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Egg consumption and risk of cardiovascular diseases and diabetes: A meta-analysis

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ABSTRACT

Objectives: To assess the dose–response relationship between egg consumption and the risk of cardiovascular diseases (CVD) and diabetes.
Methods: We systematically searched MEDLINE database through December 2012. Fixed- or random-effects model was used to pool the relative risks (RRs) and their 95% confidence intervals (CIs). Subgroup analyses was performed to explore the potential sources of heterogeneity. Weighted linear regression model was used to estimate the dose–response relationship.
Results: Fourteen studies involving 320,778 subjects were included. The pooled RRs of the risk of CVD, CVD for separated diabetes patients, and diabetes for the highest vs lowest egg intake were 1.19 (95% CI 1.02–1.38), 1.83 (95% CI 1.42–2.37), 1.68 (95% CI 1.41–2.00), respectively. For each 4/week increment in egg intake, the RRs of the risk for CVD, CVD for separated diabetes patients, diabetes was 1.06 (95% CI 1.03–1.10), 1.40 (95% CI 1.25–1.57), 1.29 (95% CI 1.21–1.37), respectively. Subgroup analyses showed that population in other western countries have increased CVD than ones in USA (RR 2.00, 95% CI 1.14 to 3.51 vs 1.13, 95% CI 0.98 to 1.30, $P = 0.02$ for subgroup difference).
Conclusions: Our study suggests that there is a dose–response positive association between egg consumption and the risk of CVD and diabetes.

1. Introduction

Egg is one of the most common, available, and inexpensive food in our daily life. Egg serves as the major source of dietary cholesterol, containing 213 mg cholesterol per egg [1,2]. Evidence from animal and human metabolic studies have found that dietary cholesterol from egg could raise serum levels of low density lipoprotein cholesterol (LDL-C), a well-established independent risk factor for cardiometabolic diseases including cardiovascular diseases (CVD) and diabetes [3–6]. The main effect of dietary cholesterol is not on fasting lipids, but on the post-prandial state [7]. Dietary cholesterol increases postprandial inflammation and oxidative stress, and impairs endothelial function [8,9]. Furthermore, lecithin (approximately 250 mg in a large egg yolk) is converted by intestinal bacteria to trimethylamine, in turn oxidized by the liver to trimethylamine oxide, which is pro-atherosclerotic [10,11]. On the other hand, egg also provides other essential nutrients including high-quality proteins, unsaturated fat, folate, and various vitamins, which are regarded as the protective factors for health status [1,2]. Partly owing to the multifacet effect of egg intake, current international dietary guidelines are conflicted in recommending or limiting egg consumption for prevention of cardiometabolic diseases. For example, guidelines from American Heart Association (AHA) and the National Cholesterol Education Program (NCEP) Adult Treatment Panel III advice healthy adults limit dietary cholesterol intake less than 300 mg each day and egg intake [12–14]. However, several other guidelines have yielded different points, ranging from no restriction to recommend regular intakes of egg [15,16].

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The controversy among the dietary guidelines maybe directly derived from inconsistent results of epidemiologic studies about the relationship of egg consumption and cardiometabolic diseases. Some observational studies have reported that frequent egg consumption was associated with high risk of CVD or diabetes [17–27], while others have found null disease-specific association [1,28–34]. Given the mixed results among the studies, a systematic review and meta-analysis will help to clarify this issue. The purpose of this meta-analysis was to provide quantitative assessment of relationship between egg consumption and the risk of CVD and diabetes. Furthermore, we tried to quantify the dose–response relationship as well as to explore the potential modifiable factors.

2. Materials and methods

We performed this meta-analysis according to the MOOSE (Meta-Analysis of Observational Studies in Epidemiology) guidelines [35].

2.1. Search strategy

We searched MEDLINE (from 1930 to Dec 2012), reviews and relevant articles. The keywords used in the search were "egg or egg consumption or diet cholesterol" paired with "CVD or diabetes or mortality or coronary heart disease or heart failure". No language restriction was applied.

2.2. Outcomes and study selection

One outcome was risk of CVD which included coronary heart disease, ischaemic heart disease, or heart failure. The other outcome was the risk of diabetes. Both of the outcomes were defined by each individual study.

Inclusion criteria for retrieved studies were: (1) cohort, case–control or cross-sectional design; (2) provided at least one of the pre-mentioned outcomes; (3) provided the multi-variable adjusted relative risk (RR) and their 95% confidence intervals (CIs); (4) considered the lowest category of egg consumption as the referent group and other categories as exposed group; (5) studies were not performed in special population such as pregnant women.

2.3. Data extraction

Data were extracted by two independent author (Y.L. and C.Z.). Discrepancies were resolved by group discussion. The extracted data included source of study (author, publication year, country), population characteristics (including mean age, male proportion, number of subjects and cases), study design, follow-up term, category of egg intake, methods for measuring egg consumption, adjusted covariates, the outcomes, RRs and their 95% CIs. For each category, we extracted the most fully adjusted RR.

2.4. Data synthesis and analysis

We pooled the RRs and their 95% CIs from the highest versus lowest category of egg consumption in each study. We primarily used the fixed-effects model weighted by inverse variance. If there was significant heterogeneity, we would report it and use the random-effects model [36]. The heterogeneity was assessed by Q statistic, I-squared and P value ($P < 0.1$ was considered to be statistically significant) [37]. Subgroup analysis was conducted to explore the potential sources of heterogeneity by specified study characteristics including follow-up term, gender, study design and area. The weighted liner regression model was used to explore the dose–response relationship between egg consumption and the outcomes of interest [38]. The average intake of egg in each category which estimated by mean of the lower and upper bound. If the highest category of egg intake had an open upper boundary, mean egg intake was estimated to be 1.2 times the lower boundary [38].

Publication bias was assessed by Begg's funnel plot and Egg's regression asymmetry [39]. Two sided P value < 0.05 was considered to be significant, except where otherwise specified. All data analysis were performed by STATA software (10.0 version, Stata-Corporation, TX, USA).

3. Results

3.1. Search results

We identified 4198 articles by database and manual searching. We further excluded nonrelevant 4168 ones. Thirty potential articles were selected for detailed evaluations. Sixteen articles were excluded for the following reasons: reviews ($n = 3$), not relevant to the outcomes of interest ($n = 8$), performed in pregnant women ($n = 1$), without providing the multi-variable adjusted RR ($n = 2$), without providing the lowest category of egg intake as the referent ($n = 2$) (Fig. 1). Therefore, fourteen studies involved 320 778 subjects were included in our meta-analysis [1,17–25,31–34]. Because five studies separately reported the results about male and female [1,22,24,32,33], nineteen independent studies were included. Among them, twelve reported the risk of CVD [1,17–21,23,31,33,34], six reported the risk of CVD in separated diabetes patients [1,20,23,31,33], and seven reported the risk of diabetes [22,24,25,32].

3.2. Study characteristics

The main characteristics of all included trials were listed in Table 1. The sample size ranged from 488 to 117,943. Study design types were as follows: prospective cohort studies ($n = 11$) [1,17,19–23,31–34] case–control study ($n = 1$) [25], cross-sectional studies ($n = 2$) [18,24]. Studies were conducted in USA ($n = 10$) [1,19–23,31–33], other western countries ($n = 4$) [17,18,25,34], and China ($n = 1$) [24]. The mean age ranged from 33.4y to 74.5y. The follow-up term varied from 6.1y to 20y in prospective studies. Egg intake in each individual study was classified into 2 to 6 categories.

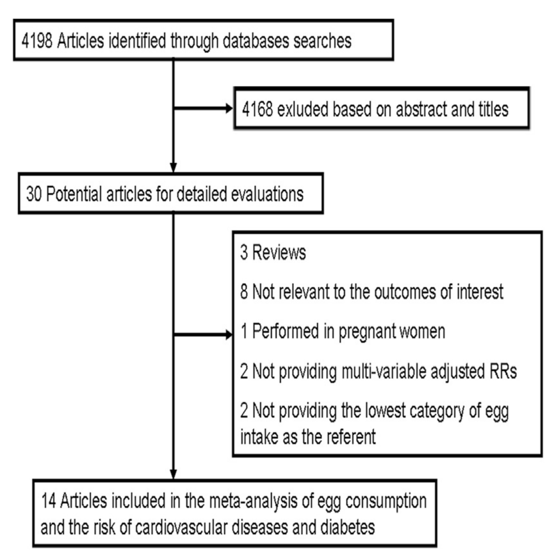

Fig. 1. Flow chart of the trial selection process. RR: relative risk.