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Review

Egg consumption and heart health: A review

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ABSTRACT

Cardiovascular disease is the leading cause of death in the United States. Until recently, reducing dietary cholesterol has been a part of the American Heart Association (AHA) and American College of Cardiology (ACC) guidelines on lifestyle management, despite inconclusive evidence to support the recommendation. Considering eggs are a rich source of dietary cholesterol (typically containing 141–234 mg per egg), individuals with increased risk for CVD are advised not to consume eggs. Furthermore, based on the 2012 AHA/ACC guidelines, individuals with lower risk for CVD have previously been advised to avoid consuming eggs due to the high content of dietary cholesterol. Rather than strictly limiting cholesterol intake, the AHA and ACC guidelines now recommend dietary patterns that emphasize fruits, vegetables, whole grains, low-fat dairy products, poultry, fish, and nuts as an approach to favorably alter blood lipid levels. Of note, the 2015–2020 Dietary Guidelines for Americans have removed the recommendation of limiting cholesterol intake to no more than 300 mg per day; however, the guidelines advise that individuals should eat as little dietary cholesterol as possible while consuming a healthy eating pattern. The purpose of this review is to summarize the documented health risks of egg consumption in individuals with low and high risk for CVD and determine whether current recommendations are warranted based on the available literature. We also aim to provide guidance for future studies that will help further elucidate the health modulating effect of eggs.

Introduction

Cardiovascular disease (CVD) accounted for $444 billion in healthcare expenditures in 2010 and remains the leading cause of death in the United States [1,2]. Until recently, reducing dietary cholesterol has been part of the American Heart Association (AHA) and American College of Cardiology (ACC) guidelines on lifestyle management, despite inconclusive evidence to support the recommendation. The current AHA/ACC guidelines [3] now recommend dietary patterns that emphasize fruits, vegetables, whole grains, low-fat dairy products, poultry, fish, and nuts, rather than strictly limiting cholesterol intake, as an approach to decrease serum low-density lipoprotein-cholesterol (LDL-C) and hypertension. Considering approximately one third of the US population has been diagnosed with hypertension and hypercholesterolemia, the AHA/ACC recommend the Therapeutic Lifestyle Changes (TLC) and the Dietary Approaches to Stop Hypertension (DASH) diet to help attenuate development of CVD. The TLC and the DASH diet recommended consuming less than 200 mg and 150 mg of cholesterol per day [4,5], respectively. Of note, the 2015–2020 Dietary Guidelines for Americans [6] have removed the recommendation of limiting cholesterol intake to no more than 300 mg/d; however, the guidelines state that “individuals should eat as little dietary cholesterol as possible while consuming a healthy eating pattern.”

Considering eggs are a rich source of dietary cholesterol (typically containing 141–234 mg per egg, depending on size), individuals with increased risk for CVD are often advised not to consume eggs. Moreover, based on the 2012 AHA/ACC guidelines [3], individuals with lower risk for CVD have previously been advised to avoid consuming eggs due to the high content of dietary cholesterol. The purpose of this review is to

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Table 1
Current dietary cholesterol recommendations from various governing bodies

Organization/Diet	Dietary cholesterol recommendation (mg/d)
Dietary Guidelines for Americans (2015–2020)	Removed the previous (2010–2015 guidelines) recommendation of limiting to <300 mg/d. Now emphasizes that individuals should eat as little dietary cholesterol as possible while consuming a healthy eating pattern.
Therapeutic Lifestyle Change (TLC) Diet	<200
Dietary Approaches to Stop Hypertension (DASH) Diet	Considering eggs are high in cholesterol, limit egg yolk intake to no more than 4/wk.
American Heart Association/American College of Cardiology	No specific recommendation. Emphasizes eating an overall healthy dietary pattern consisting of fruits, vegetables, whole grains, low-fat dairy products, skinless poultry and fish, nuts, legumes, and nontropical vegetable oils.

summarize the documented health risks of egg consumption in individuals with low and high risk for CVD and determine whether current recommendations (Table 1) are warranted based on the available literature. Furthermore, considering insulin resistance places an individual at increased risk for development of CVD and stroke [7], we describe the effect of eggs on glucose metabolism. Lastly, we aim to provide guidance for future studies that will help further elucidate the health modulating effect of eggs.

The relationship between serum cholesterol and CVD risk

Elevated serum LDL-C is a long-established risk factor for the development of heart disease; however, the relationship between serum concentrations of LDL-C and dietary cholesterol is not clear. Researchers from the Framingham Heart Study were among the first to demonstrate increased CVD risk with elevations in serum cholesterol [8]. They suggested limitations on cholesterol intake, yet no association between cholesterol intake and elevated serum cholesterol had been reported. An early meta-analysis on the topic indicated that for every 100 mg increase in dietary cholesterol, serum total cholesterol (TC), LDL-C, and high-density lipoprotein cholesterol (HDL-C) concentrations increased by 2.2 to 2.5, 1.9, and 0.4 mg/dL, respectively [9]. Subsequent feeding studies have not always detected negative impacts of cholesterol consumption on the serum lipid profile [10,11]. Variability in response to dietary cholesterol among individuals is likely responsible for the observed discrepancies. Researchers have used the term "hyper-responders," to describe individuals who experience an increase in both circulating LDL-C and HDL-C following consumption of dietary cholesterol. It is crucial to note that approximately 75% of the population experience moderate to no difference in plasma cholesterol following the consumption of dietary cholesterol, and have been described as "normal responders" or "hypo-responders" [12–14]. The potential mechanism driving the "normal" or "hypo" response is a decrease in cholesterol fractional absorption and/or endogenous cholesterol synthesis, in response to increased cholesterol intake [15].

Reducing dietary cholesterol as a strategy to lower serum cholesterol has been questioned by researchers for many years [16]. It has been suggested that dietary and lifestyle factors aside from cholesterol consumption likely modulate blood lipid profiles to a greater extent, and therefore may pose greater risks to cardiovascular health [17]. Recently, the statistical significance of dietary intake data was shown to be affected by differences in the statistical methods used to analyze these data, which may impact studies that associate disease risk factors with dietary intake. These researchers suggested that the common assumption that nutrients and food components are measured with a high degree of accuracy is incorrect, and that care is warranted in 1) choosing a statistical method that is unbiased, 2) objectively interpreting the results, and 3) adequately controlling for potentially confounding variables [18]. This is especially true for epidemiologic studies designed to assess diet-disease relationships.

Eggs and CVD risk: Prior conceptions and current evidence

As previously mentioned, cholesterol intake reduction in recent times has been a unifying characteristic of the DASH, TLC, and AHA/ACC diets. Since a single egg yolk typically contains between 141 mg and 234 mg of cholesterol, the TLC and DASH diets recommend no more than two or four egg yolks per week, respectively. In early research, elevations in serum TC concentrations were detected following whole egg consumption; however, the concentration of cholesterol among lipoproteins was not determined [19]. Because HDL particles exhibit antiatherogenic properties [20], drawing conclusions based solely on measurements of TC can be misleading. Researchers for the Framingham Heart Study reported that egg consumption was linked to higher dietary cholesterol intake; however, no relationships to serum cholesterol, all-cause mortality, coronary heart disease, myocardial infarction, or angina were detected [8]. They concluded that rather than simply limiting egg consumption, diet as a whole must be considered as a means of decreasing CVD risk. Importantly, a clear connection between egg consumption and increased CVD risk have not been established by meta-analyses of dose response prospective cohort studies [10] and other prospective studies [11,21]. In fact, some researchers have actually detected that HDL-C increases with the consumption of whole eggs during moderate carbohydrate restriction in overweight individuals, suggesting that eggs may even promote some heart-healthy effects [22]. Because moderate carbohydrate restriction alone can independently decrease TG [23], consideration must be made when studying egg consumption during normal carbohydrate intake.

Controlled dietary intervention trials demonstrating widespread negative effects of egg consumption on CVD risk are not available in individuals who are at either lower risk or higher risk for heart disease. The lack of detection of negative effects can be explained through two types of reasoning. One issue is that eggs are a rich source of key nutrients that may protect against heart disease. For example, lutein and zeaxanthin, which are within the xanthophyll class of antioxidants, may protect against lipid oxidation [24]. The other is that when increased dietary cholesterol via egg intake has been demonstrated to elevate circulating LDL-C in individuals classified as "hyper-responders," minimal changes in the overall ratio of LDL-C to HDL-C have been detected due to proportional increases in HDL-C [12]. It is critical to note that 75% of the population appears to experience little or no alteration in plasma cholesterol concentration following challenges of high cholesterol intake [12].

Egg consumption by individuals at lower risk for CVD

In the past, limiting egg consumption has frequently been recommended as a means of decreasing CVD risk in the population rather than only for individuals at higher risk. Multiple groups of researchers have examined the potential lipid modulating effects of eggs in low- and high-risk individuals alike. Here we describe