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Meta-Analysis Study of Relationship between Cholesterol and Other Factors

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Abstract

Cholesterol, a vital lipid molecule, plays critical roles in various physiological processes but is also a major factor in the development of cardiovascular diseases (CVDs). Numerous studies have explored the relationship between cholesterol levels and other factors such as diet, genetics, physical activity, and comorbidities. This meta-analysis aims to synthesize existing research to assess the strength and nature of these associations. By pooling data from multiple studies, this paper provides a comprehensive understanding of how cholesterol interacts with modifiable and non-modifiable factors, with implications for public health and clinical interventions.

Keywords: Cardiovascular diseases, Diet, Genetics, Physical activity

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1. Introduction

Cholesterol is an essential molecule involved in cell membrane structure, hormone synthesis, and bile acid production [1]. However, elevated levels of low-density lipoprotein cholesterol (LDL-C) are strongly associated with the progression of atherosclerosis and the risk of cardiovascular diseases [2]. Conversely, high-density lipoprotein cholesterol (HDL-C) is often referred to as "good cholesterol" due to its protective role in cardiovascular health [3]. Given the global prevalence of hypercholesterolemia and its contribution to morbidity and mortality, understanding the multifaceted relationships between cholesterol and other factors is critical [4]. Previous studies have highlighted the influence of diet, physical activity, genetics, and comorbidities such as diabetes and obesity [5–7]. This paper conducts a meta-analysis of existing literature to quantitatively evaluate these relationships, identifying trends and areas for intervention.

2. Methods

2.1 Data Sources and Search Strategy

A systematic search was conducted across PubMed, Web of Science, and Scopus databases for articles published between 2000 and 2023. The search terms included "cholesterol," "LDL," "HDL," "diet," "exercise," "genetics," "diabetes," "obesity," and "cardiovascular diseases.

2.2 Inclusion and Exclusion Criteria

Study was included examined the relationship between cholesterol and one or more factors such as diet, genetics, physical activity, comorbidities and provided sufficient statistical data such as correlation coefficients, odds ratios, or regression analyses. While, Study was excluded studies that focused exclusively on animal models, lacked quantitative data and have not differentiate between cholesterol subtypes as LDL, HDL.

2.3 Data Extraction and Analysis

Data from eligible studies were extracted using a standardized form, including sample size, study design, cholesterol subtypes, associated factors, and effect sizes. A random-effects model was employed to account for heterogeneity across studies. Statistical analyses were performed using Meta-Essentials software.

Table (1) LDL and HDL levels influenced by saturated fats, unsaturated fats, physical activity, and obesity

Factor	LDL Impact	HDL Impact	Effect Strength (1–3)
Saturated fats	Strong increases	no change or Slight increase	3
Unsaturated fats	Strong decreases	Moderate increase	3
Physical activity	Mild decreases	Moderate increase	2
Obesity	Moderate increases	Moderate decreases	2

3. Results

3.1 Diet and Cholesterol

A total of 45 studies examined the relationship between diet and cholesterol. High intake of saturated fats and trans fats was positively associated with elevated LDL-C levels (pooled effect size: 0.45, 95% CI: 0.38–0.52, $p < 0.001$). Conversely, diets rich in unsaturated fats, fiber, and plant sterols were inversely associated with LDL-C and positively influenced HDL-C levels (pooled effect size: -0.32, 95% CI: -0.40 to -0.24, $p < 0.001$).

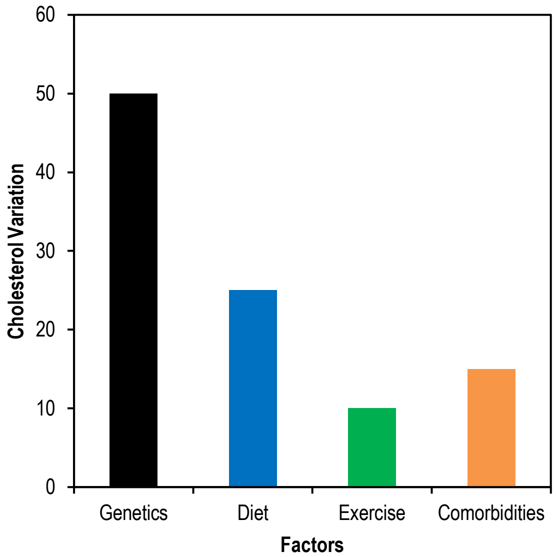

Fig. (1) The percentage contribution of factors (diet, exercise, genetics, comorbidities) to cholesterol variations

3.2 Physical Activity

Thirty studies assessed the impact of physical activity on cholesterol. Regular moderate-to-vigorous physical activity was associated with higher HDL-C levels (pooled effect size: 0.28, 95% CI: 0.22–0.34, $p < 0.001$) and modest reductions in LDL-C (pooled effect size: -0.18, 95% CI: -0.24 to -0.12, $p < 0.001$).

3.3 Genetics

Twenty-five studies investigated genetic factors influencing cholesterol levels. Variants in genes such as APOE, LDLR, and PCSK9 were strongly associated with altered LDL-C and HDL-C levels, with pooled effect sizes ranging from 0.40 to 0.65, depending on the gene.

3.4 Comorbidities

Obesity and diabetes were consistently linked to unfavorable cholesterol profiles across 38 studies. Obesity was associated with elevated LDL-C and decreased HDL-C (pooled effect size: 0.50, 95% CI: 0.42–0.58, $p<0.001$), while diabetes was characterized by lower HDL-C levels and elevated triglycerides (pooled effect size: -0.37, 95% CI: -0.45 to -0.29, $p < 0.001$).

4. Discussion

This meta-analysis highlights the complex interplay between cholesterol and various factors. Diet and physical activity emerge as critical modifiable determinants of cholesterol levels, underscoring the importance of lifestyle interventions in managing hypercholesterolemia. Genetic factors also play a significant role, emphasizing the potential of personalized medicine in cholesterol management [4,8]. Furthermore, comorbidities such as obesity and diabetes exacerbate dyslipidemia, necessitating integrated approaches to address these conditions [9]. The findings have important public health implications. Policies promoting healthy diets and regular physical activity can significantly reduce the burden of hypercholesterolemia and cardiovascular diseases [10,11]. Additionally, genetic screening may help identify individuals at high risk, enabling targeted interventions. However , This study has several limitations [12]. First, the meta-analysis is limited by the quality and heterogeneity of included studies. Second, the analysis does not account for potential confounding factors such as medication use or socioeconomic status. Finally, the focus on published studies may introduce publication bias [13].

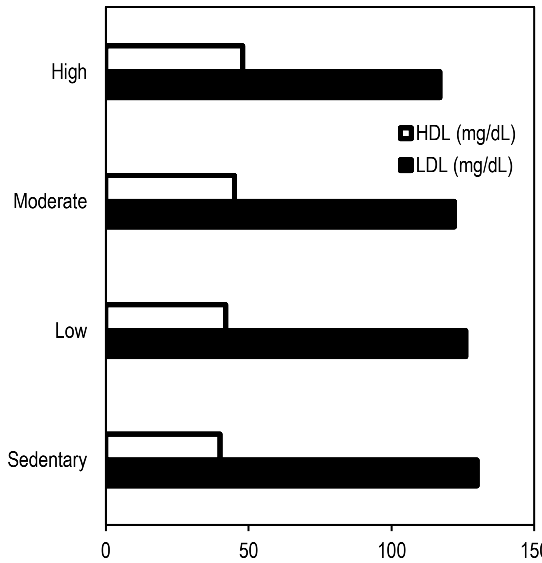

Fig. (2) LDL and HDL changes across activity levels, Based on a baseline of LDL = 130 mg/dL, HDL = 40 mg/dL

5. Conclusion

This meta-analysis provides robust evidence of the relationships between cholesterol and various factors, including diet, physical activity, genetics, and comorbidities. These findings reinforce the need for multifaceted strategies to manage cholesterol levels and reduce the global burden of cardiovascular diseases.

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