Position Statement for Healthcare Professionals

Eggs, Plasma Cholesterol and Lipoproteins

Updated June 2016

According to the most recent Australian Health Survey[1], in which blood cholesterol levels were measured, one in three Australians aged 18 years and over (32.8% or 5.6 million people) have abnormal or high total cholesterol levels. Yet only 10.1% of this group self-reported having high cholesterol as a current long-term health condition, suggesting the majority of people with high cholesterol results were either unaware they had the condition or did not consider it to be a long-term or current problem. In addition, one in three Australian adults (33.2%) had abnormal or high LDL cholesterol.

Since high plasma cholesterol levels, in particular high LDL cholesterol levels, are an important traditional risk factor for heart disease and stroke, it is of importance to understand the dietary factors which negatively impact these lipid levels. When it comes to the impact of sources of dietary cholesterol (including egg intake), the majority of research conducted over the past 50 years suggests egg consumption has only a small effect on raising total plasma cholesterol levels in most healthy people. The Heart Foundation agrees, stating that *"saturated and trans fat intake lead to a greater increase in LDL cholesterol levels compared to dietary cholesterol. Furthermore, it is recognised the dietary cholesterol in eggs only has a small impact on cholesterol levels"*[2].

The effects of dietary cholesterol on lipids appear to be limited to population subgroups[3]. There is also a lack of a significant relationship between dietary cholesterol intake and heart disease incidence reported from numerous epidemiological studies[4]. The most recently published systematic review and meta-analysis investigating this relationship concluded that higher intakes of dietary cholesterol were not associated with an increased risk of incident cardiovascular disease[5].

Summary of evidence to date

The most recent meta-analysis of 18 human intervention studies reporting the effect of dietary cholesterol on serum cholesterol levels showed a significant increase in serum total, LDL and HDL cholesterol levels when comparing intervention with control doses of dietary cholesterol, though the authors did note the significant heterogeneity in the studies and the lack of association between dietary cholesterol intake and CVD risk[5]. In terms of dose, intakes up to 900mg per day resulted in statistically significant increases in serum cholesterol however were no longer significant once dietary intakes exceeded 900mg/day. Researchers also found a statistically significant increase in the LDL:HDL cholesterol ratio of 0.17 (95% CI: 0.01,0.32).

The doses of dietary cholesterol used in the studies included in the meta-analysis, however ranged from 500 to 1400mg per day – well above the average Australian intake of 300mg reported in the most recent National Nutrition and Physical Activity Survey[6].

The results of this meta-analysis differ from a 2001 meta-analysis of 17 human experimental studies which found on average, increasing dietary cholesterol from eggs by 100mg daily, equivalent to half a 60gram egg or 3-4 eggs a week, results in minimal increases in serum lipid changes[7]. The differing results may be explained by the variation in study inclusion criteria used[5].

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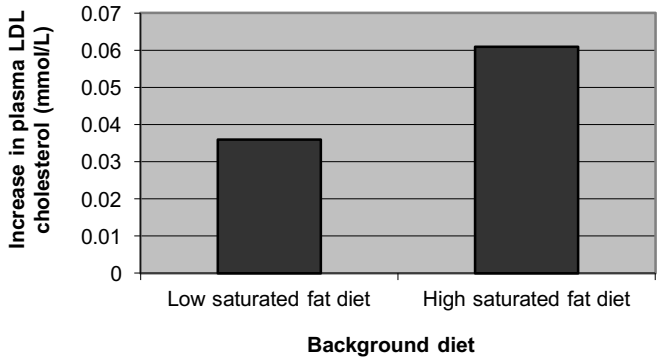
It should be noted that previous research has shown the effect on LDL cholesterol from an increase in dietary cholesterol from eggs is 1.7 times greater when the background diet is high in saturated fat compared to a low saturated fat background diet[8]. This finding reinforces the recommendations from heart associations worldwide to reduce dietary saturated fat as a key strategy for reducing serum cholesterol levels. Dietary saturated fat has a significant effect on serum cholesterol levels with research showing that for every 1% increase in total daily kilojoules from saturated fatty acids, serum LDL cholesterol rises by about 2%[9].

Figure 1: Change in LDL cholesterol with an additional 100mg dietary cholesterol from eggs (independent of saturated fat)



The intervention studies included in the meta-analyses mentioned above have been conducted in a range of populations (both healthy and at risk populations) and over a range of different time frames. These studies are summarized in Appendix 1. These studies show the diversity in populations studied, intervention doses administered and timeframes which may account for some of the variability in results.

HDL Cholesterol:

Some evidence, including the 2015 meta-analysis[5] and 2001 meta-analysis[7] showed a small but significant increase in HDL cholesterol with increasing cholesterol intake from eggs/diet. The National Heart Foundation of Australia and the American Heart Association recognise low HDL as a risk factor for coronary heart disease[10,11] with higher levels found to be cardio-protective[12]. Further evidence, however is needed to understand how effective increasing HDL levels via diet or medication is at reducing cardiovascular risk.

Factors affecting the response to dietary cholesterol:

It has been established that there is significant individual variation in response to dietary cholesterol[13]. This variation is in part due to ethnicity, hormonal status, body weight, lipoprotein disorders and genetics. For example, the Chicago Western Electric Study, a prospective cohort study of 1,903 middle-aged men, showed a change in intake of dietary cholesterol was positively associated with a change in serum cholesterol for men in the lowest tertile of body mass index (< 24.2kg/m^2) but not for men in the highest tertile (>26.6 kg/m^2)[14]. This has since been supported by studies conducted in obese insulin-resistant postmenopausal women consuming up to four eggs per day showing no change in LDL cholesterol levels[15].

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More recently, a study found cholesterol absorption was highest in lean insulin sensitive participants whereas cholesterol synthesis was highest in lean insulin resistant and obese insulin resistant subjects. The authors suggest for lean insulin-sensitive subjects a low intake of dietary cholesterol should be emphasized but the focus for insulin resistant individuals should be weight loss to decrease cholesterol overproduction by the body[16]. The latest systematic review assessing the effect of dietary cholesterol intake on lipid levels contained studies with limited data on subgroup populations which may account for the results obtained. Studies assessing the effect of dietary cholesterol and egg intake in people with diabetes have also been conducted and a review of this area can be found in the *ENC Eggs & Diabetes statement.*

Overall, evidence to date suggests the increase in total and LDL cholesterol levels seen with increased dietary cholesterol intake from eggs is small and doesn't translate into increased risk of cardiovascular disease, and many studies show eggs can be incorporated into a weight loss or weight maintenance diet with little to no impact on cholesterol levels. Increases are greater when the background diet is high in saturated fat or with dietary intakes well above the average daily consumption of dietary cholesterol reported in the 2011-12 National Nutrition and Physical Activity Survey. The effect may be attenuated even further in overweight, insulin-resistant people.

Apolipoproteins

A number of studies have assessed the effect of changes in dietary cholesterol intake from eggs on apolipoprotein levels with varying results. Some have shown no change in apolipoprotein B (the main apolipoprotein of LDL and VLDL levels which are considered important risk factors for cardiovascular disease) with increased dietary cholesterol from eggs[17-20] while others have shown an increase[21-25]. However, a 2011 study in adults with type 2 diabetes showed a statistically significant decrease in apolipoprotein B when subjects consumed 2 eggs per day as part of an energy restricted diet[26]. Most studies have found no change in apolipoprotein A-1 (the main protein of HDL) with increased intakes of dietary cholesterol from eggs [17-19,21,22,24,25].

Hyper-responders

It has been estimated that 15-25% of the population are hyper-responders to dietary cholesterol[27]. In those individuals plasma cholesterol levels increase by 0.06-0.22mmol/L for each 100mg of dietary cholesterol consumed[27-30].

A study conducted with 42 postmenopausal women and men aged sixty years and over with healthy lipoprotein profiles[28], found consumption of three eggs per day for one month increased both plasma total, LDL and HDL cholesterol levels for hyper-responders but not hypo-responders. Hyper-responders who consumed eggs had on average 20% higher total cholesterol (5.4mmol/L versus 4.5mmol/L), 26% higher LDL cholesterol (3.4mmol/L versus 2.7mmol/L), 10% higher HDL cholesterol (1.5mmol/L versus 1.4mmol/L) and 2% higher triglycerides (1.1mmol/L versus 1.08mmol/L) compared to the control group following egg consumption.

In hyper-responders, while increased egg consumption affects plasma lipids to a greater extent than in hypo-responders, further research is required to determine how this translates into cardiovascular disease risk.

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Guidelines Relating to Cholesterol and Egg Consumption

The Heart Foundation's 2009 Position Statement on Dietary Fat[31] states there is good evidence that an increase in the consumption of saturated fatty acids is associated with an increase in risk of CHD, and moderate evidence that dietary cholesterol increases total cholesterol and LDL-C but substantially less so than saturated and trans fatty acids. They recommend that within a low saturated fat diet, individuals may consume six eggs per week without adversely affecting CVD outcomes. More recently, the 2013 Australian Dietary Guidelines suggest daily egg consumption is not associated with increased risk of coronary heart disease[32] . Similarly, the 2015 US Dietary Guidelines no longer specify a daily limit to dietary cholesterol intake and recommends the consumption of eggs as part of a healthy eating pattern[33].

Conclusions

The Egg Nutrition Council concludes the following:

- Reducing saturated fat intake is the primary dietary strategy recommended for reducing serum cholesterol levels.
- In a healthy Western population, there is insufficient evidence to excessively restrict egg intake as part of a healthy diet. Eggs should be considered in a similar way as other protein rich foods and selected as part of a varied diet that is consistent with the Australian Dietary Guidelines, low in saturated fat and contains a variety of cardio-protective foods such as fish, wholegrains, fruits, vegetables, legumes and nuts.
- Research supports the inclusion of eggs daily as part of a healthy diet.

This statement is for healthcare professionals only.

As diet-induced changes in total cholesterol and lipoproteins vary considerably between individuals, the Egg Nutrition Council recommends individual discussion of the recommendations regarding egg intake with their health care professional.

Useful links:

Egg Nutrition Council
www.enc.org.au

Egg Nutrition Centre
www.enc-online.org

Heart Foundation
www.heartfoundation.org.au

Australian Dietary Guidelines
www.eatforhealth.gov.au/guidelines

American Dietary Guidelines
www.health.gov/dietaryguidelines/2015/guidelines/

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Appendix 1

Table 1: Summary of intervention studies assessing the effect of egg consumption on serum cholesterol levels in the general population

Study reference	Population	Cholesterol/Egg Intake	Effect on lipids	Additional comments
Katz et al 2005[34]	Healthy Adults	2 eggs daily for 6 weeks	No effect on total cholesterol or endothelial function	
Greene et al 2005[35]	Healthy postmenopausal women and men >60 years	3 eggs per day for 1 month	LDL and HDL cholesterol levels increased; LDL:HDL and TC:HDL ratios did not change.	
Goodrow et al 2006[36]	Adults >60years	1 egg per day for 5 weeks	No increase in cholesterol levels	
Mutungi et al 2008[37]	Overweight or obese men (40-70yrs)	3 eggs per week as part of a CHO restricted weight loss diet (compared to egg substitute)	Increased HDL cholesterol; no change in LDL cholesterol levels	
Harman et al 2008[38]	Overweight or obese adults (18-55years)	2 eggs (verses no egg) as part of an energy restricted weight loss diet	Decreased total and LDL cholesterol levels	Equal weight loss in both egg and no egg group. Egg fed group consumed average 582mg cholesterol per day.
Rueda et al 2013[39]	University students	Breakfast with eggs 5x per week for 14weeks versus breakfast without eggs	No significant differences in cholesterol levels between the 2 groups.	The egg breakfast contained 400mg more cholesterol than the breakfast without eggs.
Clayton et al 2015[40]	Healthy young adults (18-35 years)	2 eggs per day (compared to a bagel breakfast)	No impact on cholesterol levels	The egg breakfast also led to improvements in triglyceride levels.

Table 2: Summary of intervention studies assessing the effect of egg consumption on serum cholesterol levels in individuals with cardiometabolic disease (including type 2 diabetes)

Study reference	Population	Cholesterol/Egg Intake	Effect on lipids	Additional comments
Edington et al 1987[41]	Adults with hyperlipidemia	2 eggs or 7 eggs per week as part of a low fat, high fibre diet for 8 weeks	No change to total, LDL or HDL cholesterol	
Knopp et al 1997[42]	Adults with combined hyperlipidemia	2 eggs per day as part of an American Heart Association diet for 6 weeks	Increased LDL and HDL cholesterol levels	Adults with only high cholesterol had only non-significant increases in LDL cholesterol
Knopp et al 2003[15]	Adults with insulin resistance	4 eggs per day for 4 weeks	Increased LDL cholesterol	The increase in LDL cholesterol was less in insulin resistant individuals compared to insulin sensitive individuals
Tannock et al 2005[43]	Lean insulin-sensitive adults and lean or obese insulin-resistant adults	4 eggs per day as part of a low fat diet for 4 weeks	HDL cholesterol increased in all subjects; non-HDL cholesterol levels increased in lean insulin-sensitive subjects but not insulin-resistant subjects.	
Pearce et al 2011[26]	Adults with Type 2 diabetes or impaired glucose tolerance	2 eggs (versus no egg) as part of an energy restricted diet	Decreased total and non-HDL cholesterol levels	Blood pressure and apoB levels were also improved.
Klangjareonchai et al 2012[44]	Adults taking cholesterol lowering medication	3 eggs per day for 12 weeks	Increased HDL cholesterol; lower LDL:HDL ratio	
Blesso et al 2013[45]; Blesso et al 2013[46]; Blesso et al 2013[47]	Adults with metabolic syndrome	3 eggs per day as part of carbohydrate restricted diet for 12 weeks (compared to egg	No change in total or LDL cholesterol; Increased HDL cholesterol;	Triglyceride levels reduced. Insulin levels and insulin resistance reduced in egg group only.

		substitute)	Increased LDL particle size	Increased lutein and zeaxanthin levels (carotenoids carried by HDL particles)
Andersen et al 2013[48]	Adults with metabolic syndrome	3 eggs per day as part of carbohydrate restricted diet for 12 weeks (compared to egg substitute)	Favourable shifts in HDL lipid composition and function	
Fuller et al 2015[49]	Overweight or obese adults with type 2 diabetes or impaired glucose tolerance	2 eggs per day as part of a 3 month weight maintenance diet	No difference in change in cholesterol levels compared to group consuming <2 eggs per week	
Katz et al 2015[50]	Adults with coronary artery disease	2 eggs per day for 6 weeks	No adverse effect on cholesterol levels compared to a high-carbohydrate breakfast	