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Egg consumption and the risk of type 2 diabetes mellitus: a case–control study

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Abstract

Objective: Type 2 diabetes mellitus appears to involve an interaction between susceptible genetic backgrounds and environmental factors including highly calorific diets. As it is important to identify modifiable risk factors that may help reduce the risk of type 2 diabetes mellitus, the aim of the present study was to determine the association between egg consumption and the risk of type 2 diabetes mellitus.
Design: A specifically designed questionnaire was used to collect information on possible risk factors of type 2 diabetes mellitus. The odds ratios and 95 % confidence intervals for type 2 diabetes mellitus were calculated by conditional logistic regression.
Setting: A case–control study in a Lithuanian out-patient clinic was performed in 2001.
Subjects: A total of 234 cases with a newly confirmed diagnosis of type 2 diabetes mellitus and 468 controls free of the disease.
Results: Variables such as BMI, family history of diabetes, cigarette smoking, education, morning exercise and plasma TAG level were retained in multivariate logistic regression models as confounders because their inclusion changed the value of the odds ratio by more than 10 % in any exposure category. After adjustment for possible confounders more than twofold increased risk of type 2 diabetes mellitus was determined for individuals consuming 3–4·9 eggs/week (OR = 2·60; 95 % CI 1·34, 5·08) and threefold increased risk of the disease was determined for individuals consuming ≥5 eggs/week (OR = 3·02; 95 % CI 1·14, 7·98) compared with those eating <1 egg/week.
Conclusions: Our data support a possible relationship of egg consumption and increased risk of type 2 diabetes mellitus.

Keywords
Egg consumption
Type 2 diabetes mellitus
Case–control study

Type 2 diabetes mellitus is increasing in prevalence globally[1] and is becoming a world pandemic. The total number of people with diabetes is projected to rise from 171 million in 2000 to 366 million in 2030[2]. The number of people with diabetes is increasing due to population growth, ageing, urbanization and the increasing prevalences of obesity and physical inactivity[2]. The prevalence of type 2 diabetes mellitus is 4·5 % among people aged 35–65 years in Lithuania[3].

Type 2 diabetes appears to involve an interaction between susceptible genetic backgrounds and environmental factors including highly calorific diets[4]. Eggs are a major source of dietary cholesterol, with an average egg containing about 200 mg of cholesterol. On the other hand, eggs contain other nutrients such as minerals, folate, B vitamins, fat-soluble vitamins A, D, E and K, carotenoids and saturated, monounsaturated and polyunsaturated fatty acids[5–7].

In the last decade, usage of eggs increased in Lithuania (from 176 to 191 eggs per capita)[8]. In food ration eggs are often used, because poultry farming is highly developed and eggs are one of the cheapest food types in Lithuania.

As consumption of eggs is related to the development of some chronic non-infectious diseases[9], we decided to investigate if an increase in incidence of type 2 diabetes mellitus could partly be related to habits of egg consumption. Thus we performed a case–control study in an out-patient clinic in Kaunas, Lithuania, with the aim to determine the relationship between egg consumption and risk of type 2 diabetes mellitus.

Materials and methods

A case–control study was carried out at an out-patient clinic in Kaunas, Lithuania, in 2001. The study included 234 cases

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aged 35–86 years with a newly confirmed diagnosis of type 2 diabetes mellitus according to WHO criteria[10]. In total, 468 controls who had neither impaired fasting glucose level nor type 2 diabetes mellitus after a glucose tolerance test were recruited from patients of the same clinic. They were individually matched to the diabetic patients by gender and age (± 5 years). The ratio of cases to controls was 1:2.

Information on age, gender, family history of diabetes, education, occupational and marital status, egg consumption, alcohol consumption, cigarette smoking, physical activity and stress level was assessed by a special questionnaire designed by our research group. All study participants were asked to fill out the questionnaire by themselves.

Participants were asked to fast for 12 h and to avoid smoking and heavy physical activity for at least 2 h before the examinations. After a 5 min rest in a quiet room, systolic and diastolic blood pressure levels were measured twice at an interval of a few minutes on the right arm with a standard mercury sphygmomanometer with 2·0 mmHg column accuracy. Anthropometric measurements were made according to the guidelines of WHO[11]. Height and weight were measured twice. Height was measured without shoes in centimetres (0·1 cm accuracy). Weight was measured with light clothing in kilograms (0·5 kg accuracy). BMI (kg/m^2) was calculated as weight (in kilograms) divided by the square of height (in metres)[12]. Waist circumference was measured by holding a non-stretchable measuring tape snugly around the waist, defined as the midpoint between the bottom rib and the tip of the hipbones, and hip circumference was measured at the level of the great femur trochanters; both were measured in centimetres (0·1 cm accuracy).

Laboratory blood tests included fasting blood samples drawn from participants' elbow vein and venous plasma samples analysed for glucose and TAG levels. Plasma glucose was estimated by the GOD–PAP method (EBIO compact analyser; Eppendorf, Germany). Plasma TAG was estimated by the GPO–PAP method (RA-50 clinical chemistry analyser; Bayer Diagnostics, Ireland). According to the recommendations of WHO[10], a 75 g oral glucose tolerance test for assessing carbohydrate disorders was performed and evaluated in each study participant.

Study variables were categorized as follows.

1. Egg consumption: <1 egg/week, 1–1·9 eggs/week, 2–2·9 eggs/week, 3–4·9 eggs/week and ≥5 eggs/week.
2. BMI: 18·5–24·9 kg/m^2, 25·0–29·9 kg/m^2 and ≥30·0 kg/m^2.
3. Family history of diabetes: first-degree relatives with diabetes and first-degree relatives without diabetes.
4. Cigarette smoking: non-smoker, ex-smoker, infrequent smoker and current smoker.
5. Level of education (number of years): ≤10 years, 11–13 years and ≥14 years.
6. Morning exercise (of at least 30 min duration) during the last 12 months: no, sometimes and yes.
7. Plasma TAG: <1·7 mmol/l and ≥1·7 mmol/l.

Conditional logistic regression was used to calculate odds ratios and corresponding 95 % confidence intervals for diabetes mellitus in relation to exposures of interest. Variables such as BMI, family history of diabetes, cigarette smoking, education, morning exercise and plasma TAG level were retained in models as confounders when their inclusion changed the value of the odds ratio by more than 10 % in any exposure category.

All reported trend test significance levels (P values) were two-sided[13]. The χ^2 test was utilized to calculate the difference between proportions. The level of significance was set at 5 %. All calculations were performed with the STATA statistical software package version 7 (StataCorp., College Station, TX, USA).

Results

The characteristics of the case (type 2 diabetic patients) and control groups are displayed in Table 1. In our study there were 28·21 % men and 71·79 % women. The mean age was 64·09 (SD 7·85) years (range: 39–86 years) for men and 65·23 (SD 8·3) years (range: 34–86 years) for women. The cases had significantly lower education level compared with the controls. Their BMI was higher than in the controls'. There were more controls without a family history of diabetes (first-degree relatives without diabetes) than cases.

Univariate regression modelling showed that participants who consumed ≥5 eggs/week had a higher risk of type 2 diabetes mellitus (crude OR = 1·27; 95 % CI 1·10, 1·46) than those who consumed <1 egg/week. A dose–response relationship was defined between risk of this disease and egg consumption (P for trend = 0·001).

Variables such as BMI, family history of diabetes, cigarette smoking, education, morning exercise and plasma TAG level were retained in multivariate logistic regression models as confounders because their inclusion changed the value of the odds ratio by more than 10 % in any exposure category. Multivariate logistic regression data showing the relationship between type 2 diabetes mellitus and egg consumption are presented in Table 2. After adjusting for BMI, family history of diabetes, smoking and education, it was found that the excess risk of type 2 diabetes mellitus because of egg consumption changed a little, but remained statistically significant. After further controlling for BMI, family history of diabetes, smoking, education, morning exercise and plasma TAG level, we found a threefold increased risk of type 2 diabetes mellitus in participants who consumed ≥5 eggs/week (OR = 3·02; 95 % CI 1·14, 7·98) compared with those eating <1 egg/week.

Discussion

The present study has demonstrated an increased risk of type 2 diabetes mellitus related to egg consumption.

Table 1 Characteristics of the study participants: cases (*n* 234) with a newly confirmed diagnosis of type 2 diabetes mellitus and age/gender-matched controls (*n* 468), Kaunas, Lithuania, 2001

	Cases		Controls		
Variable	*n*	%	*n*	%	*P* value for χ^2
Gender					
Male	66	28·21	132	28·21	Matched
Female	168	71·79	336	71·79	
Age (years)					
≤44	12	5·13	22	4·70	Matched
45–54	21	8·97	44	9·40	
55–64	90	38·46	178	38·03	
≥65	111	47·44	224	47·86	
Education (years of education)					
≤10	115	49·15	157	33·55	
11–13	70	29·91	192	41·03	
≥14	49	20·94	119	25·43	<0·0001
Marital status					
Married	137	58·55	296	63·25	
Divorced/separated	16	6·84	40	8·55	
Single	13	5·56	25	5·34	
Widowed	68	29·06	107	22·86	NS
Family history of diabetes					
First-degree relatives without diabetes	166	70·94	422	90·17	
First-degree relatives with diabetes	68	29·06	46	9·83	<0·0001
BMI (kg/m^2)					
≤24·9	21	8·97	124	26·50	
25·0–29·9	57	24·36	185	39·53	
≥30·0	156	66·67	159	33·97	<0·0001

Table 2 Odds ratios and 95 % confidence intervals for type 2 diabetes mellitus in relation to egg consumption among cases (*n* 234) with a newly confirmed diagnosis of type 2 diabetes mellitus and age/gender-matched controls (*n* 468), Kaunas, Lithuania, 2001

	Cases		Controls							
Variable	*n*	%	*n*	%	OR*	95 % CI	*P*	OR†	95 % CI	*P*
Egg consumption										
<1 egg/week	36	15·38	115	24·57	1·00	–		1·00	–	
1–1·9 eggs/week	78	33·33	161	34·40	1·76	1·04, 2·98		1·73	1·00, 3·00	
2–2·9 eggs/week	64	27·35	114	24·36	1·97	1·12, 3·46		1·88	1·05, 3·34	
3–4·9 eggs/week	40	17·09	60	12·82	2·56	1·35, 4·85		2·60	1·34, 5·08	
≥5 eggs/week	16	6·84	18	3·85	3·38	1·35, 8·49		3·02	1·14, 7·98	
							0·001			0·003

*OR adjusted for BMI, family history of diabetes, smoking and education level.
†OR adjusted for BMI, family history of diabetes, smoking, education level, morning exercise and plasma TAG level.

We found that consumers of ≥5 eggs/week had three times greater risk of type 2 diabetes mellitus than those eating <1 egg/week. Prospective studies have shown similar results. Djoussé *et al.*[14] found that multivariable-adjusted hazard ratios for type 2 diabetes among individuals who consumed ≥7 eggs/week were 1·58 in men and 1·77 in women, compared with no eggs consumed. In their study of 2849 Chinese adults (aged ≥20 years), Shi *et al.*[15] found that egg consumption was positively associated with the risk of diabetes. Participants who consumed ≥1 egg/d had 2·28 (95 % CI 1·14, 4·54) times greater risk of type 2 diabetes mellitus than those who consumed <2 eggs/week, and women who consumed ≥1 egg/d had three times greater risk[15]. Djoussé *et al.*[16] studying 3898 older men and women from the Cardiovascular Health Study did not find the association between egg consumption or dietary cholesterol and increased risk of incident type 2 diabetes.

Salmeron *et al.*[17] found that total fat, SFA and MUFA intakes were not associated with risk of type 2 diabetes in women, but *trans*-fatty acids increased the risk and PUFA reduced the risk.

Eggs are a source of high-quality protein, with little total fat. Compared with other animal protein sources, eggs contain proportionately less saturated fat, which has generally been recognized as a strong dietary determinant of elevated LDL levels[18]. Epidemiological studies suggest that, among hyper-responders, dietary cholesterol from eggs leads to a modest increase in serum LDL cholesterol (LDL-C) and HDL cholesterol (HDL-C) concentrations and no effect on the ratio of LDL-C to HDL-C[19–23]. It is estimated that each additional 100 mg of dietary cholesterol intake results in an increase of 1·9 mg/dl in LDL-C and 0·4 mg/dl in HDL-C[23]. Dietary cholesterol increases the susceptibility of LDL to oxidation, increases postprandial

lipidaemia and potentiates the adverse effects of dietary saturated fat. Dietary cholesterol, including egg yolks, is harmful to the arteries[24]. Endothelial function refers to arterial vasomotor responses mediated predominantly by the release of nitric oxide (vasodilating) and endothelin (vasoconstricting) from the vascular endothelium, and plays an important role in the pathogenesis of atherosclerosis, hypertension, CVD and diabetes[25,26].

Feskens and Kromhout[27] studied 394 non-diabetic men (aged 50–70 years) in the Zutphen Study and found that saturated fat and dietary cholesterol intakes may affect glucose tolerance detrimentally. However, in their investigation of twenty-eight overweight or obese male patients (aged 40–70 years) on a carbohydrate-restricted diet, Mutungi *et al.*[28] found that use of 3 eggs/d had no effects on fasting glucose compared with no egg consumption. On the other hand, Pearce *et al.*[29] studied sixty-five participants with type 2 diabetes or impaired glucose tolerance and investigated the effect of a hypoenergetic high-protein/high-cholesterol diet *v.* a diet with a similar amount of animal protein (high-protein/low-cholesterol) on plasma lipids, glycaemic control and cardiovascular risk markers. They found that the high-protein energy-restricted diet high in cholesterol from eggs improved glycaemic and lipid profiles, blood pressure and apo-B in individuals with type 2 diabetes[29].

Djoussé and Gaziano[30] from the Physicians' Health Study reported that egg consumption was positively related to total mortality in male physicians. This association was stronger among diabetic participants, who had a twofold increased risk of death (2·01; 95 % CI 1·26, 3·20) when comparing the highest with the lowest category of egg consumption *v.* non-diabetic participants.

Our work has some limitations that need to be acknowledged. First, egg consumption was self-reported by the participants and we cannot exclude reporting bias in the present study. The second limitation is that we did not calculate detailed nutrient and energy intakes from dietary habits.

Conclusion

Our data support a possible relationship of egg consumption and increased risk of type 2 diabetes mellitus.

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