



The Impact of Including Whole Eggs as a Supplementary Source of Protein on the Academic Performance of Thai Children in Primary Schools

Tanyaluk Tatiyatrirong*

Faculty of Nursing Establishment Project, Dhonburi Rajabhat University, Samut Prakan, 10540 Thailand

Article info

Article history:

Received : 19 February 2024

Revised : 9 April 2024

Accepted : 19 April 2024

Keywords:

Eggs, Dietary patterns, Children, Academic performance

Abstract

Studies have demonstrated that eggs promote growth and alleviate malnutrition due to their abundant nutritional composition. This study aimed to assess the impact of egg consumption on the academic performance of Thai school-age children. A whole egg refers to a single chicken egg, which includes both the egg white and the egg yolk, weighing approximately 50 g without shell. The sample consisted of over a thousand students who were currently enrolled in grades 1st to 6th in two government schools in Thailand, encompassing both large and small schools. The children were selected randomly using stratified random sampling. The main guardian filled out a survey, which functioned as a research tool and examined the dietary habits of students. The process of data collection commenced in 2023. The data analysis involved employing Pearson's correlation, calculating percentages, determining mean values and standard deviation, and conducting one-way ANOVA and post-hoc analysis. The study's results indicated that children who consistently ingested an average of 60 to 90 whole eggs per month exhibited excellent academic performance and had the greatest average height compared to other groups of children in grades 1st to 2nd. During the 3rd grade, children start adapting to the school environment, and the significance of growth and nutrition has diminished. There was no significant alteration in GPA from grades 4th to 6th as a result of growth and nutrition. It was observed that students in every grade who eat 5 eggs per month attained a Grade Point Average (GPA) of 2.80 (GPA is a number representing the average value of the accumulated final grades earned in courses over time, usually ranging between 0 and 4.0.). The results suggest that there was a significant difference in the academic performance of students who ingested different quantities of whole eggs per month (20, 30, 60, and 90) when compared to the group of students who consumed only 5 whole eggs per month (P -value < 0.0001). This study suggests that it is advisable for children to consume meals on a regular basis and incorporate one egg into each meal. Children in the 4th to 6th grades begin to cultivate the ability to think logically and coherently, as well as have a more profound comprehension of how to utilize technology. At this stage of development, teachers and parents should actively promote and counsel their children on the prudent use of technology.

Introduction

The advancement of individuals of all age groups in Thailand encounters persistent obstacles in terms of scholastic attainment, educational excellence and behaviors that pose health risks. Within the childhood cohort, the mean IQ score experienced a decrease from 91 to 88 between the years 1997 and 2009. It is worth noting that the World Health Organization has established the range of 90-110 as the standard for IQ levels. (Thai Health Promotion Foundation, 2010). Furthermore, there has been an increase in the prevalence of malnutrition among students. Malnutrition encompasses both overnutrition (characterized by overweight and obesity) and undernutrition (marked by underweight, stunting and wasting), as well as imbalances in micronutrient levels, either excessive or deficient (Dukhi, 2020). Protein-energy malnutrition is a critical problem that leads to inadequate nutrition, poor academic performance and hampers social and emotional growth (Padhani et al., 2022). The reporting system of the Policy and Strategy Office of the Health Data Center (HDC) of the Ministry of Public Health has shown that the nutritional status of school-age children is within the normal range, with proportions of 64.3, 64.2, 63.2, 65.2, 65.5 and 61.5, respectively. However, these proportions indicate a decreasing trend and fall short of the target value of 66%. The prevalence of overweight and obesity was initially found to be 9.7%, 10.2%, 11.1%, 11.1% and 11.7%, respectively. These rates exceeded the goal value of 10% and showed an increasing trend. The rates in the underweight state were regularly higher than the anticipated level, ranging from 5.0 to 5.6%. (Not exceeding 5%.) The presence of short stature was seen at 6.6, 6.1, 5.9, 5.1, 5.5 and 8.9%, respectively, with a tendency to increase and surpass the target value (which should not exceed 5%) (Thanacharoenwat, 2021). According to the Department of Health's 2017 survey on desirable health habits, the majority of children consumed insufficient quantities of essential food items such as milk, eggs and vegetables in a single day (Aorgart & Pinyoanuntapong, 2016).

Children in the age range of school-aged individuals are a significant demographic. Given the rapid growth, it is imperative to seize this final opportunity to motivate children to achieve their utmost potential, both intellectually and physically. Nevertheless, permitting children to experience malnourishment has a profound effect on the development of their brains,

leading to diminished cognitive abilities and hindered learning. Additionally, it exposes children to the potential of developing chronic conditions such as diabetes, high blood pressure, arterial fat accumulation, knee arthritis, bowed legs and respiratory arrest, among others (Trirapongsawat et al., 2021).

Highly nutritious meals, such as eggs, fish, milk and other protein sources can significantly enhance the process of optimal growth in children. In 1968, the American Heart Association released dietary guidelines that advised individuals to consume no more than three egg yolks per week (American Heart Association, 1968). Nevertheless, their present stances are founded on misconstrued information and multiple nations have eliminated dietary cholesterol limitations from their dietary recommendations. Excessive consumption of cholesterol is not a matter of concern in terms of nutrient intake (Fernandez & Calle, 2010). Eggs contain a diverse range of nutrients that support growth, such as protein with a balanced combination of amino acids to fulfill the body's needs for vitamins and minerals, including vitamin A and vitamin B12 (Caswell et al., 2021). Eggs are rich in phosphorus, selenium, iodine, vitamins B2, folate, fatty acids and linoleic acid, all of which are essential for the body's functioning (Saiwan et al., 2015; Kase et al., 2022). In addition, eggs are a cost-effective food option in comparison to other protein sources in the meat category. Readily accessible in the marketplace, eggs offer a substantial amount of top-notch protein and possess a significant nutritional value. Tissue formation and healing are crucial for the body's well-being and eggs are rich in amino acids and choline, both of which contribute to the enhancement of the immune system. Choline is a micronutrient that has a crucial role in promoting cognitive function, particularly in brain growth and memory enhancement (Bragg et al., 2022). Thomas et al. (2022) conducted research that found greater plasma choline concentrations in young adults who consumed three eggs per day. Plasma choline concentrations are higher, with significant increases in plasma choline from the baseline (7.9 ± 2.0 nmol/mL) to the end of the intervention (9.9 ± 2.2 nmol/mL) (Thomas et al., 2022). An optimal protein source is one that has sufficient amounts of all essential amino acids to fulfill the body's needs. The body can easily digest and absorb protein from egg whites and egg yolks, which are high in vitamin A. Vitamin A is essential for growth, development and bodily transformations that commence during infancy and enhances optimal growth as well

as enhancing skeletal and dental functionality. Tabatabaeyan et al. (2023) found that consumption of eggs reduces the likelihood of developing metabolically unhealthy obesity (MUO). Obese teenagers who consumed the most eggs had a reduced likelihood of developing MUO. Obese children, who consume fewer eggs, typically have higher blood sugar levels and are less physically active compared to their counterparts. Moreover, consuming eggs in moderation can enhance vascular and intestinal function while reducing the risk of developing cardiovascular disease or other metabolic disorders (Liu et al., 2022). Consequently, the consumption of eggs is advantageous for children who are both overweight and underweight.

An examination of the Thai literature unveiled numerous investigations into the dietary habits of children. Nevertheless, there is a lack of research undertaken on children to examine the impact of egg consumption on their academic achievement. Generally, children prefer consuming food based on their individual preferences. In the absence of adult supervision, children will experience inadequate protein and macro-micronutrient intake (Maytapattana, 2017). This study expects the results to clarify the relationship between egg consumption and children's scholastic achievement at different ages and demonstrate that eggs can serve as an effective substitute for protein in situations where children have difficulty acquiring protein-rich diets. Enhancing brain growth and development is a crucial aspect. Researchers have confirmed eggs' role as a cost-effective alternative to traditional protein sources like meat or fish, particularly in areas with limited access. Factors such as economic hardships within families, remote geographical locations and natural disasters can hinder access to alternative protein sources. Cooking eggs requires energy until they reach a fully cooked and consumable state. This cooking process is often simpler than cooking other types of proteins. Eggs preserve more readily. If not properly preserved, proteins from various sources like fish, shrimp, or poultry may deteriorate rapidly and lose their nutritional value. There are food preservation methods, such as refrigeration or freezing, to maintain their benefits. Unlike eggs, which are more resistant to harm, they can remain at room temperature without requiring any special care while still preserving all of their advantages. Historically, farmers have always derived milk from their agricultural activities. However, obtaining milk with specific ingredients and high quality nowadays necessitates substantial business and

may be somewhat challenging to acquire. A metropolitan community could alleviate this issue. In summary, while eggs present several advantages over other protein sources, it's essential to note that this research does not specify that eggs have better quality protein than other types of protein. Instead, it aims to confirm that the affordability and availability of eggs can help alleviate socioeconomic inequality when access to other protein sources is limited.

Materials and methods

1. Participants

This cross-sectional study was conducted at two Thai government schools located in Samut Prakan Province. The two schools included in the study were a small school and a large school, with a student population exceeding 1,000. The selection of children was done randomly, resulting in a stratified sampling of 400 primary caregivers when authorization was granted. Stratified random sampling are formed based on characteristics such as GPA. The inclusion criteria consist of the following: 1) being the primary caregiver, who can be a father, mother, grandfather, grandmother, or a blood relative of the student; 2) residing in the same household as the student and providing the highest number of hours of care each day over the past 6 months. 3) must be at least 18 years of age. 4) proficient in reading, writing and verbal communication in Thai. The exclusion criteria encompass individuals who are incapable of fully responding to all questionnaire items or offering incomplete replies.

2. Eggs consumption assessment

The assessment of whole egg consumption was conducted through the administration of a questionnaire on the dietary habits of children aged 6–13 years. The form used for assessing food consumption behavior was adapted from the Department of the Ministry of Public Health. It evaluates the typical food consumption of every student during the previous 6 months. The questionnaire includes inquiries about the child's daily egg consumption as well as their monthly egg consumption. A whole egg refers to a single chicken egg, which includes both the egg white and the egg yolk, weighing approximately 50 g without shell. The primary caregivers were required to fill in the complete questionnaire. Three experts assessed the content validity of the questionnaire. The recommendations were subsequently implemented to enhance the product prior to conducting a trial with a

sample size of 30 individuals. Subsequently, the questionnaire was administered to a group of 400 primary caregivers and the questionnaire's reliability was assessed using Cronbach's alpha coefficient, which yielded a value of .71.

3. Academic performance assessment

Academic performance was evaluated based on the grade point average (GPA). GPA is a number representing the average value of the accumulated final grades earned in courses over time, usually ranging between 0 and 4.0. The primary caregivers were required to complete the form by providing the grade point average in the designated space. The researcher explained how to answer the questionnaire and gave the respondent an opportunity to answer the questionnaire independently. The waiting time to receive the questionnaire back was approximately 15 min. Prior to evaluating and coding the data, the research assistant thoroughly verified the comprehensiveness of the replies.

4. Dietary pattern assessment

The questionnaire inquired about dietary patterns, including the consumption of meat, fish and milk. This was done using a checklist questionnaire that categorizes responses into three levels: Eating less than recommended, Eating as recommended and Eating more than recommended. The dietary pattern questionnaire employs the same questionnaire for egg consumption pattern issued by the Ministry of Public Health.

5. Statistical analysis

The study was evaluated using the statistical software program SPSS, with a significance level of 0.05, as demonstrated below.

5.1 General information such as gender and age. The factors that need investigation regarding the eating behavior of school-age children, such as weight, height and GPA. The data was analyzed using frequency, percentage, mean, standard deviation and Pearson's correlation.

5.2 This study examines the influence of many factors on the academic achievement of school-age children, such as their weight, height and the number of eggs they consume daily and monthly, as reported by their primary caregivers. The one-way ANOVA statistical test was employed to examine the diverse fluctuations in academic performance and compare the means within each pair (Post-hoc: LSD analysis).

6. Ethical approval and consent to participate

The Human Research Ethics Committee of Dhonburi Rajabhat University granted approval for the research

protocol and research tools, as indicated by Ethics Code No. DRUIRB-GOV-66-00015. The researcher elucidated the objective of the investigation to the sample group. Methods for conducting research, research instruments and the entitlement to engage in research endeavors while retaining the option to exit at any moment without incurring any repercussions. It is important to notify the participants that the data collected will be kept confidential and to disclose the research findings in their entirety. Furthermore, it is exclusively utilized for research purposes. The researcher diligently safeguards the data. Additionally, ensure the complete eradication of all data once the research has been officially disseminated. Consent to participate. Informed consent was obtained from all participants involved in the study.

Results and discussion

1. Participants demographics

Table 1 presents the demographic information of the overall participants in the study. An assessment was conducted on the data pertaining to weight and growth outcomes. When observing children who are underweight or overweight in each year, there was a large drop in the percentage of underweight children in Grade 2 compared to Grade 1 (approximately 12%), whereas there was a considerable increase in the percentage of overweight children in Grades 4-6 compared to Grades 1-3 (approximately 15%). Children who are overweight tend to increase from grades 1-6. The height of students in grades 1-3 has a significant influence on their academic achievement ($r = .558$, $r = .331$, $r = .352$; $P\text{-value} < 0.05$). Nevertheless, the impact of height and weight on academic performance in children in grades 4-6 did not demonstrate any statistically significant results. There was a statistically significant positive correlation between weight (kg) and height (cm) in all students. ($r = .77$, $P\text{-value} < .01$).

2. Consumption of whole eggs on academic performance

The results that will be discussed below refer to Tables 1, 2, 3, 7 and 8.

2.1 The 1st grade

Grade 1 functions as a transitional phase, bridging the gap between pre-school and school-age children. The study by Cahoon et al. (2021) followed participants over the course of three 8-month intervals, from preschool to their first year of primary education. Research indicates

Table 1 Baseline characteristics of participants

Variable	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Grade 6
Mean±SD/ n(%)						
Gender, Male	20 (27.00%)	33 (50.80%)	35 (61.40%)	35 (42.70%)	31 (50.80%)	32 (52.50%)
Gender, female	54 (73.00%)	32 (49.20%)	22 (38.60%)	47 (57.30%)	30 (49.20%)	29 (47.50%)
Age (Years)	6.51±0.50	7.55±0.49	8.45±0.50	9.54±0.50	10.61±0.47	11.63±0.48
Height (cm)	120.50±6.52	127.23±8.16	131.16±8.26	137.82±8.63	144.41±7.44	152.0±12.22
Weight (kg)	22.67±6.62 ^{H**}	28.19±9.11 ^{H**}	30.93±10.25 ^{H**}	35.47±11.31 ^{H**}	41.81±12.59 ^{H**}	49.24±14.61 ^{H**}
Underweight (n)	13 (18.10%)	4 (6.20%)	5 (9.10%)	6 (7.20%)	5 (8.60%)	4 (1.70%)
Overweight (n)	9 (12.50%)	10 (15.7%)	9 (16.4%)	16 (19.2%)	19 (32.70%)	21 (36.20%)
Obese (n)	5 (6.90%)	3 (4.70%)	5 (9.10%)	5 (6.00%)	5 (7.80%)	15 (25.90%)
Academic performance (GPA 0-4)	3.55±0.50 ^{H*}	3.48±0.44 ^{H*}	3.44±0.50 ^{H*}	3.55±0.55	3.35±0.54	3.36±0.53

Remark: 1) n means the number of samples in each grade. Mean = average, SD = standard deviation
2) H** means Positive correlations between height and weight in each grade show significant differences at a P-value < 0.01 by using Pearson's correlation.
3) H* means Positive correlations between height and academic performance show significant differences at a P-value < 0.05 by using Pearson's correlation.
4) The underweight, overweight and obese of all grade students use the weight-height reference graph and nutritional indicators for Thai children from 6–19 years of age (Bureau of Nutrition, Department of Ministry of Public Health, 2021). Underweight means less than 1.5 SD, overweight means more than 1.5 SD, and obese means more than 3 SD.

that there are five distinct trajectories of mathematics learning, with certain groups of children exhibiting faster initial success upon entering school compared to other groups. The children in the low-skill pathway have a slower pace of growth compared to those in more advanced pathways. Hence, physical development holds great significance throughout this transitional phase. The statement cited above is consistent with this research that is currently being analyzed: there is a significant correlation between being taller than one's classmates and having higher academic achievement among first-grade students.

Based on the aforementioned references, the question at hand is: “What are the factors that contribute to optimal growth and development in children?” There is ample data that substantiates the hypothesis that nutrition enhances children's growth and progress. According to a study by Suta et al. (2023), school-age children in rural Thai schools aged 8 to 14 who consumed an additional two eggs per school day for 35 weeks experienced a significant increase in both weight and height compared to the control group P-value <0.001). Papanikolaou & Fulgoni (2019) study looked at the relationships between egg consumption and nutrient intake, diet quality and growth outcomes in children and adolescents in the United States aged 2 to 18 years. Consuming eggs was associated with an elevated daily calorie intake in comparison to not consuming eggs. Children and adolescents who ate eggs had increased daily consumption of protein, polyunsaturated, monounsaturated and total fats, α -linolenic acid, docosahexaenoic acid (DHA), choline, lutein, zeaxanthin,

vitamin D, potassium, phosphorus and selenium. Egg consumers had greater consumption of sodium, saturated fat and reduced total and added sugar compared to egg non-consumers. Both studies concluded that consuming eggs promotes enhanced growth and provides sufficient amounts of essential macronutrients and micronutrients. Based on this study, it was shown that students in the first grade who consume 60 whole eggs per month exhibit superior academic performance compared to other groups (mean GPA = 3.90±0.006) and the group had the highest average height (130 ± 0.0) (Table 3).

What was the reason for the superior academic achievement of children who consumed a total of 60 whole eggs per month? By incorporating protein-rich foods such as seafood, meat, poultry, nuts and seeds into the diet and including two large 50-g eggs each day, a child would consume roughly 295 mg of choline. This amount accounts for more than 50% of the recommended daily intake of choline (Iannotti et al., 2014). Total choline in the egg consumers group was significantly different from the egg non-consumers group (176.4 ± 5.5, P-value <0.0001) in comparison to the study by Papanikolaou & Fulgoni (2019). Choline has a vital role in the development of the brain, particularly in the growth of the dentate gyrus area of the hippocampus, which is essential for the formation of declarative memory (Bragg et al., 2023). Scientists have discovered that essential amino acids, sometimes referred to as indispensable amino acids, are amino acids that cannot be produced by humans and other vertebrates through metabolic intermediates. The human body is unable to produce certain amino acids due to the absence of the necessary

metabolic pathways; hence, they must be obtained from an external diet. In the field of nutrition, amino acids are categorized into two groups: essential and non-essential. These classifications arose from initial investigations into human nutrition, which demonstrated that certain amino acids are necessary for development or nitrogen balance, even in the presence of sufficient amounts of other amino acids. While various metabolic states may introduce some variability, it is generally accepted that there are nine indispensable amino acids, namely phenylalanine, valine, tryptophan, threonine, isoleucine, methionine, histidine, leucine and lysine (Michael & Shamim, 2023). The nine essential amino acids include the following along with the role in promoting health: 1) Histidine promotes children's growth as well as enhances the functionality of the nervous system to promote optimal growth and development. 2) Isoleucine supports the growth and operation of the nervous system, aiding in the development of learning abilities. 3) Leucine enhances cognitive performance and muscular strength along with promoting the health of nerve cells. 4) Lysine facilitates the restoration of fatigued muscles and aids in fat oxidation while enhancing focus and facilitates calcium absorption. Consequently, it aids in the prevention of osteoporosis. 5) Methionine functions as an antioxidant. It detoxify the body and facilitate lipid metabolism. 6) Phenylalanine promotes heightened vigilance, induces a sense of vitality, improves cognitive retention, and alleviates symptoms of sadness as well as suppress hunger. 7) Threonine enhances the immune system. It facilitates lipid oxidation, enhances digestive function and promotes optimal food assimilation inside the body. 8) Tryptophan, which is found in egg yolk, alleviates stress and despair and the symptoms of migraines as well as facilitating the promotion of natural sleep. 9) Valine enhances cognitive function and promotes muscular coordination. Upon examination it is evident that 2 eggs include the nine essential amino acids, which are both comprehensive and adequate for first-grade children. Receiving a comprehensive set of amino acids provides the benefit of achieving optimal growth. Possessing robust physical well-being, resilient immunity and a receptive nervous system allows for children to be primed for learning and engaging in diverse activities and to experience continuous happiness throughout the entire day. Essential amino acids contribute to the growth and maintenance of children's bodies. The process of repairing worn parts involves strengthening muscles and producing hormones and

messengers that have an impact on energy levels, mood, sleep and nutrient absorption. Furthermore, eggs provide protein with an optimal balance of amino acids to meet the body's requirements for vitamins and minerals. Table 2 presents the nutrients in eggs that includes vitamins and minerals for enhancing immunity, the nervous system and eyesight.

Table 2 Nutrients are contained in eggs and children need each day

Variable	Quantity of nutrients contained in 100 grams of hard boiled-eggs (U.S. Department of Agriculture, 2018).	Quantity of nutrients that Thai school-age children need each day (Bureau of Nutrition, Department of Ministry of Public health, 2020)
		(Nutrient (g)/BW 1 kg)
Energy	155 kcal	1,320-1,800 kcal
Carbohydrates	1.12 g	130 g
Fat	10.6 g	47-57 g
Protein	12.6 g	28-45 g (1-1.5)
Tryptophan	0.153 g	0.135-0.225 g (0.005)
Threonine	0.604 g	0.460-0.900 g (0.020)
Isoleucine	0.686 g	0.437-0.855 g (0.019)
Leucine	1.075 g	0.966-1.89 g (0.042)
Lysine	0.904 g	0.87-1.71 g (0.038)
Methionine+Cystine	0.684 g	0.437-0.855 g (0.019)
Phenylalanine+Tyrosine	1.181 g	0.759-1.485 g (0.033)
Valine	0.767 g	0.552-1.08 g (0.024)
Arginine	0.755 g	B/S
Histidine	0.298 g	0.322-0.63 g (0.014)
Alanine	0.700 g	B/S
Aspartic acid	1.264 g	B/S
Glutamic acid	1.644 g	B/S
Glycine	0.423 g	B/S
Proline	0.501 g	B/S
Serine	0.936 g	B/S
Vitamins		
Vitamin A equiv.	149 µg	350-550 µg
Thiamine (B1)	0.066 mg	0.6-0.9 mg
Riboflavin (B2)	0.5 mg	0.6-0.9 mg
Niacin (B3)	0.064 mg	8-12 mg
Pantothenic acid (B5)	1.4 mg	3-4 mg
Vitamin B6	0.121 mg	0.6-1.0 mg
Folate (B9)	44 µg	180-240 mg
Vitamin B12	1.11 µg	1.2-1.8 µg
Choline	294 mg	250-375 mg
Lutein + zeaxanthin	353 µg	6,000-10,000 µg
Vitamin D	87 IU	600 IU
Vitamin E	1.03 mg	9-13 mg
Vitamin K	0.3 µg	55-60 µg
Minerals		
Calcium	50 mg	800-1,000 mg
Iron	1.2 mg	6.6-11.5 mg
Magnesium	10 mg	120-170 mg
Phosphorus	172 mg	500-1,000 mg
Potassium	126 mg	1,625-3,325 mg
Sodium	126 mg	325-1,175 mg
Zinc	1.0 mg	6.3-9.5 mg
Other constituents		
Water	75 g	1,400-2,550 g
Cholesterol	373 mg	-

Remark: The amount of nutrition children need each day is based on their body weight, which ranges from 23 to 45 kg, depending on their age. IU = International units, B/S = The body can synthesize it on its own in healthy children., BW = body weight

2.2 The 2nd grade

The second year of elementary school is still considered a transitional phase, bridging the gap between pre-school children and school-age children. The research findings align with grade 1. The group of children that ingested a total of 90 whole eggs on a monthly basis had the highest level of academic achievement in comparison to the other groups (mean GPA = 3.73 ± 0.13). Additionally, they had the greatest average height (130 ± 5.13) (Table 3). According to their grade point average, children who are growing rapidly are capable of demonstrating strong academic performance. Regardless of the children's weight status, if their height exceeds the specified threshold, based on this research, there was a large drop in the percentage of underweight children in Grade 2 compared to Grade 1 (approximately 12%), whereas there was a considerable increase in the percentage of overweight children in Grades 4-6 compared to Grades 1-3 (approximately 15%) (Table 1). In addition, there was a statistically significant positive correlation between weight (kg) and height (cm) among all students ($r = .77$, $P\text{-value} < 0.01$) (Table 1). It signifies that children who are overweight or obese tend to surpass their classmates in terms of academic achievement at every school level. There is a positive correlation between the height (measured in centimeters) of children in Grades 1-3 and their academic performance ($r = .558$, $r = .331$, $r = .352$, respectively, $P\text{-value} < 0.05$) (Table 1). The meta-analysis by He et al. (2019) of 60 papers from various nations regarding the relationship between body mass index (BMI) and academic performance offers evidence that there was a very weak negative correlation between BMI and academic achievement in elementary school ($r = -0.075$, $P\text{-value} < 0.01$). The study found that the observed phenomenon was larger in American and European samples than in Asian samples. Nevertheless, the research findings are consistent with this study, which collected data in Asia. It can be inferred that overweight or obese children tend to come from affluent backgrounds, enabling them to have access to sufficient nutrition (including protein, carbohydrates, fats and micronutrients) as well as indulgent foods such as pastries and cakes. This is the reason why children who are overweight or obese experience rapid growth. Dong et al. (2019) conducted a study that revealed a direct correlation between socioeconomic variables and the prevalence of overweight and obesity in Chinese school-age and adolescent children. The correlation between accelerated enhancement of socioeconomic

indicators and altered nutritional status in children and adolescents was observed, with variations observed between urban and rural areas. The correlation between socioeconomic position and overweight and obesity had a greater magnitude in rural areas as compared to metropolitan areas.

2.3 The 3rd grade

During the third grade, children start to adapt to the demands of their school years. The significance of physical development had diminished. The research findings indicate that there was a notable disparity in academic performance between the group of students who consumed 20, 30, or 60 eggs and the group of students who consumed 10 eggs each month. ($P\text{-value} < 0.05$) (Table 3). The scholastic performance of the groups of children who consumed 20, 30, or 60 whole eggs per month did not vary significantly (3.52 ± 0.12 , 3.51 ± 0.11 and 3.46 ± 0.13 , respectively). (Table 3). The group of students who consumed 60 whole eggs per month had the highest average height (134 ± 1.85). (Table 3). What factors contribute to the diminishing significance of physical growth in the third grade? The age range of children in this grade often falls between 8 and 9 years old. Piaget (1983) hypothesized that late in the second year, children develop representation, which is the capacity to think about things that are not present in their immediate experience, such as an object that has disappeared. He suggested that, starting with these representations, children show a gradual increase in the complexity of representations throughout the preschool years, culminating in a new stage of equilibrium called "concrete operations" beginning at age 6 or 7. The child comes to be able to deal systematically with the complexities of representations and so can understand what Piaget described as the logic of concrete objects and events. In social cognition, the child develops the capacity to deal with complex problems from multiple perspectives. And the third level, usually called formal operations, first emerges at age 10–12. According to Piaget's hypothesis, children in this stage tend to adapt themselves as their brain undergoes full growth and development. Nevertheless, physical growth remains very impactful (with statistical significance), although its significance has diminished.

2.4 The 4th to 6th grade

During the years of 4th to 6th grade, no significant difference was observed between growth and nutrition on the GPA as noted on Tables 3, 7 and 8. At this stage, children begin to link the development of their early

thinking abilities with practical thinking. They acquire the ability to establish connections between events and engage in higher-level thinking, which may then be cultivated to foster a mindset of problem-solving that is rational and logical Piaget (1983). The third level, usually called formal operations, first emerges at age 10–12 in middle-class children. Children develop a new ability to generalize across concrete instances and to manage the complexities of some tasks requiring hypothetical reasoning as well as the ability to abstract or to think hypothetically. Cognitive development does not stop at the level that emerges at ages 10–12. Indeed, performance on Piaget’s formal operations tasks continues to develop throughout adolescence.

As children develop logical thinking skills, they start contemplating effective learning methods. Provided

that the children are resolute in their desire to study, they will commence studying proficiently. Once individuals choose a preferred pastime, they embark on a quest for knowledge, gradually transforming it into a hobby that has the potential to foster personal growth. The children are acquiring a greater understanding of utilizing technology. They are transitioning from utilizing it solely for recreational activities such as playing games, making images, or watching entertaining videos to utilizing it as a tool for discovering intriguing knowledge. Furthermore, the children utilize it to establish communication with more beneficial acquaintances. At this stage of development, educators and caregivers should actively promote and counsel their children on the prudent use of technology.

Table 3 Groups of students who consumed eggs per month affect their GPA in each grade and overall

Variable	Monthly consumption of eggs (Number of eggs per whole egg)	5 whole eggs per month	10 whole eggs per month	20 whole eggs per month	30 whole eggs per month	60 whole eggs per month	90 whole eggs per month	120 whole eggs per month	150 whole eggs per month
Mean±SE		Mean GPA (SE)/ Mean±SE							
Grade 1	32.77±2.37	2.80 (0.00)	3.57 (0.105)	3.14 (0.197)	3.6***(0.073)	3.90***(0.006)	3.50*(0.00)	-	-
Weight (kg)		17.00±0.00	22.16±0.16	28.25±2.50	22.43±1.10	20.50±0.16	20.0±0.00		
Height (cm)		111.00 ±0.0	115.00±0.00	118.00±1.80	120 ± 0.88	130.00±0.00 ^H	115.00±0.00		
Grade 2	38.04±3.49	2.80 (0.0)	3.01 (.17)	3.54***(.07)	3.49***(.120)	3.62***(.099)	3.73***(.13)	3.24 (0.0)	3.20 (0.0)
Weight (kg)		17.00±0.00	23.73±2.40	26.66 ±1.10	32.40±2.30	25.30±1.60	34.00±8.30	40.00±00	12.00±0.00
Height (cm)		111.00±0.00	120.00±3.80	129.00±1.40	128.00 ± 2.00	124.00 ±1.35	130.00±5.13 ^H	125.00±0.00	120.00±0.00
Grade 3	35.63±2.55	-	2.82 (0.110)	3.52*(0.128)	3.51*(0.110)	3.46*(.133)	3.00 (0.00)	-	-
Weight (kg)			24.25±1.90	28.26±2.20	32.42±2.90	33.84±2.00	23.00±0.00		
Height (cm)			123.00±1.22	129.00±2.64	131.00±1.59	134.00±1.85 ^H	125.00±0.00		
Grade 4	36.62±2.73	-	3.81 (0.062)	3.60 (0.089)	3.47 (0.105)	3.47 (0.173)	3.63 (0.131)	-	-
Weight (kg)			33.28±3.80	34.62 ± 2.50	34.21±1.70	37.70±3.10	41.60±4.50		
Height (cm)			140.00±3.84	134.90±1.40	137.90±1.70	137.10±1.90	145.00±1.60 ^H		
Grade 5	36.2±2.36	-	2.96 (0.389)	3.56 (0.137)	3.38 (0.102)	3.32 (0.121)	3.39 (0.00)	-	-
Weight (kg)			37.60±3.30	35.80±5.10	42.30±2.30	45.50±3.20	37.00±0.00		
Height (cm)			145.00±2.20	140.00±2.60	144.00±1.20	146.70± 2.20	147.00±0.00 ^H		
Grade 6	31.37±2.37	2.80 (0.00)	3.22 (0.20)	3.53 (0.136)	3.40 (0.10)	3.26 (0.19)	3.26 (0.00)	-	-
Weight (kg)		62.00±0.00	51.20±5.10	53.0 ±5.2	47.20±2.90	45.30±3.40	59.00±0.00		
Height (cm)		151.00±0.00	159.50±2.70	157.00± 4.40	149.00±2.00	147.90±4.00	161.00±0.00 ^H		
Overall	35.16±1.11	2.80 (0.00)	3.28 (0.09)	3.52***(0.051)	3.50***(0.04)	3.49***(0.057)	3.58***(0.07)	3.24 (4.60)	3.20 (0.00)

Remark: 1) Mean = average, SE = standard error

2) Grade 1

*The mean difference is significantly different in academic performance at the P-value < 0.05 level, and **The mean difference is significantly different academic performance at the P-value < 0.01 level compared with the 5-egg/month group by using post-hoc analysis.

3) Grade 2

**The mean difference is significantly different in academic performance at the P-value < 0.01 level compared with the 5 and 10 eggs/month groups by using post-hoc analysis.

4) Grade 3

*The mean difference is significantly different in academic performance at the P-value < 0.05 level is significantly different academic performance at the P-value < 0.01 level compared with 10 eggs/month group by using post-hoc analysis.

5) Overall

**The mean difference is significantly different in academic performance at the P-value < 0.01 level compared with the 5-egg/month group by using post-hoc analysis.

6) The “H” superscript number means the highest group.

2.5 All grades

Undernutrition continues to have a detrimental impact on academic performance across all grade levels. Upon careful observation of the study findings, it was evident that all students in grades 1-6 who consumed 5 whole eggs per month had a Grade Point Average (GPA) of 2.80 as noted on Table 3. The results suggest that there was a significant difference in the academic performance of students who ingested different quantities of whole eggs per month (20, 30, 60 and 90) when compared to the group of students who consumed only 5 whole eggs per month. (P-value <0.0001) (Table 3). Ayalew et al. (2020) found a significant link between being underweight or experiencing stunting and a decline in academic performance. Significant associations were found between severe underweight (POR = 0.25; 95% CI: 0.09, 0.71) and severe stunting (POR = 0.03; 95% CI: 0.01, 0.37) and a reduced likelihood of achieving high average semester scores in school-aged children.

In continuation of Erikson's theory (Erikson, 1963), children in this age group are in the industry vs. inferiority period. Thus, the inner stage seems all set for "entrance into life," except that life must first be school life, whether school is a field, jungle, or classroom. The child must forget past hopes and wishes while his exuberant imagination is tamed and harnessed to the laws of impersonal things. Children now learn to win recognition by producing things. They have mastered the ambulatory field and the organ modes. They have experienced a sense of finality regarding the fact that there is no workable future within the womb of their family and thus becomes ready to apply themselves to given skills and tasks, which go far beyond the mere playful expression of their organ modes or pleasure in the function of their limbs. Children develop a sense of industry; they adjust themselves to the inorganic laws of the tool world. Their ego boundaries include their tools and skills-the work principle. In all cultures, at this age, children receive some systematic instruction. Although, the fundamentals of technology are developed as the child becomes ready to handle the utensils, tools and weapons used by the older people. Literate people, with more specialized careers, must prepare children by teaching them, first of all, teach them to be literate and provide the widest possible basic education for the greatest number of possible careers. The more complicated social reality, the vaguer are the father's and mother's roles in it. School seems to be a culture all by itself, with its own goals and limits, its own achievements

and disappointments.

Based on the aforementioned references, by providing support to the children in the program, it will foster dedication and instill confidence in their own capacity to achieve success. Conversely, when the family or teachers restrict their proactive behavior, it engenders feelings of inferiority in the children. A lack of self-confidence in one's own talents can have a detrimental impact on academic success. The study's goal was to thoroughly analyze the connection between test anxiety and test performance among German university students, drawing on research by Schillinger et al. (2021). Their findings revealed that interference and a lack of confidence exhibited highly significant negative correlations with all performance measures. The study conducted by Roos et al. (2023) examined how several components of test anxiety (affective, cognitive, motivational and physiological) act as mediators between control and performance in high school students. The cognitive anxiety component had a notable adverse impact on performance ($b = -0.23$, $SE=0.09$, P-value <0.01). According to Pekrun's control-value hypothesis, people themselves would report feeling less anxious at higher levels of control.

3. Consumption of other protein patterns affects academic performance

The results that will be discussed below refer to Tables 4 to 8.

3.1 The 1st grade

Table 4 details the impact of incorporating other protein patterns on academic achievement in the first grade. When observing the impact of fish consumption on academic achievement in each group of students, the group of children who consumed fish more than three days per week had a significantly higher GPA compared to the group of children who consumed fish a minimum of three days every week ($.63 \pm .22$, P-value <0.01). Students who consumed fish more than three times per week achieved a perfect GPA of 4.00. The findings of this investigation align with those of Lehner et al. (2020). The study found a statistically significant link between eating 8 g of fish every day and getting better grades in German (OR = 1.193; 95% CI = 1.049–1.358) and math (OR = 1.16; 95% CI = 1.022–1.317) by one point compared to people who didn't eat fish or only ate very small amounts. Fish have high levels of the long-chain fatty acids docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA), which are specific forms of Omega-3. Omega-3 long-chain polyunsaturated fatty

acids (n-3 LC-PUFAs), particularly docosahexaenoic acid (DHA), are vital nutrients that support cognitive function and behavior. Evidence demonstrates that DHA builds up in the cerebral cortex and hippocampus, regions of the brain linked to cognitive functions such as learning and memory (Lehner et al., 2020). Furthermore, fish have a protein content of 18–20% and are rich in eight vital amino acids, including lysine, methionine and cysteine, which include sulfur. It offers a readily digestible protein with high biological value, which is crucial for body growth and development, tissue preservation and repair, as well as the creation of enzymes and hormones that are essential for various bodily functions. Additionally, it contains less fat compared to red meat. Fish is a crucial and rich source of vitamins, including vitamins A and D from lipids, as well as thiamine, riboflavin and niacin (vitamins B1, B2 and B3) (Maulu et al., 2021). The advantages of essential amino acids and vitamins have already been mentioned.

When observing the group of students who consumed milk, the study revealed that the group of children who consumed milk at a daily intake of 750 mL and more showed a significantly higher GPA compared to children who consumed less than 750 mL of milk per day (0.62 ± 0.10 , 0.63 ± 0.16 , respectively, P -value < 0.0001). Milk is rich in all the necessary amino acids and vitamins. The advantages of essential amino acids and vitamins have already been mentioned.

On the contrary, there were no statistically significant differences between the grade point average (GPA) among each group of students who consumed meat.

3.2 The 2nd grade

There was no significant differences in GPA identified among the groups of grade 2 students who consumed different types of meat, milk and fish. However, upon examination of the data, it was discovered that the research findings aligned with those of the 1st grade. Upon observing the association between fish consumption and academic performance, it was found that the group of children who consumed fish more than 3 days per week showed a better grade point average (GPA) compared to the group of children who consumed fish 3 days per week or less. The group of children who consumed milk more than 750 mL per day had a better grade point average (GPA) compared to the children who consumed less than 750 mL of milk per day (Table 5). The rationale behind the research outcomes remain the same as in first grade.

3.3 The 3rd grade

The findings of the investigation aligned with those of grades 1 and 2 regarding the academic achievement of the fish group. The study revealed that the group of children who consumed fish more than 3 days per week had a significantly higher GPA compared to the group of children who consumed fish

Table 4 Groups of students who consumed other protein sources affect their GPA in the 1st grade

Variable	The recommendation is to consume a daily portion of meat group meal, equivalent to 6 tablespoons (eating meat groups)	The recommendation is to consume a daily amount of 750 ml of milk, which is equivalent to 3 glasses, on a regular basis (eating milk groups)	The recommendation is to consume fish a minimum of three days every week. (eating fish groups)
Mean GPA (SE)/Mean $\pm$ SE			
Eating less than recommended	3.56 (.08)	3.14 (0.10)	3.67 (0.06)
Monthly consumption of eggs (Number of eggs per whole egg)	38.53 $\pm$ 3.81	20.00 $\pm$ 1.73	34.54 $\pm$ 3.20
Eating as recommended	3.45 (.09)	3.77 (0.06)**	3.36 (0.09)
Monthly consumption of eggs (Number of eggs per whole egg)	24.23 $\pm$ 1.68	35.26 $\pm$ 2.65	31.47 $\pm$ 3.99
Eating more than recommended	3.96 (.00)	3.77 (0.08)**	4.00 (0.00)**
Monthly consumption of eggs (Number of eggs per whole egg)	30.00 $\pm$ 0.00	56.00 $\pm$ 10.54	30.00 $\pm$ 0.00

Remark: 1) Mean = average, GPA = grade point average, SE = standard error

2) Eating milk groups

** The mean difference is significantly different in academic performance at the P -value < 0.01 level, compared with eating less than recommended by using post-hoc analysis.

3) Eating fish groups

** The mean difference is significantly different in academic performance at the P -value < 0.01 level, compared with eating as recommended by using post-hoc analysis.

Table 5 Groups of students who consumed other protein sources affect their GPA in the 2nd grade

Variable	The recommendation is to consume a daily portion of meat group meal, equivalent to 6 tablespoons (eating meat groups)	The recommendation is to consume a daily amount of 750 mL of milk, which is equivalent to 3 glasses, on a regular basis 3 (eating milk groups)	The recommendation is to consume fish a minimum of three days every week (eating fish groups)
Mean GPA (SE)/Mean±SE			
Eating less than recommended	3.45 (.10)	3.51 (.10)	3.59 (.10)
Monthly consumption of eggs (Number of eggs per whole egg)	25.00±4.11	24.31±2.23	33.33±5.49
Eating as recommended	3.48 (.07)	3.45 (.06)	3.43 (.06)
Monthly consumption of eggs (Number of eggs per whole egg)	42.88±4.54	46.15 ± 5.13	40.33 ± 4.54
Eating more than recommended	3.69 (.11)	3.69 (.09)	3.71 (.15)
Monthly consumption of eggs (Number of eggs per whole egg)	32.50±9.46	33.33±13.33	30.00±10.00

Remark: Mean = average, GPA = grade point average, SE = standard error

less than 3 days per week (mean GPA of 0.72 ± 0.25 , with a P-value of 0.006). When examining the impact of consuming milk on academic performance, the study revealed that the group of children who consumed 750 mL/day of milk had a significantly higher GPA compared to children who consumed less than 750 mL/day of milk (mean difference of 0.36 ± 0.13 , P-value < 0.05). Conversely, there was no statistically significant difference in the GPA among each group of students who consumed meat (Table 6). The rationale behind the research outcomes remain the same as in the first grade.

3.4 The 4th grade

No statistically significant differences in GPA were detected among the groups of students who

ingested meat, milk and fish in grade 4. However, upon examination of the data, it was discovered that the findings of the study aligned with those of grades 1-3. Upon examining the impact of fish consumption on academic achievement, it was shown that children who consumed fish more than 3 days per week had a higher GPA compared to those who ingested fish 3 days per week or fewer. The children who consumed milk in quantities exceeding 750 mL per day had a better grade point average (GPA) in comparison to children who consumed less than 750 mL of milk daily. Why doesn't diet have a statistically significant effect on academic performance? This topic was already discussed in the section on eating eggs.

Table 6 Groups of students who consumed other protein sources affect their GPA in the 3rd grade

Variable	The recommendation is to consume a daily portion of meat group meal, equivalent to 6 tablespoons (eating meat groups)	The recommendation is to consume a daily amount of 750 mL of milk, which is equivalent to 3 glasses, on a regular basis (eating milk groups)	The recommendation is to consume fish a minimum of three days every week (eating fish groups)
Mean GPA (SE)/Mean±SE			
Eating less than recommended	3.26 (.13)	3.20 (.10)	3.17 (.13)
Monthly consumption of eggs (Number of eggs per whole egg)	22.00±3.34	32.50±4.80	37.85±6.96
Eating as recommended	3.52 (.08)	3.57 (.09)*	3.48 (.08)
Monthly consumption of eggs (Number of eggs per whole egg)	40.83±2.79	36.96±3.03	36.66±2.73
Eating more than recommended	3.32 (.23)	3.64 (.03)	3.90 (.07)**
Monthly consumption of eggs (Number of eggs per whole egg)	36.00±14.00	45.00±15.00	22.00±2.00

Remark: 1) Mean = average, GPA = grade point average, SE = standard error

2) Eating Milk Groups

* The mean difference is significantly different in academic performance at the P-value < 0.05 level, compared with eating less than recommended by using Post-hoc analysis.

3) Eating Fish Groups

** The mean difference is significantly different in academic performance at the P-value < 0.01 level, compared with eating less than recommended by using Post-hoc analysis.

Table 7 Groups of students who consumed other protein sources affect their GPA in the 4th grade

Variable	The recommendation is to consume a daily portion of meat group meal, equivalent to 6 tablespoons (eating meat groups)	The recommendation is to consume a daily amount of 750 mL of milk, which is equivalent to 3 glasses, on a regular basis (eating milk groups)	The recommendation is to consume fish a minimum of three days every week. (eating fish groups)
	Mean GPA (SE)/Mean±SE		
Eating less than recommended	3.50 (.12)	3.42 (.11)	3.59 (.05)
Monthly consumption of eggs (Number of eggs per whole egg)	31.85±4.20	33.0±3.56	32.56±3.38
Eating as recommended	3.60 (.06)	3.62 (.07)	3.50 (.10)
Monthly consumption of eggs (Number of eggs per whole egg)	39.60±3.80	39.78±4.17	41.19±4.31
Eating more than recommended	3.36 (.26)	3.84 (.09)	3.89 (.06)
Monthly consumption of eggs (Number of eggs per whole egg)	33.33±8.43	22.50±2.50	20.00±0.0

Remark: Mean = average, GPA = grade point average, SE = standard error

3.5 The 5th to 6th grade

No statistically significant differences in GPA were detected among the groups of students who ingested meat, milk and fish in grades 5-6.

fish, may influence academic performance. Secondly, the sample size for this investigation was relatively small. Consequently, the findings may not be applicable to the entire student population.

Table 8 Consumption of other protein patterns affects academic performance in the 5th and 6th grade

Variable	Eating meat groups		Drinking milk groups		Eating fish groups	
	Grade 5	Grade 6	Grade 5	Grade 6	Grade 5	Grade 6
F	2.64	.513	.087	1.81	1.46	.072
sig	.080	.602	.917	.172	.241	.930

Remark: Analyzed by one-way ANOVA for different change in academic performance

Based on this study, the ingestion of milk and fish has a discernible effect on the academic achievement of children. Upon closer scrutiny, it is imperative for children to consume fish with a frequency exceeding three days each week. Fish is far more expensive than eggs. Children should have a minimum of 750 mL of milk daily and occasionally exceed this amount. Milk is roughly 100–200% more costly than eggs. In addition, children who consume an excessive amount of milk may experience satiety, which might hinder their intake of other healthy things. By focusing just on the protein content, it was shown that children who consumed 2 eggs per day acquired an average of 12.6 g of protein, which represents almost 50% of their daily protein needs.

Limitation

There are some limitations to this investigation. Firstly, the cross-sectional nature of this study makes it impossible to definitively determine cause and effect. Additional variables, such as consumption of milk or

Conclusion

Egg eating serves as a protein supplement that facilitates growth in school-aged children. Eggs are rich in diverse nutrients that encourage growth, including protein with an optimal balance of amino acids to meet the body's requirements for vitamins and minerals. According to this study, students in grades 1st to 3rd who consumed either 60 or 90 whole eggs per month exhibited superior academic performance and had the highest average height compared to other groups. However, other sources of protein, such as fish and milk, also stimulate growth. However, when considering cost, eggs are significantly more affordable than other protein sources. Additionally, eggs are widely available, contributing to their accessibility. It is worth noting that the affordability and availability of eggs can help alleviate socioeconomic inequality. In children who are overweight or obese, their height exceeds the normal range. Due to their family's favorable economic condition, the children in this group have access to

sufficient nourishment, including protein, carbohydrates, fats and essential micronutrients. Additionally, they are able to enjoy pastries and cakes. As a result, these children demonstrate high scholastic achievement. During grades 4-6, the consumption of eggs continues to support physical development; however, no substantial impact on GPA was observed. During this developmental stage, children start to engage in logical and rational thinking. Several factors influence GPA, such as self-directed learning facilitated by technology and the acquisition of beneficial resources through new acquaintances made via technology.

However, undernutrition continues to impact academic performance across all grade levels. Based on the findings of this study, it was observed that all students in grades 1st to 6th who consumed 5 eggs per month had a Grade Point Average (GPA) of 2.80. There was a significant difference in the academic performance of students who ingested different quantities of whole eggs per month (20, 30, 60 and 90) when compared to the group of students who consumed only 5 whole eggs per month. School-age children are experiencing the industry-versus-inferiority period. If the children receive help in the endeavor, it will foster diligence and instill confidence in their own capacity to achieve success. Conversely, when the family or teachers restrict their drive, it engenders a sense of inferiority in the child. Insufficient self-confidence in one's own capabilities negatively impacts academic success.

Acknowledgments

We would like to thank the study participants, classroom teachers, data collectors and school directors.

References

- American Heart Association, Committee on Nutrition. (1968). Diet and heart disease. American Heart Association: Dallas, TX, USA.
- Aorgart, W., & Pinyoanuntapong, S. (2016). The study of early childhood in accordance with food behavioral consumption in case of "the school in Bangkok". *Journal of Education Srinakharinwirot University*, 17(2), 13-27.
- Ayalew, M., Bayray, A., Bekele, A., & Handebo, S. (2020). Nutritional status and educational performance of school-aged children in Lalibela town primary schools, Northern Ethiopia. *International Journal of Pediatrics*, 2020, 5956732.
- Bragg, M.G., Prado, E.L., Caswell, B.L., Arnold, C.D., George, M., Oakes, L.M., ... Stewart, C.P. (2023). The association between plasma choline, growth and neurodevelopment among Malawian children aged 6–15 months enrolled in an egg intervention trial. *Maternal & Child Nutrition*, 19(2), e13471.
- Bureau of Nutrition, Department of Ministry of Public Health. (2020). Dietary reference intake for Thais. Bangkok: A.V. Progressive.
- Bureau of Nutrition, Department of Ministry of Public health. (2021). A guide to using the growth reference criteria for children aged 6-19 years (2nd ed.). Samutprakarn: TS Interprint.
- Cahoon, A., Gilmore, C., & Simms, V. (2021). Developmental pathways of early numerical skills during the preschool to school transition. *Learning and Instruction*, 75, 101484.
- Caswell, B.L., Arnold, C.D., Lutter, C.K., Iannotti, L.L., Chipatala, R., Werner, E.R., ... Stewart, C.P. (2021). Impacts of an egg intervention on nutrient adequacy among young Malawian children. *Maternal & Child Nutrition*, 17(3), e13196.
- Dong, Y., Jan, C., Ma, Y., Dong, B., Zou, Z., Yang, Y., ... Patton, G.C. (2019). Economic development and the nutritional status of Chinese school-aged children and adolescents from 1995 to 2014: An analysis of five successive national surveys. *The Lancet Diabetes & Endocrinology*, 7(4), 288-299.
- Dukhi, N. (2020). Global prevalence of malnutrition: Evidence from literature. In M. Imran (Ed.), *Malnutrition* (pp. 1–16). London: IntechOpen.
- Erikson, E.H. (1963). *Childhood and society* (2nd ed.). New York: Norton.
- Fernandez, M.L., & Calle, M. (2010). Revisiting dietary cholesterol recommendations: Does the evidence support a limit of 300 mg/d? *Current Atherosclerosis Reports*, 12, 377-383.
- He, J., Chen, X., Fan, X., Cai, Z., & Huang, F. (2019). Is there a relationship between body mass index and academic achievement? A meta-analysis. *Public Health*, 167, 111-124.
- Iannotti, L.L., Lutter, C.K., Bunn, D.A., & Stewart, C.P. (2014). Eggs: the uncracked potential for improving maternal and young child nutrition among the world's poor. *Nutrition Reviews*, 72(6), 355-368.
- Kase, B.E., Frongillo, E.A., Isanovic, S., Gonzalez, W., Wodajo, H.Y., & Djimeu, E.W. (2022). Determinants of egg consumption by infants and young children in Ethiopia. *Public Health Nutrition*, 25(11), 3121-3130.
- Lehner, A., Staub, K., Aldakak, L., Eppenberger, P., Rühli, F., Martin, R.D., & Bender, N. (2020). Fish consumption is associated with school performance in children in a non-linear way: Results from the German cohort study KiGGS. *Evolution, Medicine, and Public Health*, 2020(1), 2-11.

- Liu, X., Shao, Y., Sun, J., Tu, J., Wang, Z., Tao, J., & Chen, J. (2022). Egg consumption improves vascular and gut microbiota function without increasing inflammatory, metabolic, and oxidative stress markers. *Food Science & Nutrition*, 10(1), 295-304.
- Maulu, S., Nawanzi, K., Abdel-Tawwab, M., & Khalil, H.S. (2021). Fish nutritional value as an approach to children's nutrition. *Frontiers in Nutrition*, 8, 780844.
- Maytapattana, M. (2017). Factors associated with food consumption behavior of nursing students. *The Journal of Faculty of Nursing Burapha University*, 25(3), 20-29.
- Michael, J.L., & Shamim S.M. (2023). Biochemistry, essential amino acids. Retrieved January, 15, 2024 from <https://www.ncbi.nlm.nih.gov/books/NBK557845/>
- Padhani, Z.A., Das, J.K., Akhtar, S., Ismail, T., & Bhutta, Z.A. (2022). Tackling protein-calorie malnutrition during world crises. *Annals of Nutrition and Metabolism*, 78(Suppl. 1), 27-38.
- Papanikolaou, Y., & Fulgoni III, V.L. (2019). Egg consumption in US children is associated with greater daily nutrient intakes, including protein, lutein+ zeaxanthin, choline, α -linolenic acid, and docosahexanoic acid. *Nutrients*, 11(5), 1137.
- Piaget, J. (1983). Piaget's theory. In P. Mussen (Ed.), *Handbook of Child Psychology* (pp. 41-102). New York: Wiley.
- Roos, A.L., Goetz, T., Krannich, M., Donker, M., Bieleke, M., Caltabiano, A., & Mainhard, T. (2023). Control, anxiety and test performance: Self-reported and physiological indicators of anxiety as mediators. *British Journal of Educational Psychology*, 93, 72-89.
- Saiwan, T., Puwastien, P., Deeaum, A., & Judprasong, K. (2015). Nutritive value of commonly eggs and effects of cooking. *Thai Science and Technology Journal*, 23(4), 651-666.
- Schillinger, F.L., Mosbacher, J.A., Brunner, C., Vogel, S.E., & Grabner, R.H. (2021). Revisiting the role of worries in explaining the link between test anxiety and test performance. *Educational Psychology Review*, 33, 1887-1906.
- Suta, S., Surawit, A., Mongkolsucharitkul, P., Pinsawas, B., Manosan, T., Ophakas, S., ... Mayurasakorn, K. (2023). Prolonged Egg Supplement Advances Growing Child's Growth and Gut Microbiota. *Nutrients*, 15(5), 1143.
- Tabatabaeyan, A., Lotfi, K., Mirzaei, S., Asadi, A., Akhlaghi, M., & Saneei, P. (2023). The association between egg consumption and metabolic health status in overweight and obese adolescents. *Scientific Reports*, 13(1), 2778.
- Thai Health Promotion Foundation. (2010). *Annual report 2010*. Retrieved January, 8, 2024 from <https://www.thaihealth.or.th/?p=137059>
- Thanacharoenwat, N. (2021). A study of the management Food and Nutrition in School. Retrieved January, 21, 2024 from https://nutrition2.anamai.moph.go.th/download-06/download?id=85361&mid=32009&mkey=m_document&lang=th&did=27550
- Thomas, M.S., DiBella, M., Blesso, C.N., Malysheva, O., Caudill, M., Sholola, M., ... Fernandez, M.L. (2022). Comparison between egg intake versus choline supplementation on gut microbiota and plasma carotenoids in subjects with metabolic syndrome. *Nutrients*, 14(6), 1179.
- Trirapongsawat, K., Sontua, J., Khumhirun, S., Phuriwatpakorn, M., Pissawongprakan, P., Rattanapanya, R., Namta, P., & Phonrat, S. (2021). Dietary patterns of behavior in school children, Health area region 7. *Journal of Regional Health Promotion Center 7 Khonkaen*, 13 (2), 23-36.
- U.S. Department of Agriculture. (2018). *Egg, whole, cooked, hard-boiled*. Retrieved January, 21, 2024 from <https://fdc.nal.usda.gov/fdc-app.html#/food-details/173424/nutrients>