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Review

Impact of Egg Consumption on Cardiovascular Risk Factors in Individuals with Type 2 Diabetes and at Risk for Developing Diabetes: A Systematic Review of Randomized Nutritional Intervention Studies

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ABSTRACT

Observational studies have reported inconclusive results regarding the relationship between egg consumption (and dietary cholesterol) and the risk for cardiovascular diseases (CVDs) in individuals with type 2 diabetes, which has led to inconsistent recommendations to patients. We reviewed the evidence of egg consumption on major CVD risk factors in individuals with or at risk for type 2 diabetes (prediabetes, insulin resistance or metabolic syndrome). We performed a systematic search in the databases PubMed, MEDLINE, EMBASE and Web of Science in January 2016. Inclusion criteria included randomized controlled trials in which the amount of egg consumed was manipulated and compared to a control group that received no-egg or low-egg diets (<2 eggs/week). We found 10 articles (6 original trials) that met our inclusion criteria. The majority of studies found that egg consumption did not affect major CVD risk factors. Consumption of 6 to 12 eggs per week had no impact on plasma concentrations of total cholesterol, low-density lipoprotein-cholesterol, triglycerides, fasting glucose, insulin or C-reactive protein in all studies that reported these outcomes in comparison with control groups. An increase in high-density lipoprotein-cholesterol with egg consumption was observed in 4 of 6 studies. Results from randomized controlled trials suggest that consumption of 6 to 12 eggs per week, in the context of a diet that is consistent with guidelines on cardiovascular health promotion, has no adverse effect on major CVD risk factors in individuals at risk for developing diabetes or with type 2 diabetes. However, heterogeneities in study design, population included and interventions prevent firm conclusions from being drawn.

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R SUM 

Les  tudes d'observation ont rapport  des r sultats non concluants concernant la relation entre la consommation d'œufs (et le cholest rol alimentaire) et le risque de maladies cardiovasculaires (MCV) chez les individus atteints du diab te de type 2, qui ont d bouch  sur des recommandations contradictoires faites aux patients. Nous avons pass  en revue les donn es scientifiques sur la consommation d'œufs et les facteurs de risque majeurs de MCV chez les individus atteints ou expos s au risque de diab te de type 2 (pr diab te, insulino-r sistance ou syndrome m tabolique). Nous avons r alis  une recherche syst matique dans les banques de donn es PubMed, MEDLINE, EMBASE et Web of Science en janvier 2016. Les crit res d'inclusion comprenaient les essais cliniques   r partition al atoire dans lesquels la quantit  d'œufs consomm s  tait manipul e et compar e   un groupe t moin qui avait des r gimes sans œufs ou   faible quantit  d'œufs (<2 œufs/semaine). Nous avons trouv  10 articles (6 essais originaux) qui r pondaient aux crit res d'inclusion. La majorit  des  tudes ont montr  que la consommation d'œufs n'influen ait pas les facteurs de risque majeurs de MCV. La consommation de 6   12 œufs par semaine n'avait pas de r percussions sur les concentrations plasmatiques du cholest rol total, le cholest rol   lipoprot ines de faible densit , les triglyc rides, la glyc mie   jeun, l'insuline ou la prot ine C r active dans toutes les  tudes qui rapportaient ces r sultats cliniques par rapport aux groupes t moins. Une augmentation du cholest rol

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à lipoprotéines de haute densité à la suite de la consommation d'œufs a été observée dans 4 des 6 études. Les résultats des essais cliniques à répartition aléatoire suggèrent que la consommation de 6 à 12 œufs par semaine, dans le contexte d'un régime alimentaire qui est conforme aux lignes directrices sur la promotion de la santé cardiovasculaire, n'a pas d'effets indésirables sur les facteurs de risque majeurs de MCV chez les individus exposés au risque de développement du diabète ou atteints du diabète de type 2. Cependant, l'hétérogénéité de la conception des études, de la population incluse et des interventions empêche de tirer des conclusions définitives.

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Introduction

Impaired insulin signalling is associated with dysregulation of lipoprotein metabolism, leading to an increased risk for cardiovascular disease (CVD) in individuals with diabetes (1). Dyslipidemia, which most commonly affects individuals with diabetes, includes elevated plasma triglycerides (TGs) and reduced high-density lipoprotein-cholesterol (HDL-C) concentrations along with atherogenic small, dense low-density lipoprotein (LDL) particles (1). A key component of the management of dyslipidemia is dietary modification aimed at achieving and maintaining healthy body weight. Although saturated fat has been identified as the most important element of a cholesterol-lowering diet, restriction of dietary cholesterol is also often incorporated into guidelines (1,2). However, there is considerable controversy regarding the evidence that modification of dietary cholesterol influences plasma cholesterol, and the relationship seems to be affected by saturated fat intake in the diet, along with individual differences in the response to dietary cholesterol (3).

The recommendations for egg intake in individuals with and without diabetes vary among countries. The clinical practice guidelines of the Canadian Diabetes Association, now Diabetes Canada, recommends that individuals with type 2 diabetes may consume 2 eggs per day as part of a high-protein, low-saturated fat and energy-reduced diet (4,5). The American Diabetes Association recommends that individuals with type 2 diabetes consume fewer than 300 mg per day of dietary cholesterol (6,7), whereas the National Heart Foundation of Australia advises that the consumption of 6 eggs per week is healthy for populations with and without diabetes (8). However, the 2015 Dietary Guidelines for Americans no longer emphasize reducing dietary cholesterol intake for the general population (9). In addition, the Diabetes United Kingdom and the British Heart Foundation do not recommend a restriction on egg intake but, rather, emphasize a diet low in saturated fat (10,11). Currently, the Practice-based Evidence in Nutrition (PEN) recommendations for egg intake, from Dietitians of Canada, state that because of the high dietary cholesterol content in eggs, individuals with type 2 diabetes or coronary heart disease or at high risk for CVD should limit their intake to no more than 2 eggs per week (12). These results cause considerable confusion, and healthcare practitioners end up selecting which guidelines they will communicate to their patients.

Several systematic reviews and meta-analyses have been published in the past several years concerning the topic of egg consumption or dietary cholesterol and the risk for CVD and/or diabetes (13–18). Prospective and observational studies have reported inconclusive results regarding the relationship between egg consumption (and dietary cholesterol intake) and the risk for CVD and diabetes in the general population (13–18). Inconsistent results have also been reported regarding egg consumption and CVD comorbidities in individuals with diabetes (14–18). Eggs are an inexpensive source of high-quality protein, with approximately 25% of the Canadian (19) and American (20) population reporting frequently consuming eggs during a 24-hour recall period. Additionally, eggs are rich in many essential nutrients (including choline, iron, vitamins A, D, B₁₂, B₁ and B₂), and recommendations to limit egg intake should be based on strong scientific evidence. To address

this situation, we conducted a systematic review of randomized controlled trials (RCTs) that assessed the impact of egg consumption on CVD risk factors in individuals with type 2 diabetes or at risk for developing diabetes (characterized as prediabetes, insulin resistance or having metabolic syndrome [MetS]). Studies were included only when there was a control group that received no-egg or low-egg (<2 eggs/week) diets.

Methods

This review is presented following the guidelines for Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement, and the PRISMA checklist is presented in the [Appendix 1 \(21\)](#).

Study eligibility criteria

The review included RCTs that assessed the impact of egg consumption (in whole-egg or supplement form) on CVD risk factors in adults with type 2 diabetes or at risk for developing diabetes, which is characterized as having prediabetes, insulin resistance or MetS. Studies were included only when eggs were the sole aspect of the diet that was manipulated; for example, studies looking at overall dietary patterns rich in eggs, such as paleolithic diets, were excluded. Studies were not excluded based on medications taken by the subjects, including statins, oral hypoglycemic medications, insulin and hormone replacement therapy. We included studies that examined biomarkers of cardiovascular risk and/or glycemic control, including blood lipid measures, blood glucose, measures of insulin sensitivity and markers of inflammation, such as C-reactive protein (CRP). We included studies examining modified eggs, such as omega-3-enriched eggs, only if there was also a regular egg group that was compared to a control group (consuming no-egg or low-egg diets). Studies investigating iodine- or lutein-enriched eggs were excluded because these products are not readily available to consumers. Only English-language studies were included. Observational studies were excluded from the systematic review. Studies were excluded if they examined only the effect of eggs in 1 meal (i.e. postprandial response); we required that studies examine the effect of eggs over a period of at least 4 weeks to be included in the review.

Search strategy

A systematic search of the literature was conducted using the databases PubMed, MEDLINE, EMBASE and Web of Science in the order listed. The following search terms were used to retrieve studies that included individuals with diabetes or at risk for developing diabetes: for the CVD risk factor- “Egg*” AND “type 1 diabetes OR type 2 diabetes OR insulin resistance OR metabolic syndrome” AND “LDL cholesterol OR LDL lipoprotein* OR HDL cholesterol OR HDL lipoprotein* OR triglyceride OR C-reactive protein” and for the glycemic control- “Egg*” AND “type 1 diabetes OR type 2 diabetes OR insulin resistance OR metabolic syndrome” AND “blood glucose OR blood sugar OR glycemic control OR hemoglobin A1C OR insulin OR HOMA-IR”. No limits were activated during the search to avoid

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