Egg intake and cardiometabolic diseases: an update

Part 1

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Abstract

Although eggs are a valuable source of nutrients, the role of egg intake has been controversially discussed due to eggs´ high content of cholesterol. Currently there is no consensus in the recommendations of (inter) national nutrition and cardiological scientific bodies on egg and cholesterol intake. Meta-analyses, systematic reviews and recent cohort studies predominantly show no association between egg intake and the risk of cardiovascular diseases in the general population. As regards people with type 2 diabetes mellitus, study results mainly indicate an increased risk for cardiovascular diseases in relation to egg intake. Controlled intervention studies are required to confirm these associations. The current knowledge on the effects of egg intake on cardiometabolic risk factors and the risk of type 2 diabetes mellitus are presented and reviewed in a second article.

Keywords: egg intake, cardiovascular diseases, type 2 diabetes mellitus, cholesterol

Introduction

Egg intake and its effects on human health has long been the subject of scientific research and discussion. Eggs can on the one hand be a good source of nutrients, but are also controversially discussed due to their high cholesterol content. The particular focus here is cardiovascular diseases [1, 2], which are among the most common causes of death in Germany. In 2016 they were the cause of a total of 37.0% of all deaths [3].

Cardiovascular risk factors include, inter alia, raised concentrations of total cholesterol and low-density lipoprotein (LDL) cholesterol [4]. In the evidence-based guideline of the German Nutrition Society (*Deutsche Gesellschaft für Ernährung*, DGE): fat intake and prevention of selected nutrition-related diseases [5] the intake of dietary cholesterol was linked to an increase in the ratio of total cholesterol to high density lipoprotein (HDL) cholesterol with probable evidence and to a small increase in the ratio of total and LDL cholesterol with convincing evidence, although this latter is probably more pronounced in what are known as responders than non-responders.[1] Studies on specific foods, such as eggs, were not considered in the guidelines on fat intake since their effects are based on the overall food matrix and it is therefore not possible to derive definitive statements on the effects of fat or cholesterol in the diet.

The association between egg intake and the risk of cardiovascular diseases has been investigated in recent years in several prospective observational studies. For coronary heart

[1] Classification as (non-)responders is based on the effect of dietary cholesterol intake on LDL cholesterol concentration, which is not comparable in everyone [6, 7].

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disease (CHD) [8, 9] and stroke [10–13] results predominantly showed no association between egg intake and risk of disease.

This article gives an overview of the effects of egg intake on the risk of cardiovascular diseases. Based on systematic literature research, it presents the results of systematic reviews and meta-analyses and recent prospective cohort studies. A second article presents the associations and effects of egg intake on the risk of type 2 diabetes mellitus and cardiometabolic risk factors and the results of both articles are discussed jointly.

Background information

Nutrient content of eggs

Eggs are rich in biologically valuable protein and other (essential) nutrients (e.g. vitamins, unsaturated fatty acids). At the same time eggs are one of the foods most rich in cholesterol: one egg (approx. 60 g) holds approx. 240 mg of cholesterol, contained in the yolk [14].

Egg and cholesterol intake in Germany

According to the German National Nutrition Survey II (NVS II, research period 2005–2006) men consume slightly more eggs than women (12 g/day vs. 10 g/day; incl. prepared eggs such as scrambled, fried or boiled eggs, and eggs in dishes; not included: eggs in baked goods, soups, sauces). According to this, men and women consume on average a little over one egg per week. If the eggs contained in soups, sauces and baked goods were included then the actual quantity of eggs consumed would be higher for both men and women [15]. According to data from the German Federal Information Centre for Agriculture (BZL), per head consumption in 2017 averaged 230 eggs [16].

According to NVS II eggs are a significant source of cholesterol intake and for women they rank above and for men below meat/meat products/sausage in first and second place respectively [17]. The median cholesterol intake (here also taking into account of eggs in baked goods, soups and sauces) is approx. 300 mg/day for men and approx. 230 mg/day for women [15].

Statements of (inter)national scientific bodies on egg and cholesterol intake

◆ Table 1 summarizes the statements of (inter) national nutrition societies on egg and cholesterol intake.

In the current Dietary Guidelines for Americans produced by the US Department of Agriculture (USDA) no upper limits are given for egg intake and the limits given for cholesterol intake in previous versions (max. 300 mg/day) have been removed. However, consideration of dietary cholesterol within the context of health-promoting nutrition patterns is still seen as relevant. Thus, in the exemplary nutrition patterns of the Dietary Guidelines for Americans [18, 19] cholesterol intake is limited to 100–300 mg/day. Comparable statements are to be found in the Dutch nutritional guidelines [20]. Italy [21] and the Nordic countries [22] give no limits for the intake of eggs and dietary cholesterol.

The DGE also gives no upper limit for egg intake. However, unlimited intake within the context of a vegetable-based diet is not recom-

Scientific body	Guiding values
German Nutrition Society (DGE) [23, 24, 36]	• Egg intake: no limit • Cholesterol intake: guiding value of max. 300 mg/day
Dietary Guidelines for Americans 2015 [18, 19]	• Egg intake: no limit • Cholesterol intake: no limit; should be kept as low as possible
Dutch Dietary Guidelines 2015 [37]	• Egg intake: no limit • Cholesterol intake: care should be taken to ensure adequate intake of cholesterol-rich food
French National Nutrition and Health Program [26]	• Eggs are listed in a food group with meat, poultry, fish and seafood whose recommended intake is given as 1–2 portions/day • Cholesterol intake: no limit
Italian Dietary Guidelines [21]	• Egg intake: no limit • Cholesterol intake: no limit
Mediterranean Diet Pyramid [25]	• Egg intake: 2–4 portions/week • Cholesterol intake: no limit
Nordic Nutrition Recommendations 2012 [22]	• Egg intake: no limit • Cholesterol intake: no limit

Tab. 1: **Guiding values for the general population by (inter)national nutrition societies on egg and cholesterol intake**

Scientific body	Guiding values
American Heart Association [34]	• Egg intake: no limit • Cholesterol intake: no limit
National Heart Foundation of Australia [28, 33]	• Egg intake: 6–7 eggs/week • Cholesterol intake: no limit
British Heart Foundation [31, 35]	• Egg intake: no limit; eggs are part of a balanced diet • Cholesterol intake: no limit
European Society of Cardiology [32]	• Egg intake: no limit • Cholesterol intake: no limit
German Heart Foundation [29, 30]	• Egg intake: max. 2 eggs/week • Cholesterol intake: max. 250–300 mg/day
National Heart Foundation of New Zealand [27]	• Egg intake: - General population: no limit - Patients with a risk of cardiovascular diseases: max. 6–7 eggs/week - Responders: individual advice from physician or nutritionist, adjusted for specific reaction to dietary cholesterol • Cholesterol intake: no limit

Tab. 2: **Guiding values of (inter)national cardiological societies on egg and cholesterol intake**

mendable according to the DGE [23]. Eggs can supplement menu plans and be part of a wholesome diet but their consumption should still be consciously planned. In Germany the guiding value for cholesterol intake remains at a maximum of 300 mg/day [24]. In the Mediterranean diet pyramid [25] a weekly egg intake of 2–4 portions is given. In the French National Nutrition and Health Program [26] there is no specific statement on egg intake. Eggs are included in a food group with meat, poultry, fish and seafood, whose recommended intake is given as 1–2 portions per day (◆ Table 1).

Specialist cardiological societies (◆ Table 2) also give recommendations on egg and cholesterol intake, some of which state clear restrictions on daily egg intake [27–29] or cholesterol intake [30], whilst others reject a limit on consumption or intake or do not give one and include eggs as part of a wholesome, balanced and cardio-protective diet [31–35].

Methodology

In the course of systematic literature research, the authors sought out systematic reviews and meta-analyses of intervention and cohort studies which investigated the association between egg intake and the risk of cardiovascular diseases. The literature research was done using the database NCBI PubMed and covered studies from January 2008 to August 2018. In addition to this a systematic search was made for more recent studies not considered in systematic reviews and meta-analyses up to now. The search strategy included, inter alia, the English language terms "egg", "cardiovascular diseases" and the search terms "meta-analysis", "systematic review", "interventional trial" and "cohort". Furthermore, the bibliographies were searched for relevant articles.

Egg intake and risk of cardiovascular diseases

Cardiovascular risk in the general population

In the meta-analyses examining the association between egg intake and risk of CHD or stroke in the general population, the analyses (highest vs. lowest intake, dose-response analyses) showed no risk relation [38–42] or respectively risk reduction for stroke [42] (◆ Table 3). Of the meta-analyses examining the association between egg intake and risk of cardiovascular diseases overall, one meta-analysis showed no relation and another showed risk increase [40, 43].

Cardiovascular risk in people with type 2 diabetes mellitus

In the systematic reviews and meta-analyses of prospective cohort studies examining the association between egg intake and risk of cardiovascular diseases in diabetics, the majority of the studies showed a positive (risk increasing) association [38, 40, 43, 44] (◆ Table 3).

Results of more recent prospective cohort studies

Four recent prospective cohort studies not included in systematic reviews and meta-analyses up to now investigated the association between egg intake and cardiovascular diseases [45–48] (◆ Table 4). In the majority of the studies no association could be determined.

Author, Year	Study type Study region Follow-up duration	Study population/ No. of cases Age	Exposition estimate of nutrition factor	Results
Bechthold et al. (2017 [41]	Meta-analysis of 17 cohort studies USA, n = 11; Australia, n = 1; Europe, n = 5 7.6–26 years	CHD: n. d./ 14,370 Stroke: n. d./ 12,735 ≥ 15 years	Range of egg intake: CHD and stroke: 0–75 g/day	Highest vs. lowest egg intake: CHD (n = 11): RR 0.99 (95%-CI [0.94; 1.05]) Stroke (n = 10): RR 0.99 (95%-CI [0.93; 1.05]) Cardiac insufficiency (n = 4): RR 1.25 (95%-CI [1.12; 1.39]) Dose-response analysis (per increase in egg intake by 50 g/day): CHD (n = 9): RR 1.00 (95%-CI [0.95; 1.06]) Stroke (n = 10): RR 0.99 (95%-CI [0.93; 1.05]) Cardiac insufficiency (n = 4): RR 1.16 (95%-CI [1.03; 1.31]) Non-linear dose-response analysis: CHD (n = 9): p = 0.81; stroke (n = 9): p = 0.39; HF (n = 3): p = 0.04
Alexander et al. 2016 [42]	Meta-analysis of 7 cohort studies each on CHD and stroke USA, n = 7; Japan, n = 3 CHD: 7.6–22 years Stroke: 8–26 years	CHD: ca. 276,000/ n. d. Stroke: ca. 308,000/ n. d. ≥ 17 years	1 egg/day vs. < 2 eggs/week)	Highest vs. lowest egg intake: CHD (n = 7): SRRE 0.97 (95%-CI [0.88; 1.07]) Stroke (n = 7): SRRE 0.88 (95%-CI [0.81; 0.97]) Non-linear dose-response analysis: No association between egg intake and risk of CHD (p = 0.57) and stroke (p = 0.49)
Tran et al. 2014 [44]	Systematic review of 6 cohort studies Study region: n. d. 4.5–20 years	Number of study participants /cases: n. d./n. d. Age: n. d.	<1 egg/week to ≥ 7 eggs/week	Risk of cardiovascular diseases in diabetics: In 4 of 6 cohort studies there was a positive association between egg intake and the risk of cardiovascular diseases
Shin et al. 2013 [40]	Meta-analysis of 8 cohort studies USA, n = 6; Europe, n = 1; Asia, n = 1 11.3 years	348,420/9,839 20–90 years	≥ 1 egg/day vs. <1 egg/week or never	Highest vs. lowest egg intake: Cardiovascular diseases (n = 8): HR 0.96 (95%-CI [0.88; 1.05]) Ischemic heart disease (n = 4): HR 0.97 (95%-CI [0.86; 1.09]) Stroke (n = 5): HR 0.93 (95%-CI [0.81; 1.07])
				Highest vs. lowest egg intake: Risk of cardiovascular diseases in diabetics (n = 3): HR 1.69 (95%-CI [1.09; 2.62])
Li et al. 2013 [43]	Meta-analysis of 9 cohort and 1 cross-sectional study USA, n = 7; Australia, n = 1; New Zealand, n = 1; Europe, n = 1 6.1–20.4 years	226,784/6,592 33–75 years	Range of egg intake: < 1 egg/ week to ≥ 2 eggs/day	Highest vs. lowest egg intake: Cardiovascular diseases (n = 10): RR 1.19 (95%-CI [1.02; 1.38]) Dose-response analysis (per increase in egg intake by 4 eggs/week): RR 1.06 (95%-CI [1.03; 1.10])
				Highest vs. lowest egg intake: Risk of cardiovascular diseases in diabetics (n = 6): RR 1.83 (95%-CI [1.42; 2.37]) Dose-response analysis (per increase in egg intake by 4 eggs/week in diabetics): RR 1.40 (95%-CI [1.25; 1.57])
Rong et al. 2013 [38]	Meta-analysis of 6 cohort studies each on CHD and stroke USA, n = 5; Asia, n = 3 CHD: 8–20 years, Stroke: 8.8–22 years	CHD: 263,938/5,847 Stroke: 210,404/7,579 ≥ 17 years		Dose-response analysis (per increase in egg intake by 1 egg/day): CHD (n = 6): RR 0.99 (95%-CI [0.85; 1.15]) Stroke (n = 6): RR 0.91 (95%-CI [0.81; 1.02])
				Dose-response analysis (per increase in egg intake by 1 egg/day): CHD/stroke risk for diabetics: CHD (n = 5): RR 1.54 (95%- CI [1.14; 2.09]) Stroke (n = 3): RR 0.80 (95%- CI [0.29; 2.15])
Mente et al. 2009 [39]	Meta-analysis of 5 cohort studies USA: n = 3; Europe, n = 1; Japan, n = 1 8–20 years	258,221/n. d. 16–79 years	Range of egg intake: < 1 egg/ week to >1 egg/ day	Highest vs. lowest egg intake: CHD (n = 5): RR 1.06 (95%- CI [0.89; 1.23])

Tab. 3: **Egg intake and risk of cardiovascular diseases: results of systematic reviews and meta-analyses of cohort studies**
CHD = coronary heart disease; CI = confidence interval; HF = heart failure; HR = hazard ratio; n. d. = no details; RR = relative risk; SRRE = summary relative risk estimate

Of the studies investigating the effects of egg intake (highest vs. lowest intake) on the risk of cardiovascular diseases in people with type 2 diabetes mellitus, two studies showed a positive association [45, 46, 48].

Conclusion

The egg has been a controversial food for many years. Its high cholesterol content of around 240 mg means that it could facilitate development of cardiometabolic diseases. To date there is no consensus in the recommendations of (inter)national nutrition and cardiological bodies as regards the intake of eggs and cholesterol.
Results from meta-analyses and systematic reviews of prospective cohort studies examining the effects of egg intake on the risk of cardiovascular diseases give a very consistent

Author, Year	Study region Follow-up duration	Study population/No. of cases Age	Exposition estimate of nutrition factor	Results
Qin et al. 2018 [47]	China 8.9 years	461,213/83,977 50.7 years	no/negligible egg intake (0.29 eggs/day) vs. daily egg intake (0.76 eggs/day)	Cardiovascular diseases: HR 0.89 (95%-CI [0.87; 0.92]) Ischemic heart disease: HR 0.88 (95%-CI [0.84; 0.93]) Haemorrhagic stroke: HR 0.74 (95%-CI [0.67; 0.82]) Ischemic stroke: HR 0.90 (95%-CI [0.85; 0.95]) Significant coronary events (fatal ischemic heart disease, myocardial infarction): HR 0.86 (95%-CI [0.76; 0.97])
Jang et al. 2018 [48]	Korea 7.3 years	9,248/570 52 years	4 categories: 0.1 port.a eggs/week, 0.7 port. eggs/week, 1.6 port. eggs/week, 4.2 port. eggs/week	Cardiovascular diseases: 0.1 vs. 0.7 port. eggs/week: HR 1.27 (95%-CI [0.99; 1.61]) 0.1 vs. 1.6 port. eggs/week: HR 1.23 (95%-CI [0.95; 1.60]) 0.1 vs. 4.2 port. eggs/week: HR 1.14 (95%-CI [0.87; 1.49]) Cardiovascular diseases in diabetics: 0.1 vs. 0.7 port. eggs/week: HR 1.72 (95%-CI [0.81; 3.64]) 0.1 vs. 1.6 port. eggs/week: HR 3.70 (95%-CI [1.65; 8.30]) 0.1 vs. 4.2 port. eggs/week: HR 2.81 (95%-CI [1.25; 6.30])
Guo et al. 2017 [45]	Great Britain 22.8 years	1,781/715 62 years	5 categories: 0 ≤ eggs ≤ 1, 1 < eggs ≤ 2, 2 < eggs ≤ 3, 3 < eggs < 5, ≥ 5 eggs	Cardiovascular diseases: 0 ≤ eggs ≤ 1 vs. 1 < eggs ≤ 2: HR 0.98 (95%-CI [0.76; 1.26]) 0 ≤ eggs ≤ 1 vs. 2 < eggs ≤ 3: HR 1.14 (95%-CI [0.89; 1.46]) 0 ≤ eggs ≤ 1 vs. 3 < eggs < 5: HR 1.01 (95%-CI [0.77; 1.33]) 0 ≤ eggs ≤ 1 vs. ≥ 5 eggs: HR 1.25 (95%-CI [0.94; 1.66]) Stroke, cardiac insufficiency and myocardial infarction: For the comparison of lowest to higher egg intake (all categories) no association could be established to risk of disease. Cardiovascular diseases in diabetics: In persons with type 2 diabetes and/or disturbed glucose tolerance the comparison of lowest to highest egg intake resulted in an increased risk of stroke.
Dìez-Espino et al. 2017 [46]	Spain 5.8 years	7,216/342 men: 55–80 yrs, women: 60–80 yrs	3 categories: < 2 eggs/week, 2–4 eggs/week, > 4 eggs/week	Cardiovascular diseases: < 2 eggs vs. 2 -4 eggs/week: HR 0.95 (95%-CI [0.75; 1.19]) < 2 eggs vs. > 4 eggs/week: HR 1.22 (95%-CI [0.72; 2.07]) Cardiovascular diseases in diabetics: < 2 eggs vs. 2 -4 eggs/week: HR 1.09 (95%-CI [0.73; 1.62]) < 2 eggs vs. > 4 eggs/week: HR 0.96 (95%-CI [0.33; 2.76])

Tab. 4: **Egg intake and risk of cardiovascular diseases: Results of prospective cohort studies**
CI = confidence interval; HR = hazard ratio; port., portions
[a] No details on portion sizes

picture for the general population and people diagnosed with type 2 diabetes mellitus. For the endpoints of cardiovascular diseases overall, CHD and stroke, meta-analyses established predominantly no risk relation to egg intake. In the case of people with type 2 diabetes mellitus studies on egg intake and cardiovascular risk predominantly showed a risk increasing association.

In order to confirm the causality of the association examined, investigations in the context of controlled intervention studies will be required. In a second article (Part 2 in Ernährungs Umschau 2/2020) the effects of egg intake on cardiometabolic risk factors and the risk of diabetes mellitus type 2 are considered and the results of both articles are discussed jointly.

Conflict of Interest
The authors declare no conflict of interest.

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