Supplement of Three Eggs a Week Improves Protein Malnutrition in Thai Children from Rural Areas

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Background: *Protein Malnutrition is one of the most important health indexes that affect children's growth and development. In Thailand National Health Survey 2004, 21.5% of primary school students living in the rural area were below the 90th percentile of the standard weight for age.*
Objective: *To compare nutritional status with serum proteins and lipids, and to determine the effect of egg supplement for primary school students aged 6-15 years.*
Material and Method: *A randomized experimental study was performed in 417 participants received an addition of either three or ten eggs per week for 12 consecutive weeks to basal diet.*
Results: *The anthropometric and biochemical indexes were measured, 29.1% and 20.8% of whom were Protein Malnutrition according to serum albumin and PreAlbumin's criteria, respectively. Albumin and PreAlbumin levels were positively correlated with Total Cholesterol and LDL-C levels. No difference in any biochemical index has been found between 3 eggs/wk group and 10 eggs/wk group. Besides, due to continuing egg supplement, Total Cholesterol, LDL and ratio of Total Cholesterol to HDL level have decreased ($p < 0.001$) but albumin, PreAlbumin and HDL levels have demonstrated significantly increasing levels ($p < 0.001$).*
Conclusion: *Nowadays in rural areas of Thailand there are still primary school students with protein malnutrition especially in rural area. An addition of at least 3 eggs/wk supplements can effectively correct the problem of protein malnutrition among primary school students at risk as shown by biochemical indices, and it benefits the blood cholesterol level as well.*

Keywords: *Protein malnutrition, Egg supplements, Lipid profiles, Thai children, Pre albumin, Rural areas*

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Protein Malnutrition (PM) is one of the most important health indexes that affect children's growth and development and may lead to, both in the short and long term, morbidity and mortality[1,2]. At present, the evaluation of malnutrition involves a number of collected variables such as weight, height, blood morphology and serum albumin level[3]. A survey by the Department of Health in 2003 found that in urban area children were least affected by protein malnutrition, with a percentage of 16.8 being registered in the central region[4]. On the contrary, the ratio of 21.5 in rural area implied greater severity of the problem in the latter case (according to W/A).

Because of its abundance of high-quality protein, general availability and low price, egg is suitable as a study object to solve the problem of malnutrition. Eggs also provide many nutritional benefits such as vitamins B12, C, E folate and lecithin[5]. Furthermore, the general misunderstanding that egg consumption increases blood cholesterol and consequently the risk of cardiovascular disease, which has been publicized by the media during the last 30 years and has led to less egg consumption, this statement needs to be widely and explicitly corrected, especially among people with low-socioeconomic status who should have had egg

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menus for their usual meals[6-8]. The statistics shows that egg consumption of Americans has decreased from 405 eggs per person per year in 1945 to 296 in 2006. A Chinese person consumes 318 eggs per year, while an average Thai consumes 156 eggs per person per year[9].

Because of high cholesterol content in eggs, dietary cholesterol may increase blood cholesterol. High serum cholesterol levels have been related to increased coronary heart disease (CHD)[10,11] yet in some study the CHD risk does not increase with continuous egg intakes inspite of their cholesterol content[8,12,13]. Over 166 cholesterol feeding studies found that a 100 mg/d increase in dietary cholesterol will raise total cholesterol 2.2 mg/dl or merely 1% in normal responders[14]. This effect corresponds to a 1.9 mg/dl and 0.4 mg/dl escalating in low density lipoprotein (LDL) cholesterol and high density lipoprotein (HDL) cholesterol, respectively, ultimately reflecting on little effect on the LDL/HDL ratio which considered minimal repercussion on CHD risk[15]. However, uncertainty about the effect of egg consumption on blood cholesterol in young age population still remains.

The purpose of this study is to assess the effect of supplementing egg on protein malnutrition and lipid response in primary school children. The comparison of pre and post supplement was used to compare protein status and lipid of the participants. An egg was supplemented by weight (approximated weight, 55 grams) according to Thailand recommended dietary intakes (Thai RDIs), contains approximately 213 mg cholesterol each. The egg was served daily at lunch[3].

Material and Method

Classification of protein malnutrition (PM)

PM was analyzed by anthropometric variables such as height for age, weight for age, weight for height, using standard values of height and weight of the Thais as benchmarks[4]. Additionally, volunteers were divided into two groups according to the degree of PM, defined by PreA values, *i.e.* the low-PreA group (less than 16 mg/dl, P1) and the normal-PreA group ($\geq$ 16 mg/dl, P2)[17]. Because in the preliminary survey we found numbers of subjects encountered PM; we therefore divided them into P1 and P2 to compare the relationship between related variables.

Participants

417 primary school students between the 4th and 6th grade, whose ages were between 10-12 years, were recruited from two schools in the same neighborhood in Sanamchaiket district, the outskirt of Chacherngsao Province Thailand (120 kilometers from central area of this province). We considered this area as rural community due to its population density of 42 people/square kilimeter, which most families did agricultures and tree farming[35]. This project conducted between October 2006 and May 2007. In the first place, the researchers collected baseline characteristics from every volunteer's parents, then other data that required standard measuring instruments, assisted by a team of specialists including coordinating dietitians and nurse practitioners. All the participants were in good health; however, individuals with extreme dietary habits, overweight (BMI > 25 kg/m^2) or significant food intolerances were excluded.

The experimental protocol had been reviewed and approved by the ethical committee of the Ramathibodhi Hospital. Informed consent had been obtained from all participants including their parents before enrolled in the study. After the study, the participants who had protein malnutrition would be referred to the local hospital for further and proper care.

Protocol

Chicken eggs were purchased from Bangkok Foodstuff Co., Ltd. (Sakaeo, Thailand). They were boiled and eaten by participants at lunch during school day under supervision of staff members of the schools. This was a free living food study and no other food was provided to participants; therefore, their parents were asked to continue providing their children with regular and same-style diet but restrain children from additional egg consumptions throughout the study. Two weeks prior to the start of the study, subjects completed a 3-day food record to determine the average daily intake of energy, carbohydrate, total protein, fat, dietary cholesterol.

This study utilized a randomized, before and after design where volunteers were matched by sex, age, BMI (body mass index) and PreAlbumin and then randomly assigned, to either 3 or 10 egg/wk in order to study the effects of egg intake on protein and cholesterol parameters. Throughout 12 wks, subjects in 3-egg group were offered one boiled egg every Monday, Wednesday and Friday, while the others in 10-egg group were offered 2 boiled eggs on every Monday through Friday. All participants were enrolled in 4 wk run-in periods before the beginning of the study, which they were provided without egg consumption at school.

Blood analysis

Venous blood samples were collected from 8-hour overnight fasting participants before the start of egg ingestion (wk-1), at wk-6, wk-12 (when egg supplement was terminated). The procedure started with the analysis of anthropometric variables which had been collected at the beginning of the project, *i.e.* weight and height which were compared to the standard defined by the Department of Health(4). Total cholesterol (TC), triacylglycerol (TG), HDL, TC: HDL ratio and Alb were analyzed by enzymatic techniques with an automatic serum analyzer, Hitachi 717 (Boehringer Mann-heim, GmbH, Mannheim, Germany). PreAlbumin (PreA) was analyzed by the method called Immuno-turbidimetric assay (Dade, Newark, NJ, USA) and serum LDL was calculated according to the Friedewald formula(16).

Statistical analysis

Demographic and baseline characteristics of all participants were represented with the mean (x) $\pm$ Standard Error of Mean (SEM). The evaluation of the nutritional status used the following two criteria: 1) Anthropometric criteria, as set by the Department of Health(4), consisting of weight for age (W/A; 90-109.9% defined as normal level), height for age (H/A; 90-104.9% defined as normal level) and weight for height (W/H; 90-109.9% defined as normal level), whereby all the three criteria at the 50th percentile counted for 100%(2). Serum protein level in reference to Frederick(17), which includes Alb and PreA point estimates and 95% confidence intervals were calculated for the mean differences in change between each group. Moreover, changes in variables after the beginning of the project were tracked by the method of Repeated Measures Analysis of Variance. Moreover, we determined correlation between dependent variables by using Mauchly's criterion. But if conditions of dependent variables did not meet the requirement of this method; for example, compound symmetry of variable was not equi-correlation or covariance between pairs of repeated parameters was not equal. Multivariate Analysis of Covariance (MANCOVA) to analyze related variables, using SPSS for Windows (Version 11.0; SPSS Inc., Chicago, IL), was applied.

Results

Out of the 417 participants, there were 30 participants (15 in 3-egg group and another 15 in 10-egg group were excluded), 21 of whom dropped out from the first blood examination, whereas 9 of whom failed to continue egg consumption. The results therefore are based on the remaining 387 participants (199 from 3-egg and 188 from 10-egg group) who completed this study. However, there was no difference in baseline characteristics between the dropouts and the studied children. No serious complications were observed during either the 12 weeks of egg consumption or blood examinations.

Table 1 showed the matched baseline characteristics for both groups. There was no difference between 3-egg and 10-egg group with the respect to baseline values in most variables; however, there was difference between certain parameters due to the randomized selection bias in TG level and TC: HDL ratio in P1 group while W/H, H/A, and Alb in P2 group. Therefore, we did not use these parameters in the analyses. We found that 56.2% of the volunteers had a W/A below the 90th percentile (P), while 32.3% had an H/A below the 95th P and 35% had a W/H below the 90th P. In addition, we found that these groups had substandardized of serum PreAlbumin 20.8% and albumin 29.1% (data not shown).

Diet and plasma lipids and proteins

Analyze amounts of calories and nutrition intakes of all subjects was done; however, we found out most of them reported their intakes with unreliable information because in rural areas nutrition qualities of foods were inconsistent. And it was difficult to obtain reliable calorie intakes and nutrition compositions from dietary record; therefore, we did not include nutrition analysis in the result.

Plasma concentrations for both P1 and P2 groups showed non-significant diet effects on plasma lipids and proteins between 3 or 10 egg per week (Table 2). However, there were statistical significances on response effects after egg consumptions both P1 and P2 groups in TC, LDL, HDL, TC:HDL, Alb and PreA ($p < 0.001$) (Table 2). Mean percentage changes in lipoprotein profiles and proteins after egg supplement are shown in Fig. 1. Fig. 1A and 1B showed that in P1 group 12-week egg consumption resulted in significantly decrease of TC, LDL, TC: HDL by the percentage of 6.4 $\pm$ 1.8, 19.3 $\pm$ 2.5 and 28.5 $\pm$ 2.1 in 3-egg diet and by the percentage of 8.0 $\pm$ 1.9, 15.7 $\pm$ 3.0 and 31.2 $\pm$ 1.9 in 10-egg diet, respectively ($p < 0.001$). Besides, HDL, Alb and PreA after egg consumption in P1 also markedly increased by the percentage of 34.4 $\pm$ 4.6, 27.7 $\pm$ 4.9, 120.6 $\pm$ 17.9 in 3-egg diet and by 36.6 $\pm$ 3.9, 28.9 $\pm$ 6.2, 138.4 $\pm$ 19.2 in 10-egg diet

Table 1. Baseline characteristics of all participants at wk-1 compare between 3-egg/wk and 10-egg/wk in each low prealbumin (P1) and normal prealbumin (P2) group

Parameters	P1		P2	
	3-egg	10-egg	3-egg	10-egg
Male/female (n)	21/18	18/22	83/77	75/73
Age (year)	10.7 ± 0.2	11.2 ± 0.2	10.9 ± 0.1	11.1 ± 0.1
W/A (%)[#]	85.8 ± 2.2	86.6 ± 2.0	92.2 ± 1.7	92.7 ± 1.6
H/A (%)[#]	96.8 ± 0.7	97.2 ± 0.8	96.8 ± 0.4*	98.5 ± 0.4
W/H (%)[#]	92.9 ± 1.1	92.5 ± 1.4	99.1 ± 1.4*	95.0 ± 1.2
TC (mg/dl)	171.1 ± 4.1	180.3 ± 4.3	179.8 ± 2.4	182.3 ± 2.3
TG (mg/dl)	90.0 ± 4.6*	114.7 ± 8.8	118.8 ± 4.6	119.9 ± 4.5
HDL (mg/dl)	40.2 ± 1.1	39.3 ± 1.4	39.6 ± 0.6	39.6 ± 0.6
LDL (mg/dl)	112.8 ± 3.6	118.1 ± 3.9	116.6 ± 2.2	118.4 ± 2.2
TC:HDL	4.3 ± 0.1*	4.7 ± 0.2	4.7 ± 0.1	4.7 ± 0.1
Alb (mg/dl)	3.1 ± 0.1	3.2 ± 0.1	3.1 ± 0.1**	3.3 ± 0.04
PreA (mg/dl)	12.8 ± 0.4	11.9 ± 0.4	21.5 ± 0.3	21.4 ± 0.4

All parameters are in means ± SEM: n, number of participants; W/A, weight for age; H/A, height for age; W/H, weight for Height; TC, total cholesterol; TG, triacylglycerols; HDL, high-density lipoproteins; LDL, low-density lipoproteins; TC:HDL, total cholesterol to HDL ratio; Alb, albumin; PreA, PreAlbumin, P1 = low-PreAlbumin group; P2-normal-PreAlbumin group

* $p < 0.05$, ** $p < 0.001$ as compared in each P1 or P2

[#] When compared with the standard defined by Division of Health 50 percentile is counted for 100%

Table 2. Concentration of lipids and protein of low-PreAlbumin (P1) and normal-PreAlbumin (P2) during the 3-egg and 10-egg group as shown in mean ± SEM

	TC	TG	HDL	LDL	TC:HDL	Alb	PreA
Low-PreAlbumin (n = 79)							
3-egg	160.7 ± 4.24	117.1 ± 7.0	53.0 ± 1.9	91.2 ± 3.0	3.1 ± 0.1	3.9 ± 0.02	25.9 ± 1.3
10-egg	165.0 ± 3.4	102.9 ± 6.4	51.9 ± 1.8	96.7 ± 2.1	3.2 ± 0.1	3.9 ± 0.02	26.4 ± 1.4
Normal-PreAlbumin (n = 308)							
3-egg	167.4 ± 2.7	127.9 ± 4.3	51.7 ± 0.9	94.3 ± 1.4	3.3 ± 0.1	3.9 ± 0.01	30.6 ± 1.0
10-egg	158.9 ± 1.9	118.3 ± 4.0	48.3 ± 0.7	95.5 ± 1.4	3.3 ± 0.04	3.9 ± 0.01	30.3 ± 0.9
Diet effect***	NA	NA	NA	NA	NA	NA	NA
Response effect***	p < 0.05	NA	p < 0.001	p < 0.001	p < 0.001	p < 0.001	p < 0.001

All parameters are in means ± SEM: TC, total cholesterol; HDL, high-density lipoprotein; LDL, low-density lipoprotein

* $p < 0.05$, ** $p < 0.001$ significant difference as determined by repeated measures ANOVA , MANCOVA

*** Diet effect; the different effect in parameters when comparing 3-egg vs. 10-egg a week. Response effect; the effect of parameters when continuous egg consumption(including both 3-egg and 10-egg group)

($p < 0.001$), respectively. TG level in both 3-egg and 10-egg supplement were not significantly changed ($p > 0.05$).

Moreover, as illustrated in Fig. 1C and 1D, results in P2 group showed similar effects on every parameter. In P2 group egg diet also decreased TC, LDL, TC: HDL by the percentage of 6.6 ± 1.5, 17.3 ± 1.3 and 27.0 ± 1.4 in 3-egg diet and by the percentage of 12.1 ± 0.9, 15.9 ± 2.0 and 27.4 ± 1.2 in 10-egg diet, respectively ($p < 0.001$). In addition, after 12 wk of the intervention HDL, Alb and PreA after egg consumption in P2 group also markedly increased by the percentage of 31.2 ± 1.9, 36.7 ± 2.8, 42.8 ± 4.1 in 3-egg diet and 24.4 ± 1.9, 20.7 ± 2.4, 44.6 ± 4.5 in 10-egg diet ($p < 0.001$), respectively. No significant changes were also observed in TG level.

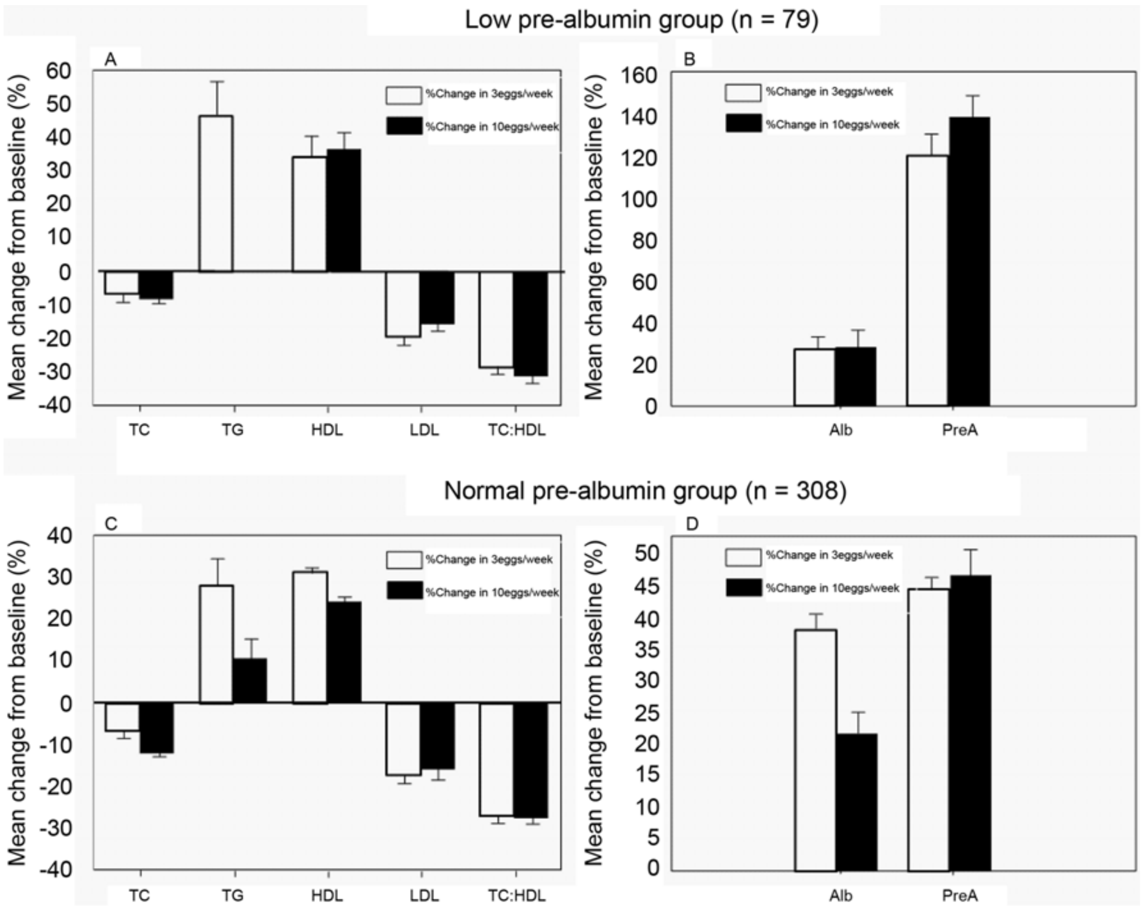

Fig. 1 The mean percentage changes in concentration of lipids and proteins in plasma after egg consumption (open bar for 3-egg and solid bar for 10-egg group) in participants with low pre-albumin (P1) (Fig. 1A and 1B) and normal pre-albumin (P2) (1C and 1D). All values are expressed as means $\pm$ SE of concentration changes from the beginning wk versus 12[th] wk. [a]All parameter are $p < 0.001$ except TG level ($p > 0.05$) when comparing the beginning of the study and the end of the study(12[th] wk)

From aforementioned variables significantly changed after egg consumption, we also determined percentages of all the subjects who had normal level of lipids and proteins between baseline and 12 wk (normal goal attainment level: TC < 200, HDL > 35, LDL < 130, Alb > 3.3 and Pre A > 16 mg/dl)[17,18]. Fig. 2 shows that from the beginning the subjects had normal level of TC, HDL, LDL, Alb and PreA by the percentage of 75.3, 74.6, 40.2, 70.9 and 80.7, respectively. On the other hand, the 12-wk intervention increased those variables into normal level by the percentage of 93.1, 100, 84.4, 100 and 97.8 respectively.

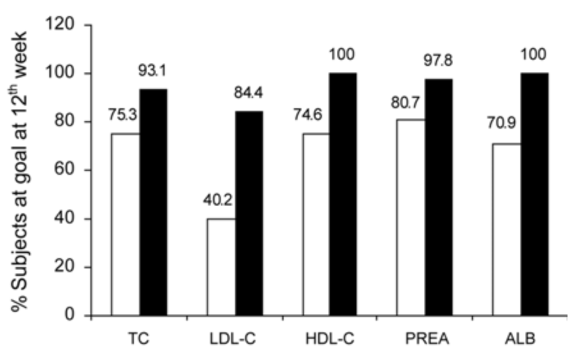

Fig. 2 In almost all subjects, egg supplement provided significant more proportion in blood lipid levels than before the beginning ,compared 12[th] week Target TC < 200 mg/dl) LDL-C < 130 mg/dl, HDL-C > 35 mg/dl, PreAlbumin > 16 mg/dl, Albumin > 3.3 mg/dl

Discussion

Protein deficit remains an essential problem for children in rural area due to insufficient funding support for nutrition program, food instabilities in communities, poor of knowledge etc. Besides, support in certain areas is provided for some categories of children, such as low W/A regardless of serum protein profiles. A nationwide health survey conducted by the Health Research Institute of Thailand illustrated that over 4,000 pupils aged between 6 and 12 yrs from the northeastern region, had the highest rate of protein malnutrition at 25.5%[4].

A current assessment of children's nutritional status-using anthropometric data such as W/A, H/A and W/H-found that the mentioned indicators could only serve as basic evidence to assume PM[19]. Low H/A or so-called stunting growth may imply long-term consequences of malnutrition and unhealthiness, while substandard weight at normal height (also known as wasting) may result from receiving insufficient energy. Finally, substandard weight and height may occur if children received insufficient or inappropriate protein intakes along with necessarily insufficient energy (Benjamin describes a community where a family has both overweight and underweight members, a status also knows as "Nutrition Paradox" that is frequently the case in developing countries)[20]. Its cause is believed to be inappropriate nutrition, *i.e.* the consumption of high-energy but low-nutritional-value food, which leads to fatness.

Still, the common handling of the problem at present focuses on information delivery to the Ministry of Health in order to find a solution, stressing on recommendations about consuming food of high nutritional value, taking additional vitamin tablets at home and drinking milk at school. However, Orapan's study which compared a group of milk-drinking children to another group that received supplement food found that the latter group gained more weight than the former, which probably implied that main food remained a necessity[21].

In order to determine body protein level, Alb and PreA are sometimes more preferred to weight and height, as the accuracy and specificity of the latter variables limit their effectiveness of predicting malnutrition status. PreA, according to a research by Frederick and Smith, have been increasingly used as a reference index because it adjusts more quickly and is more specific to nutritional and protein status than Alb[17,22]. In addition, Ogunshina SO found that PreA could separate first-stage-PM patients from healthy persons whereas weight, height and other variables were not able to[23]. This finding was supported by Potter's research, which is why our study uses this biochemical variable as a criterion[24].

This research divided volunteers into two groups, one with low-PreA (below 16 mg/dl; P1) and the other with normal PreA (over 16mg/dl; P2), at the start of the project since both groups possessed different protein fundaments which might affect other variables. Afterwards, each group was further divided into two sub-groups, one that received 3 eggs a week and the other that received 10 of such. The study concluded that there was no difference in the results of both 3-egg and 10-egg supplement sub-groups in all variables. This finding was believed that there were no differences between of 3 and 10-egg group result from the fact that in 10-egg diet we provided subjects with 2 boiled eggs per day whereas in 3-egg diet we provided them with 1 boiled egg every other day. Therefore, indeed there were a few differences of protein intakes in each day between of the two groups. Besides, after the egg consumption had been finished as illustrated in Fig. 1, total cholesterol, LDL and TC:HDL all dropped while Alb, PreA and HDL increased in both P1 and P2 participants. However, we noticed that PreA of P2, which had been higher than 16mg/dl at the beginning, increased even further and ended at a higher level than that of P1, but the level was still considered within the normal range according to Bernstein[25]. As for Alb and PreA, we found no difference in their changes in P1 and P2. Moreover, the number of the volunteers who had normal PreA and Alb increased dramatically after egg consumptions as shown in Fig. 2 as well.

The results showed that TC, LDL and TC: HDL tended to decrease during the test period, which implied that the volunteers' continuous egg consumption did not increase their cholesterol level but instead reduced it. As depicted in Fig. 2, in almost all subjects, egg supplement provided significant more proportion in blood lipid levels than before the beginning of the study, compared 12th wk of follow-up stage. Elsewhere, HDL increased significantly regardless of supplementing 3 or 10 eggs per wk, while Triaclyglycerol remained at a normal level[26]. In order to prevent factors that would increase the activities of liver and other cells in regulating blood cholesterol, resulting in a decrease in blood cholesterol as a coincidence in the study, we told all the participants to behave in the same life-style, including exercises, eating habbit.

Even though we did not determined LDL sub-class, the finding clearly showed more anti-atherogenic profiles after egg consumption as defined by lower LDL and higher HDL level. This finding is also similar to the blood result among adults conducted in a study by Mayurasakorn K and others[27,28], which concluded that HDL level of adult volunteers increased with the length of egg supplement and further assumed that the change in HDL level was caused by a substance called "Lecithin", an ingredient naturally contained in egg yolk but not in albumen[6,7]. Lecithin is classified phospholipids, similar to lipid, oil, fat or also known as phosphatidylcholine. However, there was no such positive finding regarding blood cholesterol on other cholesterol-containing food[29,30]. Moreover, HDL cholesterol content was elevated during the egg period in both P1 and P2 group. HDL is considered the 'good' cholesterol and elevations in this lipoprotein are generally considered anti-atherogenic. Surprisingly, 12-wk-egg diet increased HDL by 100% in all subjects; therefore, the response shown here indicates a cardioprotective effect in this population as HDL level has been correlated with decreased CHD risk[31,32] because they can be more efficient in taking away excessive amount of cholesterol by returning it to the liver for excretion via reverse cholesterol transport[32] as shown in our study that LDL eventually decreased after egg consumption.

According to the Thai National recommendation on egg consumption, people during childhood and teenage should consume 1-2 eggs a day (in balancing with other nutrient intakes from other foods). However, in these rural areas people still lack of adequate protein intakes, which made us find a high percentage of PM. 3 eggs a week supplement may be sufficient to help attenuate the problem of PM as shown by increased PreA. However, we still keep in mind that this protein intake should be in-balance with total energy and other nutrient intakes. A number of epidemiological studies claim that risk of cardiovascular disease is worsened by food containing high saturated fat[8,33]. Moreover, Hu F indicated that the kind of fat food is more important than its quantity[34]. Hence, the implication is that one needs not avoid every kind of fat food but only certain kinds, such as food with high saturated fat, which would decrease the risk of suffering different diseases. Several studies, including this one, encourage more egg consumption because it is not associated with increased the risk of cardiovascular disease[34]. Besides, a person who consumes less of fat food may likely to eventually receive less of good lipid (HDL) which is a lipid that helps protect blood vessels[26]. Finally, within the nutritional health there is a developing appreciation that health originated, not from avoidance of particular foods, but from an overall pattern of diet and healthy life style[31].

In conclusions nowadays PM can be found among at least 20% of primary school children in Thai rural area according to biochemical measures. Solving PM by continuous egg supplement for 12 weeks, we found that a supplement of three eggs per week increased Alb and PreA to the normal level. It also raised HDL. On the contrary, the experiment reduced TC, LDL, and ratio of TC to HDL despite continuous egg consumption but had no impact on weight for age. Therefore, supplementing 3 eggs per week for 12 weeks can solve childhood PM in an efficient and low-cost way. It also improves blood cholesterol level which probably promotes in healthy children to lower chance of coronary heart disease risk.

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การเสริมไข่ 3 ฟองต่อสัปดาห์ช่วยลดปัญหาขาดโปรตีนให้กับเด็กไทยวัยประถมในเขตชนบท

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วัตถุประสงค์: *เพื่อเปรียบเทียบภาวะโภชนาการด้วยการวัดระดับโปรตีนและไขมันในเลือด และวัดผลการเปลี่ยนแปลงที่เกิดขึ้นในเลือดหลังจากกลุ่มตัวอย่างซึ่งเป็นเด็กนักเรียนอายุระหว่าง 6-15 ปี บริโภคไข่อย่างต่อเนื่อง*
วัสดุและวิธีการ: *ผู้วิจัยใช้การศึกษาแบบทดลองชนิดสุ่มตัวอย่างในอาสาสมัครทั้งหมด 417 คน โดยแบ่งอาสาสมัครออกเป็นสองกลุ่มหลัก ๆ ระหว่างอาสาสมัครที่ได้รับไข่ไก่เสริมจากอาหารปกติจำนวน 3 หรือ 10 ฟอง ต่อสัปดาห์ เป็นเวลาต่อเนื่อง 12 สัปดาห์*
ผลการศึกษา: *อาสาสมัครได้รับการตรวจร่างกายเพื่อวัดข้อมูลทางมนุษยมาตร และวัดการเปลี่ยนแปลงของชีวเคมีในเลือด ผลการวิเคราะห์พบว่า serum albumin และ prealbumin ของอาสาสมัครร้อยละ 29.1 และ 20.8 ตามลำดับ มีภาวะพร่องโปรตีน นอกจากนี้ serum albumin และ prealbumin ยังมีความสัมพันธ์ทางบวกกับ ระดับ Total Cholesterol และ LDL และเมื่อเปรียบเทียบอาสาสมัครทั้งสองกลุ่ม พบว่าไม่มีความแตกต่างของระดับชีวเคมีในเลือดระหว่างกลุ่มที่ได้บริโภคไข่ไก่ 3 ฟอง และ 10 ฟอง อย่างไรก็ตามหลังการรับประทานไข่ไก่เสริมไปกับมื้ออาหารปกติอย่างต่อเนื่อง ทำให้ระดับ Total cholesterol, LDL and ratio of Total cholesterol to HDL level ลดลงอย่างมีนัยสำคัญทางสถิติ ($p < 0.001$) ในทางกลับกัน albumin, prealbumin และ HDL มีค่าเพิ่มมากขึ้นอย่างมีนัยสำคัญเช่นกัน ($p < 0.001$)*
สรุป: *การศึกษานี้แสดงให้เห็นว่าปัจจุบันยังคงพบเด็กวัยเรียนชั้นประถมเขตชนบทที่มีภาวะขาดโปรตีนในเลือดอยู่ การให้รับประทานไข่เสริมอย่างน้อยสัปดาห์ละ 3 ฟอง ในกลุ่มเด็กวัยเรียนสามารถแก้ไขปัญหาการขาดโปรตีนได้อย่างมีประสิทธิภาพ โดยสามารถประเมินได้จากดัชนีชี้วัดของค่าชีวเคมี นอกจากนี้ยังอาจจะส่งผลดีต่อระดับโคเลสเตอรอลในเลือดอีกด้วย*