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REVIEW

# Influence of consumption of probiotics on the plasma lipid profile: A meta-analysis of randomised controlled trials

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**Abstract** *Aims:* Human clinical studies have yielded mixed results on the effects of consumption of probiotics on the plasma lipid profile. We conducted a meta-analysis of randomised controlled trials that evaluated the effects of probiotics consumption on blood lipids.
*Data Synthesis:* A systematic literature search of Embase, Web of Science, PubMed and Cochrane Controlled Trials Registry was conducted for studies that investigated the efficacy of probiotics on the plasma lipid profile of subjects. With the help of Review Manager 4.2, data from 13 trials, which included 485 participants with high, borderline high and normal cholesterol levels, were examined. The pooled mean net change in total cholesterol for those treated with probiotics compared to controls was −6.40 mg $dl^{-1}$ (95% confidence interval (CI), −9.93 to −2.87), mean net change in low-density lipoprotein (LDL) cholesterol was −4.90 mg $dl^{-1}$ (95% CI, −7.91 to −1.90), mean net change in high-density lipoprotein (HDL) cholesterol was −0.11 mg $dl^{-1}$ (95% CI, −1.90–1.69) and mean net change in triglycerides was −3.95 mg $dl^{-1}$ (95% CI, −10.32–2.42).

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*Conclusion:* These results indicate that a diet rich in probiotics decreases total cholesterol and LDL cholesterol concentration in plasma for participants with high, borderline high and normal cholesterol levels.


## Introduction

Coronary heart disease (CHD) is a major cause of morbidity and a leading cause of premature death worldwide [1]. Although there are multiple risk factors for CHD, dyslipidemia remains a major determining factor for this pathology. Observational epidemiologic studies have shown that higher concentrations of total cholesterol and low-density lipoprotein (LDL) cholesterol are strongly associated with greater risk of future cardiovascular events.

Both pharmacologic and non-pharmacologic interventions can reduce the concentrations of cholesterol in serum. Multiple approaches to diet therapy have been initiated to improve hyperlipidaemia, such as the inclusion of ω-3 fatty acids [2], soy [3], vitamin C [4], non-soy legume [5], nicotinic acid [6] and red yeast rice [7] in the diet. The cholesterol-lowering effect of probiotics products has raised much interest in recent years. Probiotics are defined as "living micro-organisms, which upon ingestion in certain numbers exert health effects beyond inherent basic nutrition". [8] Lactic acid bacteria (LAB), predominantly selected from the genera *Lactobacillus* and *Bifidobacterium*, constitutes a significant proportion of probiotic cultures in nutritional supplements, pharmaceuticals and functional foods, but certain *Bacillus* and *Enterococcus* may also be incorporated in probiotic products [9]. Probiotic-fermented foods, including milk and dairy products, have played important roles in the diet of humans worldwide for thousands of years and are consumed on a large scale. The cholesterol-lowering activity of fermented dairy products with probiotics has been demonstrated in rats [10], hamsters [11] and pigs [12]. However, human clinical studies using various probiotics have yielded mixed results, with some studies finding no effect [13—15], while others have identified a significant cholesterol-lowering effect [16—18]. Therefore, we conducted a meta-analysis of randomised controlled trials to quantify the direction and magnitude of the potential effect that the consumption of probiotics may have on serum cholesterol and triglycerides concentrations.

## Methods

### Study selection

Online databases Embase, Web of Science, PubMed and Cochrane Controlled Trials Registry (CENTRAL) were searched for studies that investigated the efficacy of probiotics on the plasma lipid profile of subjects. Articles in both English and Chinese published up to October 2010 were included. The following headings and keywords were combined using the Boolean operation: (probiotics OR *Lactobacillus* OR Bifidobacteria OR fermented milk OR yogurt OR *Bacillus* OR *Enterococcus*) AND (cholesterol OR plasma lipids OR triglycerides OR HDL OR LDL OR serum lipids).

Articles were eligible for meta-analysis if they fulfilled the following criteria: (1) the study design comprised at least a single blind of study participants to probiotics or placebo groups; (2) the mean total cholesterol, LDL cholesterol, HDL cholesterol and triglyceride concentration changes, along with standard deviation, were reported for the intervention and control groups; (3) the probiotic yogurt and capsules did not contain prebiotics or plant sterols and (4) subjects had not undergone intestinal surgery.

### Data abstraction

Two investigators (Guo and Liu) evaluated the articles for eligibility and abstracted the data independently. Any disagreement amongst the investigators in data abstraction was resolved by discussion. The following was information abstracted from eligible articles: probiotics, study design, duration of intervention, sample size, subjects' characteristics (the ratio of male and female subjects, body mass index (BMI) and age), probiotics or their fermented dairy products dosage and intervention and treatment results on the levels of total cholesterol, HDL cholesterol, LDL cholesterol and triglycerides.

### Statistical analysis

Before meta-analysis, the lipid levels in mmol/L were conversed to mg $dl^{-1}$ prior to computations. The conversion factor was 1 mg $dl^{-1}$ = 0.0259 mmol $l^{-1}$ for cholesterol and 1 mg $dl^{-1}$ = 0.0113 mmol $l^{-1}$ for triglycerides. The mean net changes (mean values ± standard deviation) in the total cholesterol, HDL cholesterol, LDL cholesterol and triglycerides for each study were calculated. For parallel trials, mean net changes for the outcomes listed above were calculated as the difference (probiotic diet minus control diet) of the changes (baseline minus endpoint) in mean values. For crossover trials, mean net changes for the outcomes were calculated as the difference (probiotic diet minus control diet) in values at the end of the intervention and control phases. Standard errors and confidence intervals were converted to standard deviation for the analyses.

All analyses were conducted using Review Manager 4.2 (The Cochrane Collaboration, Oxford, UK). The heterogeneity of effect size amongst studies was tested. To assess potential publication bias, funnel plots for each outcome were also examined.

## Results

A flowchart on article selection for the meta-analysis is shown in Fig. 1. Although the study reported in article 13