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DISCOVERY SCIENTIFIC SOCIETY

The Potential Role of Curcumin in Cardiovascular Risk and Metabolic Syndrome: A Comprehensive Review of Scientific Evidence

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ABSTRACT

Curcumin, the main active ingredient in turmeric (Curcuma longa), has caught the attention of researchers because it seems to offer many health benefits and unusual drug-like effects. This comprehensive review explores the potential impact of curcumin in mitigating cardiovascular diseases (CVD) and metabolic syndrome (MetS), drawing upon a synthesis of recent scientific evidence. This review highlights the anti-inflammatory, antioxidant, and antidiabetic effects of curcumin and discusses how these properties may influence key molecular pathways involved in the development of cardiovascular diseases (CVD). Diseases such as atherosclerosis and hypertension closely relate to inflammation and oxidative stress mechanisms that curcumin may help modulate, offering potential therapeutic benefits. This review examines randomized clinical trials investigating curcumin's effects on lipid profiles, glucose levels, and anthropometric measures in various patient populations. Several studies underscore its ability to reduce total cholesterol, LDL-C, triglycerides, and blood glucose levels while exhibiting positive impacts on weight reduction and body fat percentage in individuals with MetS. However, the review shows that study results are not consistent, so larger and longer clinical trials are needed to better understand how effective and safe this substance is. In order to completely comprehend curcumin's role as a dietary therapeutic component in managing a variety of metabolic disorders, this review emphasizes the necessity for more thorough and ongoing clinical trials.

Keywords: curcumin, cardiovascular diseases, metabolic syndrome, lipid profiles, glucose levels.

1. INTRODUCTION

Turmeric, also known as Curcuma Longa, is called "Golden Spice" due to its acute color and versatile applications. It is a plant belonging to the ginger family, mainly originating from South Asian regions. For thousands of years, turmeric has been an

integral part of culinary traditions, particularly in the Middle East and South Asia. It has also played a significant role in traditional Indian medicine (Ayurveda) for at least 4000 years (Priyadarsini, 2014; Kotha and Luthria, 2019).

Curcumin is the main component of turmeric. Chemically known as 1,7-bis(4-hydroxy-3-methoxyphenyl)-1, 6-heptane-3, 5-dione, curcumin possesses anti-inflammatory, antioxidant, anti-cancer properties, and many other biological attributes (Lestari and Indrayanto, 2014). It is a polyphenolic compound responsible for the characteristic orange-yellow pigment of this plant. As an integral ingredient in many culinary specialties, turmeric is present in curries, spices, and dishes worldwide. However, it is not only its unique flavor that captures attention but also its health potential. Curcumin is responsible for many of the positive health properties associated with turmeric. Studies show that curcumin modulates molecular pathways involved in inflammatory and oxidative processes, which are key factors in the development of cardiovascular diseases (Kim and Clifton, 2018; Marton et al., 2021; Hewlings and Kalman, 2017).

Cardiovascular diseases, such as atherosclerosis, hypertension, and heart attacks, result from complex pathological processes in which inflammation and oxidative stress play significant roles (Furukawa et al., 2004; Grandl and Wolfrum, 2018; Masenga et al., 2023).

Cardiovascular diseases constitute one of the most common causes of death in Poland and Europe. In 2018, they accounted for 40.6% of deaths in Poland (Statistics Poland, 2020).

Curcumin significantly modulates blood lipid and triglycerides levels, lowers blood glucose concentration and glycated hemoglobin levels and supports weight reduction, including BMI, thus aiding in the treatment of components of metabolic syndrome (Rahimi et al., 2016; Jiménez-Osorio et al., 2016; Panahi et al., 2017; Adab et al., 2019; Di Pierro et al., 2015; Yang et al., 2014; Rahmani et al., 2016; Jazayeri-Tehrani et al., 2019; Chuengsamarn et al., 2012; Unhapipatpong et al., 2023).

Metabolic syndrome is a complex set of factors increasing the risk of cardiovascular diseases. It consists of abdominal obesity, insulin resistance, arterial hypertension, and abnormal levels of lipids and glucose in the blood (Alberti et al., 2009; Grundy et al., 2004). Metabolic syndrome significantly increases the risk of cardiovascular diseases (Mottillo et al., 2010; Grundy et al., 2019).

The WOBASZ II study provides epidemiological data on metabolic syndrome in Polish adults aged 20–74. In 2014, the frequency of metabolic syndrome was 33% in women and 39% in men. Since 2003 (WOBASZ I study), the frequency has increased by over 3% in women and almost 9% in men (Rajca et al., 2021).

Overall, metabolic syndrome creates conditions conducive to the development of cardiovascular diseases through multiple interactions with the circulatory and metabolic systems. Controlling risk factors of metabolic syndrome, such as maintaining a healthy body weight, following a nutritional diet, persistent engaging in physical activity, and regularly monitoring glycemic and lipid profiles, is an essential preventive strategy that can reduce the risk of heart and vascular pathology in individuals affected by this syndrome (Mottillo et al., 2010, Grundy et al., 2019).

Objective

This review explores how curcumin might help the body and whether it could be useful as a supplement to prevent heart disease and metabolic syndrome, based on results from clinical studies.

2. REVIEW METHOD

We looked through many scientific articles and publications available on PubMed. We performed the literature search and analysis over approximately three months. The inclusion criteria for literature search and selection comprised randomized clinical trials (RCTs), observational studies, meta-analyses, and systematic reviews focusing on the effects of curcumin on cardiovascular health and metabolic syndrome. The results were meticulously checked, compared, and summarized. The literature was searched using keywords in both Polish and English, including: "curcumin," "turmeric," "cardiovascular diseases," "metabolic syndrome," "randomized clinical trials," "lipid profiles," "glucose levels," and "anthropometric measures."

3. RESULTS AND DISCUSSION

In a randomized study by Rahimi et al. in 2016, using 80 mg/day of nano micelle curcumin (SinaCurcumin®) in patients with type II diabetes, a reduction in HbA1C, fasting glucose, and BMI was observed compared to placebo. However, the study did not demonstrate a statistically crucial change in serum total cholesterol, low-density lipoprotein cholesterol (LDL-C), or high-density lipoprotein cholesterol (HDL-C) concentrations.

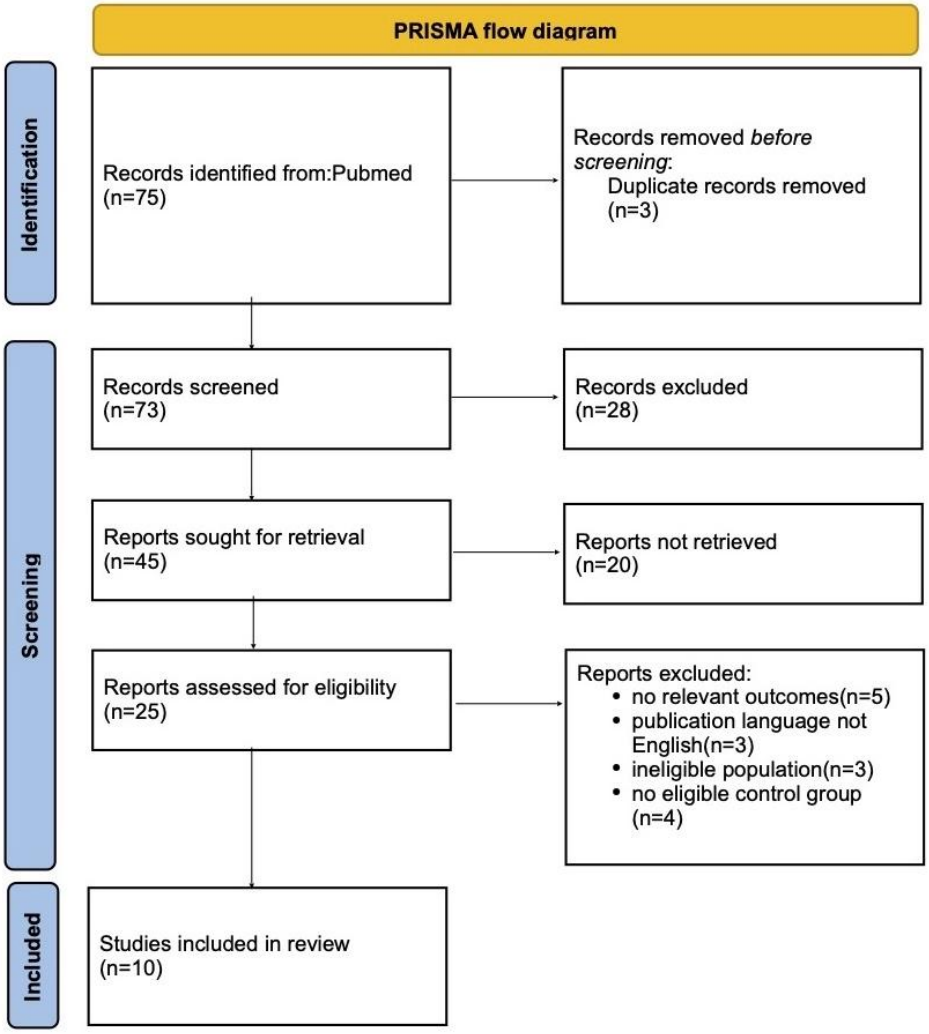

Fig 1: PRISMA flow diagram

The study was a double-masked, randomized, placebo-controlled trial conducted at Mashhad University of Medical Sciences. Researchers screened 92 patients with type 2 diabetes; 22 were excluded based on eligibility criteria or personal refusal. Seventy patients (aged ≥18, with suspected CAD and confirmed diabetes) were enrolled and randomly assigned to receive either nano curcumin (n=35) or placebo (n=35) for 12 weeks, alongside standard treatment. Exclusion criteria included pregnancy, cancer, autoimmune or chronic liver/kidney diseases, recent infections or surgeries, and use of steroids or hormone therapy. The team measured clinical and biochemical parameters before and after the intervention (Rahimi et al., 2016).

In another randomized study from Mexico by Jiménez-Osorio et al., (2016) administered 107 mg of curcumin with each meal (320 mg/day) to patients with non-diabetic and diabetic kidney disease with proteinuria (proteinuria ≥ 1 g protein/24 hours) aged 20 to 70 years; 60% were male, and 51% were diabetic. Researchers gave 26 non-diabetic CKD patients a placebo and 24 curcumin (320 mg/day). In the diabetic group, 23 received a placebo and 28 curcumin for 8 weeks. The researchers did not observe any improvement in proteinuria, estimated glomerular filtration rate, or lipid profile. However, curcumin reduced lipid peroxidation in individuals with chronic kidney disease and proteinuria without diabetes and increased antioxidant capacity in those with chronic kidney disease and proteinuria. To confirm these findings, researchers must conduct additional studies employing higher doses of curcumin and extended observation periods, as the observed effects were limited.

Panahi et al., (2017) studied the treatment of patients with type II diabetes using curcuminoids in combination with piperine. Eligible participants had a confirmed diagnosis of type 2 diabetes based on fasting glucose ≥126 mg/dL, HbA1C ≥6.5%, or current use of antidiabetic medication. Exclusion criteria included pregnancy, breastfeeding, cancer, chronic liver disease, inability to give informed

consent, or participation in another clinical trial. The results demonstrated a reduction in lipoprotein(a) (Lp(a)) concentrations and an elevation in high-density lipoprotein cholesterol (HDL-C) levels in the bloodstream. The curcuminoid group exhibited a significant reduction in total cholesterol, non-LDL cholesterol, and Lp(a), as well as an increase in HDL-c compared to the placebo group. Therefore, curcuminoids with piperine could be a valuable addition to treating lipid disorders in type 2 diabetes patients.

Adab et al., (2019) supported Panahi's results by investigating the effects of turmeric on glycemic levels, lipid profile, CRP levels, and antioxidant potential in patients with type 2 diabetes. In this double-masked, randomized clinical trial, researchers assigned 80 hyperlipidemic diabetic patients to receive either 2,100 mg/day of turmeric powder or a placebo for 8 weeks. Seventy-five patients completed the study. The trial showed a large decrease in body weight, triglyceride levels, and LDL cholesterol in the turmeric group compared to baseline. However, the researchers did not observe any substantial changes in blood glucose levels, inflammatory markers, or antioxidant capacity.

Di Pierro et al., (2015) investigated the effects of curcumin on weight management in overweight individuals. Researchers enrolled forty-four participants who had lost less than 2% of their body weight after 30 days of diet and lifestyle intervention. They then randomly assigned them to receive either curcumin in phytosome form (complexed with phosphatidylserine) or pure phosphatidylserine for an additional 30 days. The study team assessed anthropometric data and body composition at baseline, day 30, and day 60. The curcumin group showed significant reductions in body weight, fat mass, waist circumference, and BMI, suggesting curcumin may support weight loss in overweight individuals.

Yang et al., (2014) investigated the effects of daily curcumin supplementation on metabolic parameters in patients with metabolic syndrome. In this 12-week randomized, placebo-controlled trial, 65 patients were assigned to receive either curcumin extract (630 mg, three times daily; n=33) or placebo (n=32). The study showed a significant increase in HDL-C and decreased LDL levels after curcumin supplementation. Triglycerides were also reduced by 65 mg/dl. However, curcumin did not affect body weight and glucose homeostasis in patients with metabolic syndrome.

In the study by Rahmani et al., (2016) involving patients with ultrasonographically confirmed non-alcoholic fatty liver disease. Researchers randomly assigned participants to receive either an amorphous dispersion curcumin formulation (500 mg/day, equivalent to 70 mg of curcumin) or a matched placebo for 8 weeks. Curcumin supplementation resulted in a notable reduction in liver fat content in 78.9% of participants, compared to 27.5% in the placebo group. There was also a notable decrease in body mass index, cholesterol levels, triglycerides, aspartate aminotransferase, alanine aminotransferase, glucose, and glycated hemoglobin compared to the placebo group.

Jazayeri-Tehrani et al., (2019) conducted a randomized, double-blind clinical trial to study the impact of nano-curcumin in 84 overweight or obese patients with Non-Alcoholic Fatty Liver Disease (NAFLD) patients aged 25-50 years with BMI between 25 and 35kg/m2. Participants were randomly assigned to receive either nano-curcumin (40 mg twice daily) or placebo for 3 months. The investigators advised lifestyle changes in addition to supplementation. Curcumin supplementation produced a significant increment in HDL-C and a significant decrement in liver enzymes (ALT, AST), lipids (TC, LDL-C, TG), fasting glucose, insulin, HbA1c, HOMA-IR and inflammatory markers (TNF-α, IL-6, and hs-CRP). The researchers also recorded a decrease in waist circumference; however, they did not observe significant improvements in body weight, BMI, body composition, or blood pressure compared to the control group.

Chuengsamarn et al., (2021) demonstrated that curcumin may help prevent the progression of type 2 diabetes in individuals with prediabetes. In this randomized, double-blind, placebo-controlled trial, 240 participants received a curcumin extract at a dose of 1500 mg per day for 12 weeks or placebo for 9 months. Independent investigators used computer-generated numbers to randomize 120 participants into the curcumin group and 120 into the placebo group. The researchers observed improvements in insulin sensitivity and a reduction in fasting glucose levels compared to the placebo group. Additionally, he found that curcumin had no important effect on blood lipid levels, including total cholesterol, LDL-C, and HDL-C.

The study by Unhapipatpong et al., (2023) reviewed data from previous Systematic Reviews, Meta-Analyses, and earlier Randomized Controlled Trials, encompassing 50 studies with a total of 2,879 participants. The findings showed that curcumin supplementation was significantly associated with a reduction in body weight, and waist circumference. Specifically, curcumin reduced BMI by an average of −0.74, −0.41, −0.28, and −0.23 kg/m² in adults with Polycystic Ovary Syndrome (PCOS), NAFLD, obesity, and MetS, respectively. It also lowered body weight by −1.09, −1.04, and −0.71 kg in individuals with Type 2 Diabetes Mellitus (T2DM), NAFLD, and obesity, and reduced waist circumference by −2.67 and −1.64 cm in patients with T2DM and obesity. For mulations designed to enhance bioavailability produced the most pronounced benefits. These results support the use of curcumin, particularly in

high-bioavailability forms, as a valuable adjunct to lifestyle interventions for improving anthropometric parameters in individuals with metabolic disorders.

Table 1: Summary of Clinical Studies Investigating the Effects of Curcumin on Metabolic Parameters.

Author (Year)	Population	Curcumin Dose & Form	Duration	Main Outcomes
Rahimi et al., 2016	70 patients with type 2 diabetes	80 mg/day, nano micelle (SinaCurcumin®)	12 weeks	↓ HbA1C, fasting glucose, BMI; no effect on lipid profile
Jiménez-Osorio et al., 2016	101 patients with CKD and proteinuria (51% diabetic)	320 mg/day	8 weeks	No change in proteinuria, eGFR, or lipids; ↑ antioxidant capacity in non-diabetics
Panahi et al., 2017	Patients with type 2 diabetes	Curcuminoids + piperine	~8 weeks	↓ TC, non-LDL-C, Lp(a); ↑ HDL-C
Adab et al., 2019	80 patients with diabetes and hyperlipidemia	2,100 mg/day turmeric powder	8 weeks	↓ body weight, LDL-C, TG; no significant effect on glycemia or oxidative stress
Di Pierro et al., 2015	44 overweight individuals	Phytosomal curcumin	30 days (after prior 30-day lifestyle intervention)	↓ body weight, BMI, waist circumference, fat mass
Yang et al., 2014	65 patients with metabolic syndrome	1,890 mg/day curcumin extract	12 weeks	↓ LDL-C, TG; ↑ HDL-C; no effect on body weight or glycemic parameters
Rahmani et al., 2016	Patients with NAFLD	500 mg/day amorphous dispersion (70 mg pure curcumin)	8 weeks	↓ liver fat, BMI, glucose, HbA1C, cholesterol, TG, ALT, AST
Jazayeri-Tehrani et al., 2019	84 overweight or obese NAFLD patients	80 mg/day nano-curcumin	3 months	↓ ALT, AST, TG, LDL-C, glucose, HbA1C, insulin, HOMA-IR; ↑ HDL-C; no effect on body weight or BMI
Chuengsamarn et al., 2012	240 individuals with prediabetes	1,500 mg/day curcumin	9 months	↓ fasting glucose, ↑ insulin sensitivity; no effect on lipid profile

Unhapipatpong et al., 2023	Meta-analysis of 50 RCTs (n=2,879)	Various curcumin formulations	Various	↓ BMI, body weight, waist circumference; strongest effects with enhanced bioavailability forms

4. CONCLUSION

The review highlights the ambiguity in the results of scientific studies while emphasizing the promising effects of curcumin in reducing cardiovascular risk through its anti-inflammatory properties, modulation of lipid levels, support for reducing adipose tissue, and lowering blood glucose levels. Cardiovascular diseases such as atherosclerosis, arterial hypertension, and heart attacks are conditioned by these pathological processes, remaining major causes of death in Poland and Europe. The review highlights curcumin's ability to modify lipid levels, reduce fasting glucose, and support weight loss, potentially aiding in the treatment of metabolic syndrome. Metabolic syndrome, obesity, insulin resistance, high blood pressure, and unusual lipids and glucose levels significantly increase the risk of heart disease. Addressing these risk factors through lifestyle modifications reduces the risk of heart disease in individuals affected to a great extent. The review analyzes various randomized studies regarding the impact of curcumin. While some studies show favorable outcomes, such as reductions in fasting glucose levels and body mass index (BMI), others reveal limited effects on lipid profiles or glucose levels. Studies evaluating the impact of curcumin on kidney diseases in diabetes or its antioxidant potential suggest partial benefits, emphasizing the need for higher doses and more extended observation periods to obtain conclusive results. Emerging evidence suggests that curcumin may help reduce total cholesterol, blood glucose levels, adipose tissue, and body mass index (BMI). The increased availability of supplements containing curcumin, designed explicitly for obesity, dysglycemia, and general antioxidant needs, raises concerns about their purported benefits and calls for a broader assessment of their actual clinical effectiveness. Discrepancies in results highlight the optimal dose and safety profile for using curcumin to prevent heart disease and metabolic syndrome, underscoring the need for rigorous research.

Author's Contributions

Conceptualization - KK, JJ, NS; methodology -JJ, KJ, OK; Software - JJ, KJ; Check - AK, NS, OK, JLK; Formal Analysis - JJ, KK, JK; Investigation – KJ, KK, JK, JLK; Resources - KJ, JK, ŁF; Data Curation – KK, AK; Writing Rough Preparation - JJ, KJ; Writing, review and editing - JJ, ŁK, OK; Visualisation – JJ, AK, KK; Supervision - JJ, KJ; Project Administration – JJ.
All authors have read and agreed with the published version of the manuscript.

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Informed consent

Not applicable.

Ethical approval

Not applicable.

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Conflict of interest

The authors declare that there is no conflict of interest.

Data and materials availability

All data associated with this study are present in the paper.

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