 2007 WHO amino acid requirements and the PDCAAS method [27]. 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. The step-by-step process of the computation of utilizable protein was discussed elsewhere was followed [28].

Statistical Analyses

Descriptive statistics including frequencies, percentages, means, standard errors (SE) and percentiles were used to summarize social demographics, nutrient and food intake, and dietary diversity score of the participants. Food groups and nutrients used in the analysis are listed in Table 1. We also generated quartiles (Q1, Q2, Q3, and Q4) of nutrients and food groups consumed by the children using –xtile- command in Stata to form four groups representing the ordered rank intake. In estimating the usual intake of energy and key nutrients that account for between- and within-person differences in intake [8], PC-SIDE version 1.0 software (Software for Intake Distribution Estimation) was used. The best linear unbiased predictor (BLUP) of usual intake of energy and key nutrients for growth was estimated for the association study. 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.

Z-test for difference of two populations with known variance

Z-test was used to test the difference of mean usual energy and key nutrient intakes between two independent samples i.e. Normal vs Stunted children, Normal vs Underweight children, Normal vs Wasted children, and Normal vs Obese children.

Wilcoxon Rank-Sum Test (Mann –Whitney)

Wilcoxon rank-sum was used to test the hypothesis that two independent samples i.e. Normal vs Stunted, Normal vs Underweight, and Normal vs Wasted have equal distribution of food consumption.

Multiple Logistic Regression

Multiple logistic regression analyses were used to determine the impact of food groups and nutrients intakes (as independent variables) to the prevalence of stunting, underweight, wasting and obesity among school-aged children (dependent variable) while adjusting for cofounders such as age sex, urbanity, and wealth quintile. All dependent variables (underweight, stunting, obese and wasting) were categorized as dichotomous variables and odds ratios were calculated. Underweight, stunting, obese and wasting were used as outcome variables in separate logistic regression models, using the same methods for each. All predictor variables are entered into the regression equation at the same time and were expressed in quartiles. Selected nutrients were included in the logistic regression analysis. The criteria for selecting the nutrients has a minimum correlation (< 0.5 correlation coefficient) to other nutrients to minimize collinearity. 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 influence of food group and usual nutrient intakes of children to the anthropometric indices. For the regression models, covariates included were age, sex, urbanity, and wealth quintile. All independent variables were entered into the regression equation at the same time. Selected nutrients were included in the regression analysis. The criteria for selecting the nutrients has a minimum correlation (< 0.5 correlation coefficient) to other nutrients to minimize collinearity. Food group intakes were transformed using natural logarithm function $\ln(x)$.

Table 1
Variables used in the study

Food Groups	Nutrients
Grains (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 (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)

Results

Children were equally distributed by age group and sex. More than half (58.2%) of the participants were from rural residence while the others were from urban areas (41.7%). Three out ten (30%) of the participants came from households classified as poorest while 23% were considered as poor. About 29% were classified as wealthy children and 18% were considered as middle class. Prevalence of stunting, underweight, wasting and obesity among the children were 30.4%, 31.2%, 12.3% and 3.9%, respectively (Table 2).

Table 3 presents the median (10th, 90th percentile) consumption of each food group. Results showed that there was a significant difference between the median consumption of all food groups except fruits, beans, nuts & peas and mixed dishes of normal and stunted children; as well as normal and underweight children. Intakes of grains, all meats, sweets, fats and oils; beverages and milk were significantly higher in normal than among the stunted and underweight children. Intake of vegetables is significantly higher among stunted than normal children but among underweight children intake was similar with normal children. Intake of fruit and fruit juices, beans, nuts and peas and mixed dishes is similar among stunted and normal children as well as underweight and normal children. Consumption of grains and vegetables significantly differ between normal and wasted children but Intakes of all meat, sweets, fats and oils, other food and beverages, fruit and fruit juices, milk, beans, nuts and peas and mixed dishes was similar between wasted and normal children. Between normal and obese children, test showed that there was a difference on the consumption of grains, all meat, sweets, fats & oils, beans, nuts & peas and other food and beverages but among obese and normal children's intakes of vegetables, fruits, milk, and mixed dishes was similar.

Usual mean ± SE of energy and key nutrient intakes by nutritional status are presented in Table 4. Test showed that stunted and underweight children have significantly lower mean intake of all nutrient intakes compared to normal children ($P < 0.001$). However, obese children have higher mean intake of all nutrients in contrast to children with normal nutritional status ($P < 0.001$). Wasted children have lower intake all nutrients ($P < 0.001$) except thiamin compared to normal children.

The difference between means of usual utilizable protein and total protein intake is also shown in Table 4. Mean of usual total protein intake of stunted, underweight, wasted and obese children were 37 g, 33 g, 39 g, and 63 g per day respectively while mean of usual utilizable protein intake were 29 g, 26 g, 31 g, and 51 g respectively. Mean of usual utilizable protein intake was significantly lower compared to mean of total protein intake.

The prevalence of inadequacy of the total protein and utilizable protein by malnutrition status is shown in Fig. 1. Prevalence of inadequacy of utilizable protein in stunted, underweight, wasted and obese children was 42.9%, 29.1%, 19.4% and 4.9% respectively; the prevalence of inadequacy of total protein in stunted, underweight, wasted and obese children was 25.8%, 48.4%, 37.1% and 9.3% respectively. Prevalence of inadequacy of both utilizable and total protein was higher for stunted, underweight and wasted children compared to normal children. In contrast, obese children have lower prevalence of inadequacy of both utilizable and total protein compared to normal children.

Table 5 shows the adjusted ratio of food groups for nutritional status among school-aged children. Among stunted, all meat, all grains and sweets remained statistically significant after adjusting for confounders such as age sex, urbanity, and wealth quintile. Children who consumed more meat, grains and sweets were 0.99 times less likely to be stunted compared to those who consumed less from these foods.

The odds of underweight among children that consumed more grains and sweets were both 0.99 times less likely than those who consumed less. Children who consumed milk was 0.63 times (95% CI: 0.43, 0.91) less likely to be underweight than those that consumed less. Prevalence of wasting was 0.99 times less likely for those children that consumed more grains than those consumed less. The odds of children being obese was 1.89 times higher for those that consumed milk and about 1.003 times more likely for those that consumed both more grains and meat.

Table 6 shows the adjusted odds ratio (OR) of nutrients for prevalence of malnutrition among school-aged children. All factors of each model were adjusted for confounding factors such as age, sex, urbanity and wealth quintile. Only utilizable protein remained significantly associated with the prevalence of stunting. The odds of children being stunted was 69% lower for children in the highest quartile (Q4) than the lowest quartile (Q1). After adjusting for confounders, utilizable protein, calcium, and riboflavin remained significantly associated to the prevalence of underweight. Specifically, children with highest utilizable protein intake (Q4) were 56% (95% CI; 35%, 91%) times less likely to become underweight than those from lowest quartile (Q1). The adjusted ORs comparing prevalence of underweight among children in Q2 of calcium intake was 89% (95% CI; 84%, 94%) less likely than those in the lowest quartiles (Q1). The odds of underweight among children in highest intake of riboflavin (Q4) was 0.91 times lower than those of the lowest quartiles (Q1).

Riboflavin, thiamin and fiber remained significantly associated with the prevalence of wasting. The odds of wasting among children in the highest intake (Q4) of riboflavin was 1.44 (95% CI; 1.03, 2.01) times more likely than those in the lowest quartiles (Q1). The odds of children being wasted was 80.9% lower for children with higher intake of thiamin (Q3) than the lowest quartile (Q1). Children with the highest intake (Q4) of fiber have 68.7% lower odds of becoming wasted compared to those children with lowest intake (Q1).

Utilizable protein, vitamin D, fiber and vitamin C were significantly associated to the prevalence of obesity. Children with highest intake (Q4) of utilizable protein have 5.44 times higher odds of becoming obese compared to those children with lowest intake (Q1). The odds of obesity among children in the higher intake (Q2) of vitamin D was 54% (95% CI; 33%, 86%) times less likely than those in the lowest quartiles (Q1). The adjusted ORs comparing prevalence of obesity in Q3 of fiber intake was 68% (95% CI; 52%, 91%) less likely than those in the lowest quartiles (Q1). Children with the highest intake (Q4) of vitamin C have 1.56 times higher odds of becoming obese compared to those children with lowest intake (Q1).

Results showed in the linear regression analysis that for every 1-unit increase of the consumption of meat, grains, and sweets, children's height significantly increases by 0.01 (95% CI: 0.004, 0.01), 0.01 (95% CI: 0.01, 0.01), and 0.002 (95% CI: 0.001, 0.004), respectively (Table 7). Also, children consuming milk increases the height by 0.77 (95% CI: 0.02, 1.52) compared to non-consumers. Based on the results, children's body weight significantly increase by 0.01 (95% CI: 0.01, 0.01) as meat consumption increase, by 0.01 (95% CI: 0.01, 0.01) as grains consumption increase, and by 0.003 (95% CI: 0.001, 0.01) as sweets consumption increase. Also, body mass index (BMI) also increase by 0.004 (95% CI: 0.001, 0.01), 0.003, (95% CI: 0.002, 0.004), and 0.001 (95% CI: 0.0005, 0.002) for every 1-unit increase of meat, grains, and sweets consumption.

Table 8 showed that utilizable protein, calcium, vitamin D and vitamin B12 were significant dietary factors of child's height after including the cofounders in the regression model. Specifically, children's height increases by 0.07 (95% CI: 0.05, 0.09) for every 1-unit increase of 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 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 increase by 0.04 (95% CI: 0.03, 0.05) as utilizable protein intake increase by 1-unit. BMI significantly increases by 0.02 (95% CI: 0.002, 0.03) for every 1-unit increase of vitamin C intake.

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

	n	%
Age Groups		
6–9	3594	54.7
10–12	2971	45.2
Sex		
Male	3387	51.6
Female	3178	48.4
Urbanity		
Rural	3824	58.2
Urban	2741	41.7
Wealth Quintile		
Poorest	1906	29.8
Poor	1487	23.3
Middle	1168	18.3
Rich	980	15.3
Richest	848	13.3
Nutritional Status	**n**	**%**
Height-for-age Classification[a]		
Normal (-2SD to 2SD)	4466	69.5
Stunted (<-2SD)	1955	30.4
Weight-for-age Classification[a]		
Normal (-2SD to 2SD)	2439	68.8
Underweight (<-2SD)	1107	31.2
BMI-for-age Classification[b]		
Severe Wasting (<-3SD)	156	2.5
Wasting(<-2SD to -3SD)	607	9.8
Normal (-2SD to 1SD)	5143	78.2
Overweight & Obese (> 1SD)	330	5.5
Obese (> 2SD)	217	3.9
Anthropometric	**Mean**	**Standard Error**
Weight (kg)	25.9	0.32

[a]based on WHO Child Growth Standards

[b]based on the 2007 WHO Growth Reference BMI-for-age

	n	%
Height (cm)	127	0.16
BMI (kg/m^2)	15.64	0.03
[a]based on WHO Child Growth Standards		
[b]based on the 2007 WHO Growth Reference BMI-for-age		

Table 3
Comparison between Nutritional Status and food intakes of school aged children, NNS 2013

		Physical Indicators							
	All	**Stunting**		**Underweight**		**Wasting (Thinness)**		**Obesity**	
Food Group[a]	*% of Children Consuming*	*Normal*	*Stunted*	*Normal*	*Underweight*	*Normal*	*Wasted/Thin*	*Normal*	*Obese*
		Median (10th, 90th)		Median (10th, 90th)		Median (10th, 90th)		Median (10th, 90th)	
Sample, (n)		4466	1955	2439	1107	5143	763	5143	217
Grains (g)	99.9	224.2 (112.7, 431.3)	205 (105, 397.4)*	197.8 (105.6, 359.8)	184.3 (91.3, 346.2)*	217.5 (87.4)	193.8 (106.7, 384.6)*	217.5 (87.4)	297 (147.3, 534.1)*
All Meat (g)	90	93.1 (52.2, 228)	71.5 (35.2, 185.2) *	85.1 (48.3, 211.7)	68.8(36.1, 161.1)*	83 (44.5, 204.5)	84.4 (43.5, 196.6)NS	83 (44.5, 204.1)	155.3 (93.6, 329.7)*
Sweets (g)	70.4	59.4 (9.3, 331)	35 (5.3, 271.5)*	59.7 (10, 331)	33.5 (5, 265)*	50 (8, 301.8)	44.5 (5.8, 292)NS	50 (8, 301.8)	153 (10, 497)*
Fats and Oils (g)	65.9	5.1 (1.4, 15.5)	5 (1.4, 14.4) *	5 (1.4, 15)	5 (1.4, 13.4)*	5 (1.4, 15)	5 (1.5, 13.6)NS	5 (1.4, 15)	7.1 (2.1, 18.6)*
Vegetables (g)	53.1	36.4 (7.5, 132.7)	42.3 (8.6, 165.6) *	33.7 (6.7, 128.7)	36.1 (7.3, 139.1)NS	38 (8.4, 146.1)	35.2 (6.7, 123.1)*	38 (8.4, 146.1)	44.6 (8.9, 134.4)NS
Other Food and Beverages (g)	48.6	9.4 (1.2, 45)	6.4 (0.5, 30) *	9.1 (1.4, 40.8)	6 (0.5, 30)*	8 (1, 40)	7.5 (1, 40)NS	8 (1, 40_	20 (3.7, 95.9)*
Fruit and Fruit Juices (g)	17.6	61 (10.8, 200)	68 (14.4, 190.5)NS	56.2 (10.8, 180)	64.1 (14.4, 208.1)NS	63.4 (11.3, 193.5)	68 (17.3, 189.7)NS	63.4 (11.3, 193.5)	49.7 (8.1, 237)NS
Milk (g)	17.5	19.6 (6.6, 90)	18.8 (6.1, 56.6)*	20.3 (7.5, 94)	18.8 (5, 69.6)*	18.8 (6.3, 80)	18.8 (8.7, 70)NS	18.8 (6.3, 80)	28 (8.6, 120)NS
Beans, Nuts, and Peas (g)	8.9	26 (13, 90)	22.1 (13, 91.2)NS	20 (13, 72.8)	19.5 (13, 72.8)NS	26 (13, 91.2)	18.8 (11, 72.8)NS	26 (13, 91.2)	36.4 (30, 124.8)*
Mixed Dishes (g)	4.4	228 (30, 454.5)	228 (10, 303)NS	228 (20, 303)	187.7 (37, 303)NS	228 (10, 303)	228 (75.9, 303)NS	228 (10, 303)	236.8 (30, 372.8)NS
Abbreviation: NS = Not Significant									
[a]based on 24-h food recall;									
*significant using Wilcoxon signed rank test with 95% level of significance (P < 0.05)									

Table 4
Comparison between Nutritional Status and usual energy and nutrient intakes of school aged children, NNS 2013

	Physical Indicators							
	Stunting		**Underweight**		**Wasting**		**Obesity**	
Nutrients[a]	*Normal*	*Stunted*	*Normal*	*Underweight*	*Normal*	*Wasted*	*Normal*	*Obese*
	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE
Sample, **n**	4466	1955	2439	1107	5143	763	5143	217
Energy (kcal)	1418.3 ± 7.2	1220 ± 10.6*	1291.3 ± 8.5	1101.9 ± 11.4*	1324.6 ± 6.5	1269.5 ± 15.3*	1324.6 ± 6.5	1929.9 ± 33.3*
Total Protein (g)	43.7 ± 0.33	36.7 ± 0.43*	39.5 ± 0.4	33.3 ± 0.5*	40.3 ± 0.28	38.7 ± 0.71*	40.3 ± 0.28	62.6 ± 1.8*
Utilizable Protein (g)	34.8 ± 0.28	28.6 ± 0.37*	31.7 ± 0.35	26.1 ± 0.43*	31.8 ± 0.24	30.8 ± 0.61*	31.8 ± 0.24	50.9 ± 1.6*
Total Fat (g)	29.8 ± 0.25	20.8 ± 0.30*	28.4 ± 0.32	19.4 ± 0.33*	25.8 ± 0.22	24.6 ± 0.49*	25.8 ± 0.22	48.1 ± 1.3*
Carbohydrates (g)	243.4 ± 1.28	220.9 ± 1.99*	218.9 ± 1.47	198 ± 2.17*	232.5 ± 1.19	222.7 ± 2.83*	232.5 ± 1.19	311.5 ± 6*
Total Fiber (g)	6.9 ± 0.04	6.8 ± 0.07*	6.4 ± 0.05	6.1 ± 0.08*	6.9 ± 0.04	6.2 ± 0.09*	6.9 ± 0.04	8.5 ± 0.2*
Total Sugar (g)	28.8 ± 0.26	22.4 ± 0.33*	29.1 ± 0.39	22.3 ± 0.40*	25.8 ± 0.22	25.3 ± 0.51*	25.8 ± 0.22	37.6 ± 1.3*
Calcium (mg)	284.6 ± 1.90	241.3 ± 2.87*	271.5 ± 2.55	228.2 ± 3.52*	265.4 ± 1.72	253.3 ± 4.52*	265.4 ± 1.72	369.7 ± 11.3*
Phosphorus (mg)	667.9 ± 3.51	579.7 ± 5.20*	608.8 ± 4.14	524.4 ± 5.86*	624.8 ± 3.15	600.2 ± 7.56*	624.8 ± 3.15	908.1 ± 17.3*
Iron (mg)	7.9 ± 0.07	6.4 ± 0.08*	7.4 ± 0.09	6.6 ± 0.20*	7.2 ± 0.07	7.5 ± 0.23*	7.2 ± 0.07	11.4 ± 0.3*
Sodium (mg)	937.3 ± 7.58	746.6 ± 11.5*	887.5 ± 9.97	716.3 ± 13.2*	844.9 ± 6.96	827.3 ± 16.3*	844.9 ± 6.96	1440 ± 35.3*
Vitamin A RE (µg RE)	314 ± 2.99	292.1 ± 4.53*	309.8 ± 4.1	262.1 ± 5.57*	312 .3 ± 3.51	310.4 ± 7.1*	312 .3 ± 3.51	401.3 ± 9.2*
Thiamin (mg)	0.69 ± 0.004	0.54 ± 0.005*	0.65 ± 0.005	0.51 ± 0.006*	0.63 ± 0.004	0.60 ± 0.09[NS]	0.63 ± 0.004	0.95 ± 0.02*
Riboflavin (mg)	0.63 ± 0.005	0.49 ± 0.007*	0.61 ± 0.009	0.47 ± 0.008*	0.56 ± 0.004	0.55 ± 0.01[NS]	0.56 ± 0.004	0.86 ± 0.02*
Niacin (mg)	13.6 ± 0.07	11.6 ± 0.11*	12.3 ± 0.09	10.5 ± 0.12*	12.6 ± 0.07	12.2 ± 0.15*	12.6 ± 0.07	18.5 ± 0.35*

Abbreviation: NS = Not Significant

[a]based on 2 days non-consecutive food recall;

*significant using ztest with 95% level of significance (P < 0.05)

	Physical Indicators							
Ascorbic Acid (mg)	20.9 ± 0.21	21.2 ± 0.33*	19.9 ± 0.26	20.3 ± 0.50*	20.8 ± 0.20	19.1 ± 0.52*	20.8 ± 0.20	26.6 ± 1.23*
Abbreviation: NS = Not Significant								
[a]based on 2 days non-consecutive food recall;								
*significant using ztest with 95% level of significance (P < 0.05)								

Table 5
Adjusted odds ratio (OR) of food groups for nutritional status among school aged children

	Odds Ratio (95% Conf.Interval)			
Food Groups	**Stunting**[a]	**Underweight**[a]	**Wasting**[a]	**Obese**[a]
All meat (g)	0.99 (0.997, 0.999)*	0.99 (0.99, 1)	0.99 (0.99, 1)	1.003 (1.001, 1.006)**
All Grains (g)	0.99 (0.996, 0.998)**	0.99 (0.996, 0.999)*	0.998 (0.996, 0.999)*	1.003 (1.001, 1.004)**
Sweets (g)	0.99 (0.998,0.999)*	0.99 (0.997, 0.999)*	0.999 (0.998, 1)	1.001 (0.999, 1.002)
Fats & Oils (g)	1.003 (0.99, 1.01)	0.99 (0.98, 1.01)	1 (0.99, 1.02)	1.01 (0.99, 1.03)
All Milk				
Non-Consumer	ref	ref	ref	ref
Consumer	0.89 (0.67, 1.19)	0.63 (0.44, 0.91)*	1.16 (0.79, 1.68)	1.89 (1.21, 2.96)*
Fruits & Fruit Juice				
Non-Consumer	ref	ref	ref	ref
Consumer	1.16 (0.91, 1.48)	1. 54 (0.75, 1.47)	0.94 (0.67, 1.32)	0.76 (0.41, 1.4)
Beans, Nuts and Peas				
Non-Consumer	ref	ref	ref	ref
Consumer	1.35 (0.95, 1.94)	1.63 (0.99, 2.66)	0.82 (0.51, 1.32)	0.78 (0.34, 1.79)
[a]All model were adjusted for age, sex, urbanity, and wealth index.				
**p-value < 0.001, *p-value < 0.05				

Table 6
Adjusted odds ratio (OR) of nutrients for the prevalence of malnutrition among school aged children

	Odds Ratio (95% Conf.Interval)			
Nutrients	**Stunting vs. Normal [a]**	**Underweight vs Normal [a]**	**Wasting vs Normal [a]**	**Obese vs Normal [a]**
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)

[a]All model were adjusted for age, sex, urbanity, and wealth index.

**p-value < 0.001, *p-value < 0.05

	Odds Ratio (95% Conf.Interval)			
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 model were adjusted for age, sex, urbanity, and wealth index.				
**p-value < 0.001, *p-value < 0.05				

Table 7

Linear relationship between children's anthropometric measurements and Food Group factors

	B-coefficient (95% CI)		
Food Groups	**Height (m)** [a]	**Weight (kg)** [a]	**BMI (kg/m2)** [a]
Age	5.11(4.97, 5.26)**	2.59 (2.43, 2.75)**	0.27 (0.21, 0.33)**
Sex	1.48 (0.96, 2.00)**	0.47 (-0.04, 0.99)	-0.13 (-0.34, 0.08)
Urbanity	0.28 (-0.28, 0.83)	-0.03 (-0.53, 0.47)	-0.08 (-0.29, 0.12)
Wealth Index	2.13 (1.80, 2.46)**	2.20 (1.85, 2.54)**	0.71 (0.57, 0.85)**
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 model were adjusted for age, sex, urbanity, and wealth index.			
**p-value < 0.001, *p-value < 0.05			

Table 8
Linear relationship between children's anthropometric measurements and dietary factors

	B-coefficient (95% CI)		
Nutrients	Height (m) [a]	Weight (kg) [a]	BMI (kg/m^2) [a]
Age	5.24 (5.15, 5.34)**	2.79 (2.70, 2.89)**	0.38 (0.35, 0.42)**
Sex	1.38 (1.01, 1.74)**	0.65 (0.32, 0.98)**	0.01 (-0.12, 0.15)
Urbanity	0.25 (-0.14, 0.63)	-0.05 (-0.40, 0.29)	-0.13 (-0.28, 0.01)
Wealth Index	2.16 (1.94, 2.39)**	1.95 (1.73, 2.17)**	0.57 (0.48, 0.66)**
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 model were adjusted for age, sex, urbanity, and wealth index.

**p-value < 0.001, *p-value < 0.05

Discussion

I. Nutrient Intake

The present study revealed that the dietary protein intake of school-aged children is considered adequate however higher percentage of inadequacy of utilizable protein is still observed especially among stunted children (Figure 1). This implies that sources of protein intake are of low biologic value. This is evident in the diet of Filipino school-aged children as the results showed that plant-based foods specifically grains (99.9%) are the most consumed food group. Plant-based foods tend to have poorer protein quality because its proteins are less digestible and contain lower amounts of some essential amino acids such as lysine and tryptophan which is found to accelerate growth [29]. Milk (17.5%) is also included among the least consumed food groups. Milk consumption is beneficial among school-aged children since it contains high quality protein, calcium and insulin-like growth factor-I which are found to be effective for improved linear growth [30] and proper bone development [31].

Results from logistic regression showed a significant association between dietary utilizable protein and stunting. Linkages between dietary protein and stunting were also widely observed in previous literatures [29, 32-33]. A higher dietary protein intake is reported in a prior study to be possibly beneficial for growth among stunted and weight gain for wasted children [26]. Aside from dietary utilizable protein, calcium and riboflavin were also found to be significantly associated with the prevalence of underweight. Furthermore, increased dietary consumption of fiber and thiamine were found to be significantly associated with a lower wasting prevalence. This may be attributed to the role of dietary fiber on gut inflammation and increased intestinal transport that affects the availability of nutrients absorbed by the body [34] and the relationship of thiamine to growth retardation and malnutrition [35-37]. Lower risk of obesity was also revealed to be significantly 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 [38-40]. On the other hand, higher risk of obesity was found with an excessive utilizable protein and vitamin C intake. Recent evidence reported that excessive vitamin C can increase ROS generation that contributes to increased risk of obesity [41].

Correlation between several nutrients, height and weight gain is shown in the multiple linear regression. Higher dietary utilizable protein intake was found to be a significant factor affecting body weight and BMI. Several studies also stated that an increased dietary protein intake was associated with a greater height, weight and BMI [42-43]. Increased dietary intake of utilizable protein, calcium and vitamin D was found to significantly increase height. Several studies have found a positive correlation between calcium intake and height-for-age z-score among children 6 years and older [44-45]. Vitamin D may have an impact on height as it is essential for achieving optimal linear growth through proper bone development [46]. On the contrary, a prior study reported that vitamin D intake was not associated with height-for-age z-score [47].

II. Food Group Consumption

Delving specifically among food groups consumed, grains (99.9%) mainly contributed to the total energy intake of school-aged children followed by meat (90.0%) and sweets (70.4%). Among the grains, rice is the most commonly consumed food item because it is considered a staple food in the Philippines. As stated by the Food and Agriculture Organization (FAO), rice-consuming countries are more likely to have inadequate and unbalanced nutrient intake [48]. This may be attributed to the dependence of lower-income Filipinos on rice in expense of other nutrient-dense food groups such as fruits and vegetables because of its affordability. Although rice is a good source of carbohydrate, it is also a poor source of vitamins and minerals wherein losses occur during the milling process [49]. High consumption of sweets (70.4%) which is also found in the study, has also a detrimental effect on children as it is linked to dental caries, reduced micronutrient intake and increased risk of obesity [50]. In terms of high meat consumption (90.0%), the results of the study are in line with the EAT-Lancet Commission report which states that more meat and other major protein sources should be consumed by low-income countries that are rice-consumers to mitigate malnutrition [51]. This is contradicted by a previous study which reported that high meat consumption translates into increased prevalence of obesity due to its high fat and energy content [52].

In the logistic regression analysis, the present study had shown that higher consumption of grains is a consistent determinant of child malnutrition. This is in conjunction with several previous literatures that found an association between high consumption of grains and the prevalence of undernutrition [53-54] and obesity [55]. Meat consumption is also found to be associated with the prevalence of stunting and obesity among school-aged children. This is supported by a previous study which reported an increased risk of obesity among subjects who consumed high amounts of meat, specifically red and processed meat [56] and contradicted by another prior study which reported an increased height among children who had a higher frequency of meat consumption per week [56]. Instead of consuming excessive amounts of meat, an adequate intake is recommended as it is associated with a reduced likelihood of being malnourished and is beneficial for child growth [57-58].

An association between consumption of milk/milk products and the prevalence of underweight and obesity was also found in the present study. These are consistent with previous literatures [58-62]. Furthermore, high consumption of sweets was also found to be associated with both stunting and underweight. In a previous research, high intakes of added sugars, particularly in the form of soft drinks, sugar, and sweets were found to increase one's susceptibility to micronutrient deficiencies [63] which may affect child growth and nutrition.

With regards to the multiple linear regression analysis, increased consumption of meat, grains and milk were found to significantly increase the height of school-aged children which is in line with the results of the logistic regression analysis. An increase in weight and BMI were also found with a higher consumption of meat and grains. This is similar to the results of a previous study which reported body weight gain and increased BMI with higher meat intake [64-65]. On the other hand, results of this study are in contrast with previous research stating that increased consumption of grains lowers the risk of weight gain and obesity [66].

Conclusions

The present study provided important insights into the dietary factors affecting the physical growth of school-aged children aged 6–12 years. The findings showed that school-aged children had poor consumption of nutrient-dense food groups such as fruits, vegetables and milk. Grains were considered the most consumed food group followed by meat and sweets. The dietary protein intake of school-aged children is considered adequate, however malnourished children consumed lower amounts of protein than normal children. Mean usual utilizable protein intake is also specifically lower than the mean dietary protein intake. The results implicate that school-aged children consumed adequate dietary protein but their diet itself consists of poor biologic value protein. Therefore, the study suggests that nutrition interventions and policies focusing on child malnutrition should improve not just the quantity, but the quality of protein sources consumed by children to aid in proper growth and development. This study suggests more researches on the evaluation of utilizable protein and physical growth.

List Of Abbreviations

PDCAAS: Protein Digestibility Corrected Amino Acid Score; NNS: National Nutrition Survey; FNRI: Food and Nutrition Research Institute; FIERC: Food and Nutrition Research Institute Ethics Review Board; PSU: Primary Sampling Unit; EA: Enumeration Areas; WHO: World Health Organization; PC-SIDE: PC-Software for Intake Distribution Estimation; BLUP: Best Linear Unbiased Predictor; BMI: Body Mass Index; Q1: Quartile 1; Q2: Quartile 2; Q3: Quartile 3; Q4: Quartile 4; Ref: Reference group; RE: Retinol Equivalent; NE: Niacin Equivalent; SE: Standard Error; OR: Odds Ratio; CI: Confidence Interval; SD: Standard Deviation.

Declarations

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).

Consent for publication

Not applicable

Availability of supporting data

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

Competing interests

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 alone and do not necessarily reflect the views or recommendations of their affiliations.

Funding

The research described here was a collaboration of 2 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).

Author's contributions

Imelda Angeles-Agdeppa, Taro Nakamura, Mayu Siguta conceptualized and designed the study, and approved the final manuscript as submitted. Marvin B. Toledo and Pamela C. Sampaga performed the data organization and statistical processing and analysis. Pamela C. Sampaga drafted the initial manuscript and Jezreel Ann T. Zamora revised the final manuscript. All authors proof-read and approved the manuscript.

Acknowledgements

The research described here was a collaborative study of 2 organizations: The Department of Science and Technology, Food and Nutrition Research Institute (DOST- FNRI), Philippines and Institute of Food Sciences and Technologies (Ajinomoto Inc.), Japan. The authors would like to acknowledge the field staff who collected the data in the national nutrition survey and Mr. Eldridge

Ferrer of the Department of Science and Technology – Food Nutrition and Research Institute for providing the datasets for this study.

References

1. Demissie S, Worku A. 2013. Magnitude and factors associated with malnutrition in children 6–59 months of age in Pastoral community of Dollo Ado District, Somali Region, Ethiopia. Science Journal of Public Health. 2013, 1:175–183. doi: 10.11648/j.sjph.20130104.12.
2. Food and Agriculture Organization (FAO)/World Health Organization (WHO). 2003. Diet, Nutrition and the Prevention of Chronic Diseases. https://www.who.int/dietphysicalactivity/publications/trs916/en/gsfao_introduction.pdf. Accessed 20 Aug 2020.
3. United Nations International Children's Emergency Fund, World Health Organization & World Bank Group. 2018. Unicef/Who/World Bank Group Joint Child Malnutrition Estimates 2018. Levels and Trends in Child Malnutrition. Key Findings of the 2018 Edition. http://www.who.int/nutgrowthdb/estimates/en. Accessed 20 Feb 2021.
4. Abdel Wahed W-Y, Hassan S-K, Eldessouki R. 2017. Malnutrition and Its Associated Factors among Rural School Children in Fayoum Governorate, Egypt. Journal of Environmental and Public Health. 2017, doi:10.1155/2017/4783791.
5. Wenhold F, Muehlhoff E, Kruger H-S. Nutrition for school aged children. In: Temple N, Steyn NP, editors. Community Nutrition for Developing Countries. Edmonton: UNISA; Pretoria, South Africa: AU Press, Athabasca University; 2015.
6. Neinstein L-S, Kaufman F-R. 2002. Normal physical growth and development. In: Neinstein L.S., editor. Adolescent Health Care: A Practical Guide. 4th ed. Lippincott, Williams, and Wilkins; Philadelphia, PA, USA: 2002. Chapter 1.
7. United Nations Children's Fund Philippines (UNICEF Philippines). (2019, October 16). UNICEF: Many children and adolescents in the Philippines are not growing up healthily. https://www.unicef.org/philippines/press-releases/unicef-many-children-and-adolescents-philippines-are-not-growing-healthily. Accessed 30 Aug 2020.
8. World Bank. 2017. Human capital summit 2017 - Committing to Action to Drive Economic Growth. Washington DC. World Bank; 2017. http://www.worldbank.org/en/news/feature/2017/10/20/countries-commit-to-strong-action-on-human-capital-to-drive-economic-growth. Accessed 30 Aug 2020.
9. United Nations Children's Fund Philippines (UNICEF Philippines). 2014. Child survival. https://www.unicef.org/philippines/child-survival. Accessed 1 Sep 2020.
10. United Nations System in the Philippines. 2011. Supporting inclusive, sustainable and resilient development: The United Nations Development Assistance for the Philippines. http://www.un.org.ph/UNDAF%20launch_FINAL%20printing.pdf. Accessed 1 Sep 2020.
11. Laguna E. 2015. Sizing Up: The stunting and child malnutrition problem in the Philippines. Philippines: Save the Children Philippines. https://resourcecentre.savethechildren.net/node/13449/pdf/save-the-children-lahatdapat-sizing-up-the-stunting-and-child-malnutrition-problem-in-the-philippines-report-september-2015.pdf. Accessed 10 Sep 2020.
12. Food and Nutrition Research Institute-Department of Science and Technology (FNRI-DOST). Philippine Nutrition Facts and Figs. 2013: Anthropometric Survey. FNRI Bldg., DOST Compound, Bicutan, Taguig City. Philippines: Metro Manila; 2015.
13. Story M, Stang J. Nutrition needs of adolescents. In: Stang J, Story M, editors. Guidelines for Adolescent Nutrition Services. Minneapolis: University of Minnesota; 2005. pp. 21–34.
14. Weichselbaum E, Buttriss J-L. Diet, nutrition and schoolchildren: An update. Nutrition Bulletin. 2014;39(1):9–73. doi:10.1111/nbu.12071.
15. Corkins M-R, Daniels S-R, de Ferranti S-D, et al. Nutrition in Children and Adolescents. Med Clin North Am. 2016;100(6):1217–35. doi:10.1016/j.mcna.2016.06.005.
16. Semba R-D, Shardell M, Sakr F-A, et al. 2016. Child stunting is associated with low circulating essential amino acids, EBioMedicine, 6: 246–252.
17. Michaelsen K-F, Greer F-R. Protein needs early in life and long-term health. Am J Clin Nutr. 2014;99:718S–22S.
18. Joint WHO/FAO/UNU Expert Consultation. 2007. Protein and amino acid requirements in human nutrition. World Health Organization Technical Report Series, 935:1–265, back cover.

19. Thorisdottir B, Gunnarsdottir I, Palsson G-I, et al. Animal protein intake at 12 months is associated with growth factors at the age of six. Acta Paediatr. 2014;103:512–7.
20. Günther A-L, Remer T, Kroke A, Buyken A-E. Early protein intake and later obesity risk: which protein sources at which time points throughout infancy and childhood are important for body mass index and body fat percentage at 7 y of age? The American Journal of Clinical Nutrition. 2007;86(6):1765–72. doi:10.1093/ajcn/86.5.1765.
21. Nuss E-T, Tanumihardjo S. Quality Protein Maize for Africa: Closing the Protein Inadequacy Gap in Vulnerable Populations. Advances in Nutrition. 2011;2:217.
22. Hafebo A-S, Wuehler S, Gibbs M, et al. Overview of The Ethiopian National Food Consumption Survey (Nfcs): Implications for fortification Programs. European Journal of Nutrition Food Safety. 2015;5:961–2.
23. Angeles-Agdeppa I, Toledo M. Usual Nutrient and Food Intake of Filipino Stunted Children: Does It Matter? Journal of Food Nutrition Research. 2020;8:516–27. 10.12691/jfnr-8-9-8.
24. Angeles-Agdeppa I, Denney L, Toledo M, Obligar V-A, Jacquier E-F, Carriquiry A-L, Capanzana M-V. 2019. Inadequate nutrient intakes in Filipino schoolchildren and adolescents are common among those from rural areas and poor families. Food Nutrition Research. 63, 10.29219/fnr.v63.3435. doi:10.29219/fnr.v63.3435.
25. Food and Nutrition Research Institute - Department of Science and Technology (FNRI-DOST). 2015. Facts and Figs. 2013, 8th National Nutrition Survey Dietary Survey; Food and Nutrition Research Institute, Department of Science and Technology: Metro Manila, Philippines, 2015.
26. Food and Nutrition Research Institute - Department of Science and Technology (FNRI-DOST). 2015. Facts and Figs. 2013, 8th National Nutrition Survey Overview; Food and Nutrition Research Institute, Department of Science and Technology: Metro Manila, Philippines, 2015.
27. World Health Organization. 2007. Protein and Amino Acid Requirements in Human Nutrition: Report of a Joint WHO/FAO/UNU Expert Consultation (WHO Technical Report Series) (1st ed.). World Health Organization.
28. Shivakumar N, Jackson A-A, Courtney-Martin G, Elango R, Ghosh S, Hodgkinson S, Tomé D. Protein Quality Assessment of Follow-up Formula for Young Children and Ready-to-Use Therapeutic Foods: Recommendations by the FAO Expert Working Group in 2017. Journal of Nutrition. 2020;150(2):195–201.
29. Skinner J-D, Bounds W, Carruth B-R, et al. 2004. Predictors of children's body mass index: a longitudinal study of diet and growth in children aged 2–8 y. International Journal of Obesity and Related Metabolic Disorders. 2004;28:476 – 82. doi: 10.1038/sj.ijo.0802405.
30. Arsenault J-E, Brown K-H. Effects of protein or amino-acid supplementation on the physical growth of young children in low-income countries. Nutrition Reviews. 2017;75(9):699–717. doi:10.1093/nutrit/nux027.
31. Uauy R, Kurpad A, Tano-Debrah K, et al. Role of Protein and Amino Acids in Infant and Young Child Nutrition: Protein and Amino Acid Needs and Relationship with Child Growth. J Nutr Sci Vitaminol. 2015;61(Supplement):192–4. doi:10.3177/jnsv.61.s192.
32. Chagas C-E, Rogero M-M, Martini L-A. Evaluating the links between intake of milk/dairy products and cancer. Nutrition Reviews. 2012;70(5):294–300. doi:10.1111/j.1753-4887.2012.00464.x.
33. Hoppe C, Molgaard C, Thomsen B-L, et al. 2004. Protein intake at 9 mo of age is associated with body size but not with body fat in 10-y-old Danish children. American Journal of Clinical Nutrition. 2004;79:494–501. doi: 10.1093/ajcn/79.3.494.
34. Ghosh S. Assessment of Protein Adequacy in Developing Countries: Quality Matters. Food Nutrition Bulletin. 2013;34(2):244–6. doi:10.1177/156482651303400217.
35. Van Hul M, Karnik K, Canene-Adams K, et al. Comparison of the effects of soluble corn fiber and fructooligosaccharides on metabolism, inflammation and gut microbiome of high-fat diet fed mice. American Journal of Physiology-Endocrinology Metabolism. 2020. doi:10.1152/ajpendo.00108.2020.
36. Scully C. 2014. Dietary factors and health and disease. Scully's Medical Problems in Dentistry 659–75. doi:10.1016/b978-0-7020-5401-3.00027-8.
37. Said H-M. 2010. Thiamin. In: Coates PM, Betz JM, Blackman MR, et al., eds. Encyclopedia of Dietary Supplements. 2nd ed. London and New York: Informa Healthcare; 2010:748 – 53.

38. Dhir S, Tarasenko M, Napoli E, et al. Neurological, Psychiatric, and Biochemical Aspects of Thiamine Deficiency in Children and Adults. Front Psychiatry. 2019;10:1. doi:10.3389/fpsyt.2019.00207.
39. Greene-Finestone L-S, Garriguet D, Brooks S, et al. Overweight and obesity are associated with lower vitamin D status in Canadian children and adolescents. Paediatrics Child Health. 2017;22(8):438–44. doi:10.1093/pch/pxx116.
40. Johnson L, Mander A-P, Jones L-R, et al. Energy-dense, low-fiber, high-fat dietary pattern is associated with increased fatness in childhood. The American Journal of Clinical Nutrition. 2008;87(4):846–54. doi:10.1093/ajcn/87.4.846.
41. Barlow S-E. Expert Committee Recommendations Regarding the Prevention, Assessment, and Treatment of Child and Adolescent Overweight and Obesity: Summary Report. PEDIATRICS. 2007;120(Supplement):164–92. doi:10.1542/peds.2007-2329C.
42. Ernalia Y, Dwi Utari L-S, Restuastuti T. Different Intakes of Energy and Protein in Stunted and Non-stunted Elementary School Children in Indonesia. KnE Life Sciences. 2018;4(4):556. doi:10.18502/kls.v4i4.2318.
43. De Vries-ten Have J, Owolabi A, Steijns J, et al. Protein intake adequacy among Nigerian infants, children, adolescents and women and protein quality of commonly consumed foods. Nutr Res Rev. 2020;33(1):102–20. doi:10.1017/S0954422419000222.
44. Pimpin L, Jebb S, Johnson L, et al. Dietary protein intake is associated with body mass index and weight up to 5 y of age in a prospective cohort of twins 1,2. The American Journal of Clinical Nutrition. 2015;103(2):389–97. doi:10.3945/ajcn.115.118612.
45. Cuadrado-Soto E, López-Sobaler A-M, Jiménez-Ortega A-I, et al. Usual Dietary Intake, Nutritional Adequacy and Food Sources of Calcium, Phosphorus, Magnesium and Vitamin D of Spanish Children Aged One to < 10 Years. Findings from the EsNuPI Study. Nutrients. 2020;12(6):1787. doi:10.3390/nu12061787.
46. Rubio-López N, Llopis-González A, Morales-Suárez-Varela M. Calcium Intake and Nutritional Adequacy in Spanish Children: The ANIVA Study. Nutrients. 2017;9(2):170. doi:10.3390/nu9020170.
47. Holick M-F. 2007. Vitamin D deficiency. New England Journal of Medicine 2007;357(3):266-81. doi: 10.1056/NEJMra070553; PUBMED: 17634462.
48. García O, Ronquillo D, del Carmen Caamaño M, et al. Zinc, Iron and Vitamins A, C and E Are Associated with Obesity, Inflammation, Lipid Profile and Insulin Resistance in Mexican School-Aged Children. Nutrients. 2013;5(12):5012–30. doi:10.3390/nu5125012.
49. Food and Agriculture Organization (FAO). (1990). Nutritional problems in rice-consuming countries. http://www.fao.org/3/t0567e/T0567E05.htm. Accessed 18 Jan 2021.
50. Muthayya S, Sugimoto J-D, Montgomery S, et al. An overview of global rice production, supply, trade, and consumption. Ann N Y Acad Sci. 2014;1324(1):7–14. doi:10.1111/nyas.12540.
51. Steyn N-P, Temple N-J. 2012. Evidence to support a food-based dietary guideline on sugar consumption in South Africa. BMC Public Health 12(1). doi:10.1186/1471-2458-12-502.
52. Adesogan A-T, Havelaar A-H, McKune S-L, et al. 2019. Animal source foods: Sustainability problem or malnutrition and sustainability solution? Perspective matters. Global Food Security, 100325. doi:10.1016/j.gfs.2019.100325.
53. Wang Y, Beydoun M-A. Meat consumption is associated with obesity and central obesity among US adults. International Journal of Obesity. 2009;33(6):621–8. doi:10.1038/ijo.2009.45.
54. Tessema M, Gunaratna N, Brouwer I, et al. Associations among High-Quality Protein and Energy Intake, Serum Transthyretin, Serum Amino Acids and Linear Growth of Children in Ethiopia. Nutrients. 2018;10(11):1776. doi:10.3390/nu10111776.
55. Mwaniki E-W, Makokha A-N. 2013. Nutrition status and associated factors among children in public primary schools in Dagoretti, Nairobi, Kenya. African Health Sciences, 13(1). doi:10.4314/ahs.v13i1.6.
56. Roxas B-V, Intengan C-L, Juliano B-O. Effect of zinc supplementation and high-protein rice on the growth of preschool children on a rice-based diet. Qualitas Plantarum Plant Foods for Human Nutrition. 1981;30(3–4):213–22. doi:10.1007/bf01094026.
57. Michigan State University. 2018. New research demonstrates role of grain legumes in fighting malnutrition. AgBioResearch. https://www.canr.msu.edu/news/new-research-demonstrates-role-of-grain-legumes-in-fighting-malnutrition. Accessed 18 Jan 2021.

58. Rouhani M-H, Salehi-Abargouei A, Surkan P-J, et al. Is there a relationship between red or processed meat intake and obesity? A systematic review and meta-analysis of observational studies. Obesity Reviews. 2014;15(9):740–8. doi:10.1111/obr.12172.
59. Kim G-H, Shin S-W, Lee J, et al. 2017. Red meat and chicken consumption and its association with high blood pressure and obesity in South Korean children and adolescents: a cross-sectional analysis of KSHES, 2011–2015. Nutrition Journal, 16, 31 (2017). doi: 10.1186/s12937-017-0252-7.
60. Cockburn H. 2016, August 4. Meat contributes to obesity as much as sugar, research suggests. The Independent. https://www.independent.co.uk/life-style/health-and-families/health-news/meat-obesity-sugar-protein-fat-research-a7168066.html. Accessed 10 Feb 2021.
61. Herber C, Bogler L, Subramanian S-V, et al. 2020. Association between milk consumption and child growth for children aged 6–59 months. Scientific Reports. 10, 6730 (2020). doi:10.1038/s41598-020-63647-8.
62. Nachvak S-M, Sadeghi O, Moradi S, et al. 2020. Food groups intake in relation to stunting among exceptional children. BMC Pediatrics. 20, 394 (2020). doi:10.1186/s12887-020-02291-7.
63. Gibson S-A. Dietary sugars intake and micronutrient adequacy: a systematic review of the evidence. Nutrition Research Reviews. 2007;20(2):121–31. doi:10.1017/s0954422407797846.
64. Wang W, Wu Y, Zhang D. Association of dairy products consumption with risk of obesity in children and adults: a meta-analysis of mainly cross-sectional studies. Annals of Epidemiology. 2016;26(12):870–82.e2. doi:10.1016/j.annepidem.2016.09.005.
65. Yasmin G, Kustiyah L, Dwiriani C-M. Stunted Children Has Higher Risk of Overweight: A Study on Children Aged 6–12 Years in Eight Provinces in Indonesia. Pakistan Journal of Nutrition. 2019;18(5):455–63. doi:10.3923/pjn.2019.455.463.
66. Hernández-Alonso P, Salas-Salvadó J, Ruiz-Canela M, et al. High dietary protein intake is associated with an increased body weight and total death risk. Clinical Nutrition. 2016;35(2):496–506. doi:10.1016/j.clnu.2015.03.016.

Figures

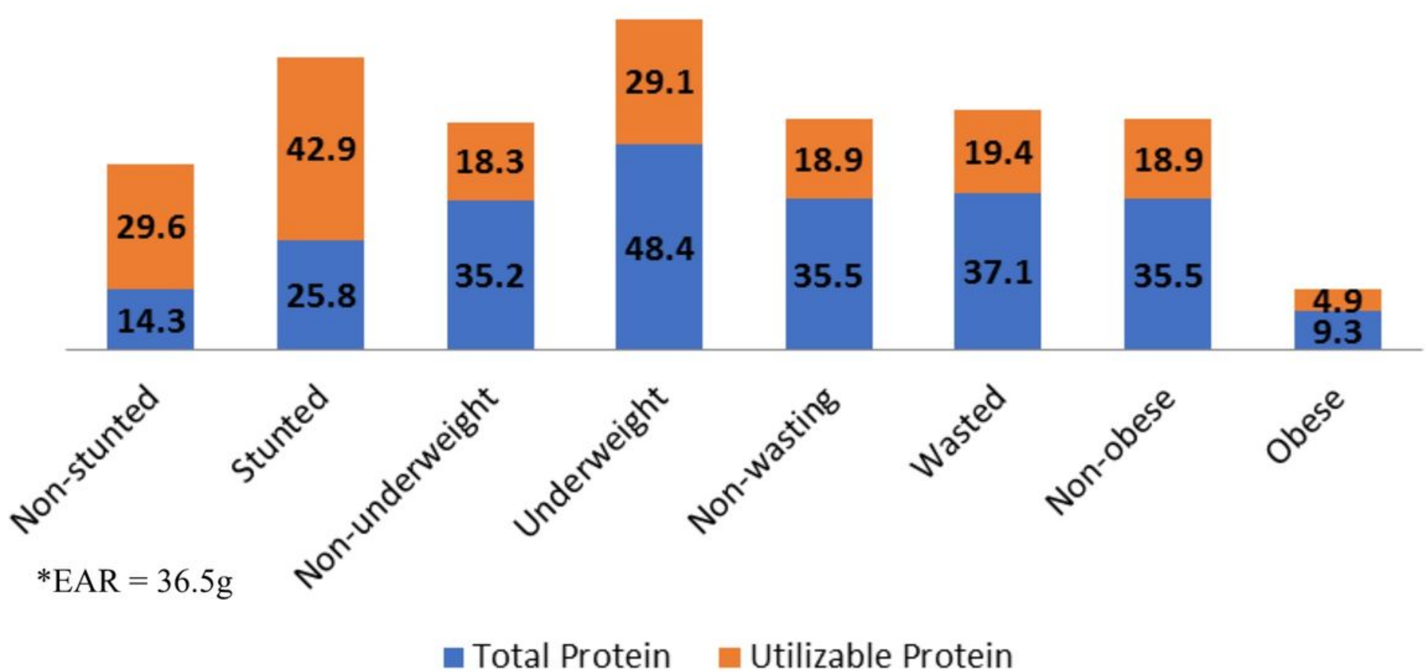

Figure 1

Prevalence of Malnutrition by prevalence of protein inadequacy represented by total protein and utilizable protein intake

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- AdditionalFile1.docx