

The Effect of Egg Consumption on Lipid Profile Among Selected 30-60 Year-Old Filipino Adults

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Egg a rich source of protein, contains vitamins and minerals. However, egg is also high in cholesterol. The objective of this study is to determine the effect of daily egg consumption on blood lipid profile of selected 30-60 year-old free-living Filipino adults. One hundred fifteen normocholesterolemic males and females in a cross-over study were randomly assigned to either an egg-eating regimen or a no egg-eating regimen for three months. After a two-week wash period, one regimen was exchanged for the other for another three months. Fasting venous blood samples were drawn to determine blood lipids before and after each period. The marginal means of serum cholesterol increased after the initial phase of intervention for both treatment groups, with cholesterol values higher for those who started with egg. Participants with normal weight who started with eggless diet exhibited higher serum cholesterol except in the final period, compared with those who started with egg. In the univariate analysis, age showed as the factor that influenced total cholesterol in the two study regimens. In both regimens, total cholesterol and LDL-cholesterol slightly increased, but HDL-cholesterol and triglycerides decreased. The GLM procedure revealed that the blood lipid levels were not significantly affected by treatment (egg or no egg), sequence (egg first or no-egg first) and time (egg eating or no-egg eating) factors. Consumption of up to one egg per day is unlikely to have substantial increase in blood lipid levels.

Key Words: adults, age, cross-over design, HDL, LDL, regular egg consumption, sex, total cholesterol

INTRODUCTION

Egg a rich source of protein, contains vitamins and minerals. It is also readily available and cheap. However, egg is also high in cholesterol. High blood cholesterol levels, especially low-density lipoprotein (LDL) cholesterol, are associated with increased risks of atherosclerosis and its consequences, including heart attacks and stroke. New scientific studies completed since 1996 have confirmed and strengthened the conclusions that dietary cholesterol has only a small effect on blood

cholesterol. Data from the Framingham Heart Study (Millen et al. 1996), the Multiple Risks Factor Intervention Trial (MRFIT) (Tillotson et al. 1997), the Lipid Research Clinics Prevalence Trial (Esrey et al. 1996) the Alpha-Tocopheral, Beta-Carotene Cancer Prevention Study (Pietinen et al. 1997), the Nurses Health Study (Hu et al. 1997) and the Health professionals Follow-up Study (Asherio et al. 1996) all reported that dietary cholesterol intake was not related to either plasma cholesterol or CHD incidence.

Two different research groups have conducted meta-analyses of data from various studies in which volunteers

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had been given different amounts of cholesterol as part of a closely controlled diet (Clarke et al. 1997, Howell et al. 1997). One analysis indicated that a 100 mg change in dietary cholesterol intake would cause blood cholesterol to change by about 2.5 mg/dl (Clarke et al. 1997), on average, and the other indicated that the change would be 2.2 mg/dl (Howell et al. 1997). In contrast, it has been estimated that a 30% decrease in saturated fat intake would reduce blood cholesterol by 9.6 mg/dl (Clarke et al. 1997).

The American Heart Association (2000), prompted by over a quarter century of research showing saturated fat—as opposed to dietary cholesterol—is a major dietary contributor to heart risk, revised the guidelines for egg consumption to “one egg yolk per day” for healthy individuals. AHA also advised the adoption of dietary habits designed to keep blood cholesterol down. Hu et al.’s 1999 prospective cohort study among health professionals and nurses showed that there is no overall significant association between egg consumption of one egg per day and risk of CHD and stroke. However, egg consumption appears to be associated with increased risk of CHD among individuals with diabetes (Hu et al. 1999). The Harvard findings are consistent with the findings of two earlier studies in the U.S. (Hu et al. 1997; Asherio et al. 1996) that specifically examined egg (rather than cholesterol) intake. Neither of these studies found an association between egg intake and the rise of coronary heart disease.

The present study aimed to determine the effect of daily egg consumption on serum cholesterol, triacylglycerol, LDL-cholesterol, and HDL-cholesterol after controlling the effects of other factors such as diet, gender, age and BMI, treatment (egg and no egg), sequence (egg first or no egg first), and time (egg-eating and no egg-eating period).

SUBJECTS AND METHODS

Subjects

Subjects of the study consisted of 115 adults who met the following inclusion criteria: male or female, aged 30-60 years, normal or overweight, normal blood cholesterol, no history of CVD and diabetes, not allergic to egg, has no intake of drugs that will affect cholesterol and blood lipids, willing to participate, and literate.

The exclusion criteria were male or female positive for CVD and diabetes, and those who would be “out of town” for periods longer than one month.

Subjects were asked to maintain their weight, habitual diet and lifestyle two weeks prior to the initiation of the study and during the 12 weeks of the study. Written informed

consent was obtained from eligible subjects to the study after requirements for participation in the study were explained. The Human Ethics Committee of the Philippine Council for Health and Research Development (PCHRD) approved the study.

Experimental Procedure

A cross-over single-blind design was used. One hundred fifteen men and women were paired for gender and age and randomly allocated into two groups. Group 1 was assigned to an egg diet first, while group 2 was assigned to a no egg diet. During the pre-study session, subjects were given detailed explanations of the research protocol and instruction on recording dietary and activity patterns. Personal data including smoking habits, alcohol consumption, and physical activity patterns were taken, and written consent were obtained.

All subjects of the study were in a mixed uncontrolled diet. On Day 1, dietary intake data were obtained using 24-hour recall and food intake patterns, and anthropometric measurements (height and weight) were taken. Baseline data on glucose, HDL, LDL, and cholesterol were also collected. The subjects were advised to ingest their usual diets for two weeks. Data collection on diet, anthropometric measurements and biochemical parameters were repeated. After stabilization period of two weeks, Group I subjects were given one whole egg (grade A, medium) cooked in a variety of methods daily, while the other group (Group II) had no egg in their daily diet for three months. Eggs cooked in a variety of ways were served daily at snacks or lunchtime during the egg-eating phase. After three months, there was a wash period of two weeks followed by a stint in which Group I had no egg in the diet while Group II had egg in the daily diet. This stint lasted for three months again. Subjects were advised to continue their customary activities. A four-day diet record was taken in the middle of each dietary regimen with the assistance of a dietitian. Diet records were validated by a food recall.

Dietary Analysis

Participants completed detailed four-day food records. They were required to maintain the food records for three (3) weekdays and one (1) weekend day. Prior to completing the food records, all participants were provided with verbal and written instructions on maintaining the food records.

Two interviewers collected the data in the appropriate language for the subject being interviewed (English, Filipino). The two interviewers worked closely and used the same questions to probe the completeness of the dietary information. Estimates of the serving portions were done with the use of household measuring cups, spoons and ruler to assist the subjects in the recall of foods eaten.

Every effort was made by the two interviewers to obtain complete records in a similar manner. Reliability of diet compliance was checked by asking the subjects to record their egg consumption both at the start and at the middle of the experiment. During the egg eating period, the subjects were asked to “check off” on a record sheet (containing most of the cholesterol containing foods) the items they consumed each day for three months.

Nutrient calculations were drawn with the use of the 1997 Philippine Food Composition Table. However, foreign values (USDA 1984; McCance 1991; US 1998) were used for the calculation of cholesterol intake.

After completing the dietary analysis of each subjects' actual intake of macronutrients, values were compared with the 2002 Philippine Recommended Energy and Nutrient Intake for the same nutrients for persons of the same gender and age. For cholesterol and dietary fiber, intakes were compared with the recommendations of the American Heart Association. Mean intakes of the various nutrients for men and women were then determined separately.

Anthropometric Measurements

The height and weight of each subject were determined using a *microtoise* and *detecto* weighing scale, respectively.

Biochemical Analysis

After a 12-hour fast venous blood samples were drawn before breakfast, before and after stabilization period, and at the end of each dietary regimen. Serum cholesterol, triglycerides, LDL-Cholesterol, and HDL-Cholesterol were determined using enzymatic kit and calibrator from Boehringer Mannheim (Reflotron). The medical technologist was blinded as to the intervention phase the patients are in (whether the patient is in the “no egg” or in the “with egg” phase of the study).

Statistical Analyses

Paired t-test was used to compare initial characteristics between normal and overweight subjects, nutrient intake and blood lipids during egg eating and no egg eating phase. Initial analysis revealed that there were no differences in terms of weight in the response to blood lipids. Thus, to improve clarity in the presentation of data, subjects with normal weight and those classified as overweight were categorized for statistical analysis. General Linear Model Univariate Analysis using SPSS (Version 9) was used to test dietary factors (energy, fiber, cholesterol) affecting serum cholesterol level and other lipids controlling all other independent variables. Using ANOVA for repeated measures, the General Linear Model for cross-over design

by SPSS was used to determine whether total cholesterol, LDL-cholesterol, HDL-cholesterol and triacylglycerol levels were affected by treatment (with egg or no egg), sequence (egg-eating first or no-egg-eating first) and time (egg-eating or no-egg-eating period). Each individual's response to diet (egg or no-egg) was considered to be repeated measure. Level of significance was determined at less than or equal to 0.05.

RESULTS

Subject characteristics and BMI status

The percentage distribution of subjects by characteristics and BMI status are shown in Table 1. There was a total of 115 subjects of which 58 were males with mean age of 42.6 ± 7.9 years and 57 were females with mean age of 44.6 ± 6.5 . The mean BMI for men were, on average slightly higher than the women (24.6 ± 3.0 versus 24.4 ± 2.71). Among the male subjects, 47.5% had normal BMI and 53.7% were overweight, using WHO cut-off points. With regard to the female subjects, 52.46% and 46.3% had normal and overweight BMI status, respectively. Majority of the subjects with normal BMI (54.1%) belonged to age group 41-50 years old.

Lifestyle characteristics according to BMI status of subjects

More than 60% of both normal and overweight subjects had no regular exercise. There were more subjects with normal BMI who performed light and moderate exercise compared to those who were overweight. However, there were more overweight subjects doing vigorous form of exercise.

With regard to prevalence of smokers, only 27.87 % among the subjects with normal BMI were smokers and 12.96% among overweight subjects. Among the smokers, there were 13.11% among normal subjects and 12.96% among overweight subjects who reported smoking at least less than half a pack or less than 10 sticks of cigarettes per day.

More than 50% from both normal and overweight subjects were alcoholic drinkers of which beer was the most common type of alcoholic beverage being consumed. Others had distilled spirits, wine and mixed drink as their alcoholic beverage.

Mean dietary cholesterol intake during the 3 months egg-eating phase

The result of subjects' food records showed that overweight subjects had a higher mean cholesterol

Table 1. Demographic, lifestyle characteristics and cholesterol intake of normal and overweight subjects.

VARIABLES	BODY MASS INDEX ¹					
	Normal ² (n=61)		Overweight ³ (n=54)		Total ⁴ (n=115)	
Gender	N	%	N	%	N	%
Male	29	(47.5)	29	(53.7)	58	(50.4)
Female	32	(52.4)	25	(46.3)	57	(49.6)
Age in years						
30 – 40	17	(27.9)	22	(40.7)	39	(33.9)
41 – 50	33	54.10	22	(40.7)	55	(47.8)
51 – 60	11	(18.0)	10	(18.5)	21	(18.3)
Regular exercise						
Yes	21	(34.4)	21	(38.9)	42	(36.5)
No	40	(65.6)	33	(61.1)	73	(63.5)
Smoking ⁵						
Prevalence	17	(27.9)	7	(13.0)	24	(20.9)
Drinking alcohol ⁶						
Prevalence	33	54.10	29	53.70	62	53.91
Cholesterol intake ⁷	Mean (mg/d)	247		261		

¹ Body mass index (BMI) is equal to weight in kilogram divided by height in meter squared

² normal subjects with BMI of 18.5-24.9

³ overweight subjects with BMI of >25

⁴ Total subjects with normal and overweight BMI

⁵ those who smoke at least less than half a pack to more than 1 pack a day

⁶ alcoholic drinker are those whose frequency of drinking alcohol ranged from daily to occasionally

⁷ intake during the 3 months egg-eating phase

intake of 262 mg compared with 247 mg intake of subjects with normal BMI.

Univariate Analysis of Independent Variable and Blood Lipid Levels

Results of the general linear model univariate analysis revealed that among the participants first subjected to egg diet, total energy, total fiber, and dietary cholesterol did not affect the serum cholesterol levels before and after egg consumption. Age, however, is a significant factor that influenced total cholesterol in the two study periods. For subjects who started with no egg, the interaction of age-group, and sex showed significant effect when in the egg-eating phase ($p < 0.05$) while the reverse was seen when in the no-egg eating phase (Table 2). Except for age, no interaction between LDL-cholesterol and the other independent factors were seen.

Mean Blood Lipids by Treatment Period and Source of Variation

To control for individual variation, the difference between the initial and final serum lipids in the egg or no-egg diet was used in the cross-over analysis. Total cholesterol and LDL-cholesterol slightly increased both in the egg-eating and no egg-eating phase. There was a decrease in HDL-cholesterol and triacylglycerol levels in both phases. Thus, results of the GLM for cross-over design showed that blood lipids were not significantly affected by the treatment (egg or no egg), sequence (egg

first or no egg first) and time (egg-eating or no egg-eating) factors (Table 3).

DISCUSSION

Studies have shown that an increase in dietary cholesterol raises plasma concentration particularly when the intake of saturated fat is also high (Clarke et al. 1997) but there is a considerable variation in the degree of individual increase. Thus a low cholesterol and low saturated fat has been recommended as one of the effective means of controlling serum cholesterol levels (Keys & Parlin 1966). This led to the American Heart Association (1968) recommendation of limiting egg yolk consumption to no more than 3 per week. Although Filipinos consume less than 3 eggs per week (Villavieja et al. 1997) data from other studies (Geizerova & Yason 1985) have shown that there seem to be an increasing trend of blood cholesterol level which was not parallel to a decreasing intake of egg [DA. 2005].

As many epidemiological studies have provided valuable information (Millen et al. 1996, Geizerova & Yason 1985), it was of interest to investigate this relationship on apparently healthy adult Filipinos. In addition, the study sought to determine the effect of gender, age, body weight and specific dietary factors on blood lipid levels before and after regular egg consumption.

Table 2. Factors affecting serum lipids among subjects given egg first and no egg first in the egg eating and no-egg eating period.

Treatment	Variables		Egg eating		No-egg eating	
	Dependent (Serum)	Independent	F-value	p-value	F-value	p-value
Egg first	cholesterol	Age	5.176	0.01	5.379	0.008
	HDL	Dietary cholesterol	5.933	.019	--	--
	Triglyceride	Dietary cholesterol	4.090	0.049	--	--
		Sex	7.069	.011	--	--
		BMI & age	3.268	.048	--	--
		Dietary fiber	--	--	5.436	0.024
	LDL	Age	4.732	.014	3.995	.026
No egg first	cholesterol	Age and sex	3.409	0.042	--	--
	HDL	Dietary fiber	8.568	0.006	--	--
		Age	3.734	.032	--	--
			Sex	--	--	6.801
	Triglyceride	Sex	4.727	0.035	10.66	0.002
		BMI	--	--	5.523	0.024

HDL- high density lipoprotein
LDL-low density lipoprotein

Table 3. Mean blood lipids by treatment period and source of variation

DEPENDENT VARIABLE/ SOURCE OF VARIATION	EGG-EATING PERIOD			NO EGG-EATING PERIOD		
	Baseline	After	Difference	Baseline	After	Difference
Total Cholesterol ^a (mmol/L)	4.695 ± .72	4.859 ± .91	.164 ± .53	4.876 ± .92	5.033 .88	.157 ± .58
LDL-Cholesterol ^b (mmol/L)	3.45 ± .73	3.654 ± .87	.201 ± .54	3.670 ± .85	3.878 ± .85	.209 ± .54
HDL-Cholesterol ^c (mmol/L)	0.947 ± .27	0.916 ± .26	-0.0314 ± .14	.919 ± .28	.893 ± .26	-0.0255 ± .20
Triglyceride ^d (mmol/L)	1.458 ± .68	1.448 ± .74	-0.092 ± .58	1.400 ± .64	1.349 ± .57	-0.0473 ± .45

^a p-value for the effect of sequence, time & treatment on total cholesterol: 0.40, 0.91, 0.28 respectively

^b p-value for the effect of sequence, time, & treatment on LDL-cholesterol: 0.80, 0.81, 0.47 respectively

^c p-value for the effect of sequence, time, & treatment on HDL-cholesterol: 0.52, 0.91, 0.43 respectively

^d p-value for the effect of sequence, time, & treatment on Triglyceride: 0.69, 0.59, 0.84 respectively

Overall, the fact that the subjects in the study were all egg eaters and had a nutritionally complete diet at the time of recruitment may explain the insignificant change in blood lipids, similar to the results of the study (Kummerow et al. 1977) when placed on egg eating phase as the first intervention. Therefore, since many of the subjects were already eating some eggs as part of their normal diets, they are not expected to show a marked increase in plasma cholesterol level. Thus, the lower the initial levels of dietary cholesterol such as in this study, the proportionally greater the effects would be of either increasing or decreasing serum cholesterol. Subjects during this period have already been primed; thus, the changes in serum and LDL-cholesterol were less while the subjects were on egg diet than when they were on eggless diet.

Conversely, subjects, when placed on no-egg diet, showed in general an increase in total and LDL-cholesterol for both male and female, irrespective of weight and

diet sequence. Results of the study do not show that the sequence of eating eggs have significant effect on serum cholesterol. The cross-over design was set up to test the possibility that factors other than diet influenced the results (Table 3). Controlling all other factors, no significant influence of diet on serum cholesterol within each subject was noted and no interaction of sequence was found. This suggests that individual variability in serum cholesterol concentration in response to dietary cholesterol is wide regardless of diet, which is in agreement with other studies. (McGill 1979).

The diet followed the recommended distribution of macronutrient and contained dietary fiber (no table presented) similar to the 11.0 grams reported in the food consumption survey in Metro Manila (Pangan et al. 1999). Results of this study indicate that addition and deletion of the egg in the diet did not affect changes in cholesterol intake in free-living subjects who consumed a wide variety of foods commonly included in the average Filipino diet.

It is possible that the subjects may have substituted foods that raised cholesterol, thus nullifying any cholesterol lowering effect of not eating eggs.

The increment in plasma cholesterol was only 0.164 mmol/L during egg eating phase and 0.157 mmol/L during no-egg eating phase (Table 3). As expected, the subjects reported significant increase in the relative amount of calories, protein, fat and cholesterol during the egg eating phase, reflecting the difference in nutrient composition between the egg and no egg eating phase. This can be primarily attributed to the egg consumed because one egg provides 86 kcal, 8 protein and 6 g fat. These findings suggest that significant changes in the diet during the egg-eating phase were increased intake of energy from protein and fat, which was mostly the result of the addition of egg in the diet. Dietary fiber, a factor well known to influence plasma cholesterol concentration, did not differ between phases. Likewise, this suggests the good compliance of the subjects to the research protocol. The subjects were aware of the importance of reliable information. In addition, for personal interest, they would like to know the effect of their diet and lifestyle on serum lipids, thus they kept good food records. This may account for the relative stability of the food record.

In another controlled study in which only total cholesterol was measured, egg ingestion had a hypercholesterolemic effect in free-living subjects (Roberts et al. 1981). The possible presence of a response to changes in cholesterol relative to the initial level was suggested in this study (no figures presented). Among subjects 41 years and older with baseline serum cholesterol level of <5.0 mmol/L, there was an increasing trend with the addition of egg. For those with baseline serum cholesterol level of >5.0 mmol/L, there was no change in the with egg diet among female subjects and overweight males. With egg as the second intervention, overweight males and normal weight females showed a decrease in serum cholesterol, while overweight females exhibited an increase. This direction of changes related to the initial level of serum cholesterol was similar to earlier studies (Lacombe et al. 1986).

Differences in individual response to dietary cholesterol may be the result of several mechanisms, such as differences in the absorption or biosynthesis, formation of LDL and its receptor mediated clearance, and removal and excretion rates (Bevnen et al. 1987). The actual increases in serum total cholesterol and LDL-C concentrations are consistent in the meta-analysis of Clarke et al. (Clarke et al. 1997), Howell et al. (Howell et al. 1997), and Weggemans et al. (Weggemans et al. 2001). In this study, no significant increases in serum LDL-C or HDL-C were seen, possibly because the subjects consumed only one egg/day.

One explanation for this failure to connect elevated total cholesterol, experienced as a result of additional egg intake, is that eggs are a good source of essential amino acids, folate and other B-vitamins, unsaturated fatty acids, and α -tocopherol, which may offset any harmful effects of the cholesterol content. (Hu et al. 2001).

Genetic predisposition may explain variation in response to dietary cholesterol (Friedlander et al. 2000). The existence of a hypo- or hyper- response to dietary cholesterol has been clearly established in men and women (Katan et al. 1986) and is believed to be determined by genetic factors (Clifton & Abby 1997). Mutations of several gene loci, such as the APOE and APOAIV (Weggemans et al. 2001), have been identified that may explain why some individuals are insensitive to dietary cholesterol, while others experience significant plasma compartment changes in response to intake. The ability to maintain cholesterol homeostasis among hypo-responders may be the result of decreasing synthesis (Mistry et al. 1981), absorption (Stein et al. 2002) and increasing urinary excretions (Nestel & Poyster 1976; Quintao & Sperotto 1987) after increased intake of dietary cholesterol.

Other studies have shown conflicting results. The difference of other studies with the present study may be due to shorter length of experimental period (4 weeks vs 12 weeks), statistical methods used in data analysis, and variability in subject characteristics such as age, physical activity, relative body weight, and initial serum cholesterol aside from differences in dietary control. One may surmise that because cholesterol intakes were not exceedingly high, and energy intake was about the same in both groups, the egg diet's influence on LDL-cholesterol levels can be negated.

Epidemiological studies have shown an association between high concentration of HDL cholesterol and high level of physical activity and alcohol consumption. Our subjects could be considered to be light or moderately active. Only 4 out of 10 were alcohol drinkers. Thus, the exercise and alcohol relationship with HDL was not apparent.

The same determinants, namely, BMI, age group, BMI-age group showed to interact with triacylglycerol. Serum triacylglycerols are affected by dietary fat. The fat intake of subjects were shown not significant in terms of inter- and intra-variability. However, we cannot exclude the possibility that there were changes during the period of egg consumption which may influence triacylglycerol levels. On the other hand, addition of one egg to total daily food intake would not be expected to cause appreciable change in plasma triacylglycerol. Also, calorie intake was almost the same in both groups. One may consider that the increase in saturated fat intake, the most common source of which is coconut oil, rather than egg consumption, was

the reason for increased triacylglycerol levels. Since this study did not assess chylomicrons, the main lipoprotein that are carriers exogenous triglycerides, no definite relationship can be ascertained.

CONCLUSION

In conclusion, the results of the study suggest that consumption of up to one egg per day is unlikely to have substantial increase in blood lipid levels.

Replication of this study among individuals with other disease conditions such as diabetes mellitus and hypertension is recommended. It is likewise recommended that a more comprehensive approach to dietary guidelines be carried out to reduce the overemphasis on the component of the guidelines over another; allow stronger message on other aspects of lifestyle such as weight maintenance and regular exercise; and support the necessity of the dietary guidelines and lifestyle approach to disease risk reduction as a lifelong endeavor.

Results of the study add to the current understanding of the relationship of egg intake and blood lipid levels and have moved beyond the simplistic view that egg cholesterol equals blood cholesterol. It is important to remember that a well-balanced diet does not exclude any one food or food group but includes foods from all of the food groups in moderation.

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