Egg consumption, serum cholesterol, and cause-specific and all-cause mortality: the National Integrated Project for Prospective Observation of Non-communicable Disease and Its Trends in the Aged, 1980 (NIPPON DATA80)[1–3]

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ABSTRACT

Background: Because egg yolk has a high cholesterol concentration, limited egg consumption is often suggested to help prevent ischemic heart disease (IHD).

Objective: We epidemiologically examined the validity of this recommendation.

Design: We analyzed the relations of egg consumption to serum cholesterol and cause-specific and all-cause mortality by using the NIPPON DATA80 (National Integrated Project for Prospective Observation of Non-communicable Disease And its Trends in the Aged, 1980) database. At the baseline examination in 1980, a nutritional survey was performed by using the food-frequency method in Japanese subjects aged ≥30 y. We followed 5186 women and 4077 men for 14 y.

Results: The subjects were categorized into 5 egg consumption groups on the basis of their responses to a questionnaire (≥2/d, 1/d, 1/2 d, 1–2/wk, and seldom). There were 69, 1396, 1667, 1742, and 315 women in each of the 5 groups, respectively. Age-adjusted total cholesterol (5.21, 5.04, 4.95, 4.91, and 4.92 mmol/L in the 5 egg consumption categories, respectively) was related to egg consumption ($P < 0.0001$, analysis of covariance). In women, unadjusted IHD mortality and all-cause mortality differed significantly between the groups [IHD mortality: 1.1, 0.5, 0.4, 0.5, and 2.0 per 1000 person-years, respectively ($P = 0.008$, chi-square test); all-cause mortality: 14.8, 8.0, 7.5, 7.5, and 14.5 per 1000 person-years, respectively ($P < 0.0001$, chi-square test)]. In men, egg consumption was not related to age-adjusted total cholesterol. Cox analysis found that, in women, all-cause mortality in the 1–2-eggs/wk group was significantly lower than that in the 1-egg/d group, whereas no such relations were noted in men.

Conclusion: Limiting egg consumption may have some health benefits, at least in women in geographic areas where egg consumption makes a relatively large contribution to total dietary cholesterol intake. *Am J Clin Nutr* 2004;80:58–63.

KEY WORDS Eggs; total cholesterol; ischemic heart disease; National Integrated Project for Prospective Observation of Non-communicable Disease And its Trends in the Aged, 1980; NIPPON DATA80; Keys equation

INTRODUCTION

Because egg yolk has a relatively high cholesterol concentration, limited egg consumption is often recommended to reduce serum cholesterol concentrations and to help prevent ischemic heart disease (IHD) (1). Although several metabolic ward studies showed that dietary cholesterol is a major determinant of serum cholesterol concentrations (2, 3), other studies failed to show changes in serum total cholesterol concentration when eggs were added to diets that already contained moderate amounts of cholesterol (4–7). There have been few epidemiologic studies in free-living populations that explored the relation of egg consumption to serum cholesterol and IHD (8–12). A Framingham Study of 912 subjects concluded that egg consumption was not related to serum cholesterol or IHD (11). A study by Hu et al (12) of 117 933 subjects in the United States also showed no relation between consumption of ≤1 egg/d and the risk of IHD or stroke. However, in geographic areas where egg consumption makes a greater contribution to total dietary cholesterol intake than in the United States, the results may be different (13–15). Accordingly, we analyzed the relations of egg consumption to serum cholesterol concentrations and cause-specific and all-cause mortality by using the NIPPON DATA80 (National Integrated Project for Prospective Observation of Non-communicable Disease And its Trends in the Aged, 1980) database, which includes >10 000 subjects in Japan who were followed for 14 y (16–18).

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SUBJECTS AND METHODS

Subjects

The subjects in this cohort were participants in the 1980 National Survey on Circulatory Disorders (19). A total of 10 546 community-based subjects aged ≥30 y in 300 randomly selected health districts throughout Japan participated in the survey, which consisted of a medical history, physical examinations, blood tests, and a self-administered questionnaire on lifestyle, which included an essential nutritional survey performed by the food-frequency method. The cohort was followed until 1994 (NIPPON DATA80) (16–18). The overall population aged ≥30 y in the 300 participating health districts was 13 771. Therefore, the participation rate of the survey was 76.6% before exclusion for the reasons mentioned below. To clarify the cause of death, we used the National Vital Statistics. In accordance with Japan's Family Registration Law, all death certificates issued by physicians were forwarded to the Ministry of Health and Welfare via the public health centers in the district of residency. The underlying causes of death were coded according to the 9th revision of the *International Classification of Diseases* for the National Vital Statistics. We confirmed death in each health district by computer matching of data from the National Vital Statistics, with district, sex, and dates of birth and death as key codes. Of 10 546 subjects, a total of 1283 were excluded for the following reasons: past history of coronary artery disease or stroke ($n = 166$); some missing information on the baseline survey ($n = 247$); and lost to follow-up ($n = 870$). We analyzed the remaining 9263 subjects (5186 men and 4077 men). There was no significant difference in sex-specific mean total cholesterol concentration between the subjects who were lost to follow-up and those who were censored (194 compared with 192 mg/dL, respectively, in the women; 191 compared with 188 mg/dL, respectively, in the men). Therefore, the potential bias regarding the 870 subjects lost to follow-up was thought to be negligible. Permission to use the National Vital Statistics was obtained from the Management and Coordination Agency, Government of Japan. Ethical approval for this study was obtained from the Institutional Review Board of Shiga University of Medical Science (No. 12-18, 2000).

Biochemical and baseline examinations

The baseline surveys were conducted by public health centers. Baseline blood pressures were measured by trained observers using a standard mercury sphygmomanometer on the subjects' right arm while the subjects were seated and after they had rested for ≥5 min. Hypertension was defined as systolic blood pressure ≥ 140 mm Hg, diastolic blood pressure ≥ 90 mm Hg, use of antihypertensive agents, or any combination of these. Height in stocking feet and weight in light clothing were measured. Body mass index was calculated as weight (in kg) divided by the square of height (in m).

A lifestyle survey was carried out by using a self-administered questionnaire, which included questions about the average consumption of 31 food items. Egg consumption was queried on the basis of 5 categories: ≥2/d, ≈1/d, ≈1/2 d, ≈1–2/wk, and seldom. Public health nurses rechecked information with the subjects regarding consumption of eggs and other foods, smoking status, drinking habits, and present and past medical histories.

Nonfasting blood samples were drawn, centrifuged for 15 min at 1500 × *g* and room temperature within 60 min of collection, and then stored at −70 °C until analyses. Total cholesterol was analyzed in a sequential autoanalyzer (SMA12; Technicon, Tarrytown, NY) by using the Lieberman-Burchard direct method for total cholesterol at a single laboratory (Osaka Medical Center for Health Science and Promotion, Osaka, Japan). This laboratory is a member of the Cholesterol Reference Method Laboratory Network (20), and the precision and accuracy of measurement of serum cholesterol were certified in the Lipid Standardization Program administered by the Centers for Disease Control and Prevention, Atlanta. Serum glucose concentrations were measured by using the cupric-neocuproline method (21). Diabetes was defined as a serum glucose concentration ≥ 200 mg/dL, a past history of diabetes, or both. Serum creatinine was analyzed in a sequential autoanalyzer (SMA12/60; Technicon) by using Jaffe's method.

Statistical analysis

SAS version 8.02 for WINDOWS (SAS Institute Inc, Cary, NC) was used throughout the study. Women and men were analyzed separately. The chi-square test was used to compare dichotomous variables. To compare means between the 5 groups stratified by egg consumption, a one-way analysis of variance was used. To assess whether egg consumption affected total cholesterol concentrations, we performed an analysis of covariance by adjusting for age. Age-adjusted total cholesterol was determined.

The age-adjusted and multivariate-adjusted relative risks for all-cause or cause-specific mortality were calculated by using a Cox proportional hazard model. For multivariate analyses, age, serum creatinine, total cholesterol, blood glucose, body mass index, systolic and diastolic blood pressures, use of blood pressure–lowering drugs, cigarette smoking (never smoker; ex-smoker; current smoker, ≤20 cigarettes/d; and current smoker, >20 cigarettes/d), and alcohol intake (never drinker, ex-drinker, occasional drinker, and daily drinker) were entered as covariates. To rule out the possibility that subjects with a severe but subclinical disease might have affected the outcome, we performed the above Cox analyses after excluding subjects who died within the initial 5 y of follow-up. Tests of linear trends across groups with decreasing egg consumption were conducted by treating the median or representative values of egg consumption in the 5 categories (consumption per week: 21, 7, 3.5, 1.5, and 0.5 eggs, respectively) as continuous variables.

All P values were two-tailed, and $P < 0.05$ was considered significant. Data are presented as means ± SDs unless stated otherwise.

RESULTS

Baseline characteristics

Baseline characteristics in each egg consumption category for the women and the men are shown in **Table 1**. In both the women and the men, relatively few subjects (1.3–6.1%) were in the ≥2-eggs/d or seldom (ie, ≤1 egg/wk) group. Except for these 2 extreme categories, there were >1200 subjects in each category. In the women, those in the 2 extreme categories had significantly higher mean ages than did those in the other categories and were significantly more likely to have hypertension. Although similar tendencies were noted in the men, they were not as striking as those in the women.

Egg consumption and total cholesterol

Total cholesterol, age-adjusted total cholesterol, blood glucose, and serum creatinine concentrations and systolic and diastolic blood

TABLE 1
Baseline characteristics stratified by egg consumption among 5186 women and 4077 men with data in the NIPPON DATA80 database[1]

	Egg consumption					
Sex and characteristic	≥2/d	1/d	1/2 d	1–2/wk	Seldom	P^2
Women						
n	69	1393	1667	1742	315	
Age (y)	55.6 ± 12.9[3]	50.4 ± 12.7	49.3 ± 13.0	51.2 ± 13.3	55.4 ± 14.7	<0.0001
BMI (kg/m^2)	23.4 ± 3.8	22.7 ± 3.3	22.7 ± 3.2	23.0 ± 3.4	23.2 ± 3.7	0.0037
Hypertension (%)	49.3	38.3	37.0	43.7	51.8	<0.0001
Diabetes (%)	7.3	4.2	3.7	4.1	4.4	0.65
Daily drinker (%)	5.8	2.73	2.64	2.93	3.17	0.31
Current smoker (%)	11.6	7.5	7.8	10.6	10.5	0.0005
Men						
n	149	1364	1216	1204	144	
Age (y)	51.3 ± 12.6	51.0 ± 12.9	49.0 ± 12.7	50.6 ± 13.5	51.9 ± 13.9	0.001
BMI (kg/m^2)	22.2 ± 2.7	22.5 ± 2.9	22.5 ± 2.8	22.6 ± 2.9	22.4 ± 2.9	0.51
Hypertension (%)	49.3	38.3	37.0	43.7	51.8	<0.0001
Diabetes (%)	5.4	7.5	5.9	7.6	8.3	0.35
Daily drinker (%)	50.3	51.0	47.3	47.2	34.7	0.0001
Current smoker (%)	63.1	64.5	64.4	61.1	63.4	0.46

[1] NIPPON DATA80, National Integrated Project for Prospective Observation of Non-communicable Disease And its Trends in the Aged, 1980.
[2] Chi-square test for dichotomous variables and ANOVA for continuous variables.
[3] $\bar{x}$ ± SD (all such values).

pressures are shown in **Table 2**. In the women, a dose-response relation was noted between egg consumption and both total cholesterol and age-adjusted total cholesterol. No such relations were noted in the men, and total cholesterol and age-adjusted total cholesterol concentrations were almost the same in all categories.

Egg consumption and outcome: unadjusted outcome and multivariate Cox analyses

Unadjusted numbers of deaths due to all causes, stroke, IHD, and cancer for each category of egg consumption in the women and the men are shown in **Table 3**. Death rates are shown per 1000 person-years. In the women, all-cause, IHD, and cancer deaths differed significantly between the groups. In the men, no significant differences in outcome were noted. Because several baseline characteristics were different between the egg consumption categories, we performed multivariate analyses.

The results of age-adjusted and multivariate Cox analyses of associations between egg consumption and outcomes are shown in **Tables 4** and **5**. In the women, the multivariate-adjusted relative risk of all-cause death for those in the 1–2-eggs/wk category

TABLE 2
Baseline characteristics stratified by egg consumption among 5186 women and 4077 men with data in the NIPPON DATA80 database[1]

	Egg consumption					
Sex and characteristic	≥2/d	1/d	1/2 d	1–2/wk	Seldom	P^2
Women						
n	69	1393	1667	1742	315	
TCH (mmol/L)	5.23 ± 0.99[3]	4.97 ± 0.87	4.86 ± 0.84	4.85 ± 0.88	4.94 ± 1.01	<0.0001
aTCH (mmol/L)[4]	5.11 ± 0.10	4.98 ± 0.02	4.89 ± 0.02	4.83 ± 0.02	4.84 ± 0.05	<0.0001
Glucose (mmol/L)	7.39 ± 1.78	6.67 ± 1.83	7.11 ± 1.83	7.22 ± 1.94	7.28 ± 1.94	0.19
Creatinine (μmol/L)	78.7 ± 12.4	74.3 ± 11.5	74.3 ± 11.5	75.1 ± 21.2	76.9 ± 15.0	0.012
SBP (mm Hg)	139 ± 21	133 ± 21	132 ± 21	135 ± 22	140 ± 24	<0.0001
DBP (mm Hg)	83 ± 12	79 ± 12	79 ± 12	80 ± 12	81 ± 12	<0.0001
Men						
n	149	1364	1216	1204	144	
TCH (mmol/L)	4.73 ± 0.84	4.77 ± 0.83	4.78 ± 0.83	4.77 ± 0.86	4.77 ± 0.94	0.98
aTCH (mmol/L)[4]	4.76 ± 0.07	4.78 ± 0.02	4.78 ± 0.02	4.76 ± 0.02	4.79 ± 0.07	0.98
Glucose (mmol/L)	7.28 ± 1.89	7.28 ± 1.89	7.22 ± 2.11	7.33 ± 2.44	7.11 ± 1.72	0.0097
Creatinine (μmol/L)	90.2 ± 14.1	93.7 ± 26.5	93.7 ± 23.0	93.7 ± 15.0	95.5 ± 16.8	0.20
SBP (mm Hg)	139 ± 21	139 ± 20	137 ± 20	139 ± 22	142 ± 22	0.54
DBP (mm Hg)	84 ± 12	84 ± 12	83 ± 12	84 ± 12	84 ± 13	0.38

[1] NIPPON DATA80, National Integrated Project for Prospective Observation of Non-communicable Disease And its Trends in the Aged, 1980; TCH, total cholesterol; aTCH, age-adjusted total cholesterol; SBP, systolic blood pressure; DBP, diastolic blood pressure.
[2] Chi-square test for dichotomous variables and ANOVA for continuous variables except aTCH, for which ANCOVA was used.
[3] $\bar{x}$ ± SD (all such values unless indicated otherwise).
[4] $\bar{x}$ ± SE.

TABLE 3
Unadjusted outcomes by egg consumption category during 14 y of follow-up of 5186 women and 4077 men with data in the NIPPON DATA80 database[1]

Sex and characteristic	Egg consumption ≥2/d	1/d	1/2 d	1–2/wk	Seldom	*P* (chi-square test)
Women						
n	69	1393	1667	1742	315	
Person-years	877	18 591	22 276	23 270	4058	
All-cause death [*n* (/TPY)]	13 (14.8)	149 (8.0)	166 (7.5)	175 (7.5)	59 (14.5)	<0.0001
Stroke death [*n* (/TPY)]	2 (2.3)	28 (1.5)	39 (1.8)	30 (1.3)	8 (2.0)	0.69
IHD death [*n* (/TPY)]	1 (1.1)	10 (0.5)	10 (0.4)	12 (0.5)	8 (2.0)	0.008
Cancer death [*n* (/TPY)]	5 (5.7)	40 (2.2)	43 (1.9)	45 (1.9)	15 (3.7)	0.043
Men						
n	149	1364	1216	1204	144	
Person-years	1934	17 652	16 008	15 610	1875	
All-cause death [*n* (/TPY)]	23 (11.9)	227 (12.9)	164 (10.2)	201 (12.9)	25 (13.3)	0.16
Stroke death [*n* (/TPY)]	1 (0.5)	37 (2.1)	32 (1.4)	37 (2.4)	5 (2.7)	0.52
IHD death [*n* (/TPY)]	0 (0)	9 (0.5)	11 (0.7)	17 (1.1)	2 (1.1)	0.23
Cancer death [*n* (/TPY)]	11 (5.7)	65 (3.7)	60 (3.7)	67 (4.3)	5 (2.7)	0.51

[1] NIPPON DATA80, National Integrated Project for Prospective Observation of Non-communicable Disease And its Trends in the Aged, 1980; TPY, 1000 person-years; IHD, ischemic heart disease.

was significantly lower than that for those in the 1-egg/d category. The relative risks of deaths from stroke, IHD, and cancer did not differ significantly between the egg consumption categories (Table 4). In the men, no significant differences in outcome between the egg consumption categories were noted (Table 5). The results of the multivariate Cox analyses after exclusion of the subjects who died within the initial 5 y of follow-up were not significantly different from those in Tables 4 and 5 (data not shown).

DISCUSSION

Egg yolk contains relatively high amounts of cholesterol, and this has led to the recommendation to limit egg intake to reduce serum cholesterol concentrations and hopefully prevent IHD. In fact, the Third Report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III) recommended that at most 2 egg yolks should be consumed per week (1). Although several metabolic ward studies showed that dietary cholesterol is a major determinant of serum cholesterol concentrations (2, 3), other studies failed to detect changes in serum total cholesterol concentration when egg was added to diets that already contained moderate amounts of cholesterol (4–7). Furthermore, epidemiologic studies in the United States did not detect any associations between egg consumption and serum cholesterol concentrations or cardiovascular events (11, 12). However, in geographic areas where egg consumption makes a greater contribution to total dietary cholesterol intake than in the United States, the results may be different (13–15). The studies by Dawber et al (11) and Hu et al (12) reported that egg consumption in the United States accounts for 26–32% of total dietary cholesterol intake. In contrast, a study in

TABLE 4
Relative risks and 95% CIs of outcomes by egg consumption category in Cox analyses of women with data in the NIPPON DATA80 database[1]

	Egg consumption ≥2/d (*n* = 69)	1/d (*n* = 1393)	1/2 d (*n* = 1667)	1–2/wk (*n* = 1742)	Seldom (*n* = 315)	*P* for trend
Age adjusted						
All-cause death	1.57 (0.89, 2.76)	1	1.0 (0.81, 1.23)	0.82 (0.66, 1.01)	0.99 (0.74, 1.33)	0.02
P	0.12		0.97	0.06	0.93	
Stroke death	1.51 (0.36, 6.33)	1	1.42 (0.88, 2.30)	0.85 (0.51, 1.41)	0.76 (0.35, 1.66)	0.18
IHD death	1.68 (0.22, 12.9)	1	0.82 (0.36, 1.88)	0.76 (0.34, 1.66)	1.70 (0.70, 4.14)	0.90
Cancer death	2.19 (0.87, 5.53)	1	0.97 (0.64, 1.48)	0.84 (0.55, 1.27)	1.18 (0.65, 2.12)	0.10
Multivariate adjusted[2]						
All-cause death	1.48 (0.84, 2.61)	1	1.0 (0.81, 1.24)	0.78 (0.63, 0.96)	0.97 (0.72, 1.32)	0.02
P	0.17		0.98	0.02	0.86	
Stroke death	1.22 (0.29, 5.17)	1	1.46 (0.89, 2.4)	0.79 (0.47, 1.33)	0.78 (0.35, 1.73)	0.23
IHD death	1.27 (0.16, 9.80)	1	0.78 (0.35, 1.82)	0.64 (0.28, 1.44)	1.42 (0.56, 3.62)	0.71
Cancer death	2.36 (0.93, 5.98)	1	0.93 (0.61, 1.41)	0.76 (0.52, 1.20)	1.18 (0.65, 2.12)	0.06

[1] NIPPON DATA80, National Integrated Project for Prospective Observation of Non-communicable Disease And its Trends in the Aged, 1980; IHD, ischemic heart disease.

[2] Age, serum creatinine, total cholesterol, blood glucose, BMI, systolic and diastolic blood pressures, use of blood pressure–lowering drugs, cigarette smoking, and alcohol intake were entered as covariates for multivariate analyses.

TABLE 5
Relative risks and 95% CIs of outcomes by egg consumption category in Cox analyses of men with data in the NIPPON DATA80 database[1]

	Egg consumption					*P* for trend
	≥2/d (*n* = 149)	1/d (*n* = 1364)	1/2 d (*n* = 1216)	1–2/wk (*n* = 1204)	Seldom (*n* = 144)	
Age adjusted						
All-cause death	0.87 (0.57, 1.34)	1	0.88 (0.73, 1.08)	0.92 (0.77, 1.11)	0.80 (0.53, 1.21)	0.84
Stroke death	0.28 (0.03, 1.66)	1	1.04 (0.66, 1.64)	0.98 (0.63, 1.52)	0.91 (0.36, 2.40)	0.15
IHD death	—	1	1.34 (0.58, 3.10)	1.80 (0.85, 3.85)	1.51 (0.33, 6.81)	0.03
P	—		0.49	0.13	0.59	
Cancer death	1.53 (0.80, 2.88)	1	1.17 (0.83, 1.65)	1.15 (0.82, 1.61)	0.62 (0.25, 1.53)	0.51
Multivariate adjusted[2]						
All-cause death	0.89 (0.57, 1.38)	1	0.89 (0.72, 1.08)	0.94 (0.78, 1.13)	0.73 (0.48, 1.12)	0.75
Stroke death	0.25 (0.03, 1.81)	1	1.10 (0.68, 1.76)	1.09 (0.69, 1.72)	0.93 (0.36, 2.40)	0.11
IHD death	—	1	1.49 (0.63, 3.48)	1.71 (0.78, 3.76)	1.18 (0.26, 5.42)	0.08
Cancer death	1.42 (0.73, 2.76)	1	1.12 (0.79, 1.58)	1.11 (0.79, 1.57)	0.60 (0.24, 1.49)	0.57

[1] NIPPON DATA80, National Integrated Project for Prospective Observation of Non-communicable Disease And its Trends in the Aged, 1980; IHD, ischemic heart disease.

[2] Age, serum creatinine, total cholesterol, blood glucose, BMI, systolic and diastolic blood pressures, use of blood pressure–lowering drugs, cigarette smoking, and alcohol intake were entered as covariates for multivariate analyses.

Japan that used the food record method in rural and urban populations and that was conducted during a similar time as the present study reported that egg consumption in Japan accounts for ≈48% of total dietary cholesterol intake (15).

The present study found dose-response relations of egg consumption to total cholesterol and age-adjusted total cholesterol concentrations in women but not in men. On the basis of metabolic ward studies, Keys proposed an equation to predict serum cholesterol concentrations based on dietary intakes of cholesterol and saturated and polyunsaturated fatty acids (3). We surveyed essential nutritional components by the food-frequency method and therefore have no data on total calorie intake or total dietary intakes of cholesterol or saturated and polyunsaturated fatty acids. On the basis of previous studies that used the 24-h food-recall method or food record method in rural and urban populations in Japan and that had a study period similar to that of the present study (13–15), the representative daily total energy intake of female subjects can be estimated to be 1970 kcal, with 350 mg total dietary cholesterol. If egg consumption is reduced from 1/d (215 mg cholesterol/d) to 1.5/wk (46 mg cholesterol/d), total energy intake should decrease by 63 kcal (80 kcal/egg), polyunsaturated fatty acid intake should decrease from 7 to 6.4 g, and saturated fatty acid intake should decrease from 7.7 to 6.4 g. Under these conditions, the Keys equation predicts that total cholesterol concentrations should decrease by 6.5 mg/dL (0.17 mmol/L). The actual difference observed between age-adjusted total cholesterol concentrations in the 1-egg/d category and those in the 1–2-eggs/wk category was 5.8 mg/dL (0.15 mmol/L). In men, a similar calculation yields a predicted reduction in total cholesterol concentrations of 5.4 mg/dL (0.14 mmol/L) (assumed total energy and dietary cholesterol intakes of 2400 kcal and 400 mg, respectively), but the actual observed difference in age-adjusted total cholesterol was only 0.8 mg/dL (0.02 mmol/L). Thus, differences in age-adjusted total cholesterol concentration between categories conformed to the Keys equation in the women but not in the men. Why is the relation between egg consumption and total cholesterol different between women and men? Ueshima et al (13) observed a high-order relation in several groups of Japanese men, with large differences between groups in both dietary intake and total cholesterol. However, only a weak, although significant, correlation was noted between the dietary lipid score and serum total cholesterol for subjects within a culturally homogeneous population in which intraindividual variability is large compared with interindividual variability. In the study by Dawber et al (11), the distribution of daily dietary cholesterol intake was examined by tertile of egg consumption, and significant differences in total daily cholesterol intake between subjects within each egg consumption tertile were found in both women and men. However, markedly greater variability was seen in men. Therefore, men appear to consume dietary cholesterol from a greater variety of sources (ie, sources other than eggs) than do women.

A population with a low mean cholesterol concentration, such as the population in Japan, has a much lower IHD mortality rate than do Western populations (22). However, cholesterol has been shown to have predictive value for IHD mortality in Japan (18). Women in the 1–2-eggs/wk group had the lowest age-adjusted total cholesterol concentrations, and their relative risk of all-cause death was significantly lower than that of the women in the 1-egg/d group. The women in the 1–2-eggs/wk group also tended to have lower mortality due to stroke, IHD, and cancer than did the 1-egg/d group. Because of the relatively high participation rate in the present study (76.6%), generalization of the present results in Japan may be warranted.

Limitations of the study

We surveyed essential nutritional components by using the food-frequency method. Therefore, we have no data on total calorie intake or total dietary intakes of cholesterol or saturated and polyunsaturated fatty acids. To obtain this information, detailed food records or 24-h dietary recalls are needed. However, because of the large amount of effort required to collect and process multiple days of food records or recalls, these methods are impractical and seldom used as the primary method for estimating usual intakes in large-scale epidemiologic studies.

Another limitation is that we used mortality data as endpoints, which may have led to misclassification of the cause of death. However, the death-certificate diagnosis of stroke and cancer in Japan has been reported to be quite accurate (23, 24). However, it has also been reported that most cases of cardiac sudden death

tended to be described on Japanese death certificates as "coronary heart disease," "heart failure," or "unknown cause" (25, 26). Furthermore, mortality statistics for IHD may have been underestimated with the use of ICD9 by the end of 1994 because deaths coded as "heart failure" may have hidden some coronary events (25–28). Nevertheless, our results mainly focused on all-cause mortality, and thus the data were thought to be correct.

Finally, the consumption of only 1–2 eggs/wk by women may simply reflect a more health-conscious attitude that eventually results in a better outcome. We did not measure variables related to health consciousness, such as exercise or participation in sports; however, the percentage of women who smoked in the 1–2-eggs/wk category (10.6%) was not lower than that in the 1-egg/d category (7.5%) (Table 1). This suggests that the women in the 1–2-eggs/wk category did not have more health-conscious attitudes.

Conclusions

Dose-response relations of egg consumption to total cholesterol and age-adjusted total cholesterol concentrations were noted in the women, and all-cause mortality was affected by egg consumption. Among the women, tendencies for lower mortality due to stroke, IHD, and cancer in the 1–2-eggs/wk group than in the 1-egg/d group may have resulted in significantly fewer all-cause deaths. However, no such relations were noted in the men. Sources other than eggs may contribute to total cholesterol intake in men. These results suggest that limiting egg consumption may have some health benefits, at least in women in geographic areas where egg consumption makes a relatively large contribution to total dietary cholesterol intake.

For a list of the investigators and members of the NIPPON DATA80 Research Group, please see the appendix of reference 18.

YN participated in designing and conducting the study, analyzing and interpreting the data, and writing and preparing the manuscript. TO and AO participated in conducting the study and analyzing and interpreting the data. ST and TK participated in managing and interpreting the data. TH and YK participated in managing the data and conducting the study. HU was the principal investigator and participated in designing and conducting the study and analyzing and interpreting the data. None of the authors had any conflicts of interest.

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