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Effects of Specific Dietary Patterns on Glucose and Lipid Metabolism: Mediterranean Diet, DASH Diet, and Ketogenic Diet

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Abstract. As the global burden of metabolic diseases continues to rise, dietary intervention has attracted widespread attention as a non-pharmacological management strategy. The Mediterranean diet, the Dietary Approaches to Stop Hypertension (DASH) diet, and the ketogenic diet are three representative dietary patterns with distinct characteristics in glucose and lipid metabolism regulation, yet their relative advantages and applicable populations remain controversial. This article systematically reviews the research progress on the effects of these three dietary patterns on glucose and lipid metabolism, comparing their efficacy, safety, and limitations. The Mediterranean diet has the most robust evidence, with cross-sectional studies showing a significant reduction in metabolic syndrome risk and intervention studies confirming improvements in glycemic control and significant reductions in glycated hemoglobin (HbA1c). The DASH diet has unique advantages in reducing waist circumference and systolic blood pressure, but its improvement in fasting glucose is weaker than that of the Mediterranean diet. The ketogenic diet shows the most prominent effects in rapid weight loss and short-term glucose reduction, but it may reduce glucose tolerance and increase apolipoprotein B levels, with long-term safety remaining uncertain. Current evidence is dominated by cross-sectional studies and short-term interventions, with long-term safety and cross-ethnic applicability remaining unclear. Future research should include long-term randomized controlled trials and precision matching studies based on metabolic phenotypes.

Keywords: mediterranean diet, DASH diet, ketogenic diet, glucose and lipid metabolism

1. Introduction

The accelerating global aging trend and lifestyle transitions are bringing about an increased prevalence of metabolic diseases, including hyperglycemia, hyperlipidemia, and hypertension. According to the Global Burden of Disease Study (GBD 2023), high blood glucose and high body mass index were the only two of the top ten global health risk factors whose associated health loss continued to rise from 2010 to 2023, underscoring the deteriorating trend of metabolic disorders. Although clinical diagnostic and therapeutic technologies have advanced considerably, long-term glycemic and lipid control in patients with metabolic diseases remains suboptimal worldwide.

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Metabolic abnormalities are closely associated with cardiovascular events, end-stage renal disease, and premature death, and these conditions impose a heavy burden on global healthcare systems.

Current management relies mainly on glucose-lowering, lipid-lowering, and antihypertensive medications, supplemented by dietary recommendations and exercise guidance. Medications are effective in the short term but limited by adverse effects, rebound after discontinuation, and declining long-term adherence. Conventional dietary and exercise programs also have limitations: they often lack systematic behavioral support and individualized design, resulting in poor long-term adherence and substantial inter-individual variability in intervention effects. These limitations have prompted researchers to look beyond pharmacological and conventional lifestyle interventions toward overall dietary patterns as an alternative or supplement.

Three dietary patterns have received particular attention: the Mediterranean diet, the DASH (Dietary Approaches to Stop Hypertension) diet, and the ketogenic diet. The Mediterranean diet is rich in monounsaturated fatty acids, fiber, and polyphenols, and appears to improve insulin sensitivity and lipid profiles. The DASH diet emphasizes high potassium, magnesium, and calcium intake with low sodium, and has been shown to lower blood pressure and improve metabolic syndrome parameters. The ketogenic diet uses extremely low carbohydrate intake to induce ketosis, producing rapid short-term reductions in body weight and blood glucose. However, the evidence remains inconsistent. Applicable populations are not uniformly defined. Long-term safety data are limited, and the ketogenic diet raises particular concern regarding its potential effects on blood lipids and liver and kidney function [1].

This review examines what is known about how these three diets affect glucose and lipid metabolism, compares their efficacy, safety, and limitations, and considers the implications for individualized dietary strategies and future research.

2. Mediterranean diet

Patients with glucose and lipid metabolism disorders face multiple challenges in dietary intervention practice: single-nutrient recommendations have limited effects, long-term patient adherence is insufficient, the efficacy of different dietary regimens is highly heterogeneous, and precision matching strategies for different metabolic phenotypes are lacking. This chapter reviews original studies on the Mediterranean diet in the field of glucose and lipid metabolism, aiming to clarify its effectiveness, applicable conditions, and potential risks.

Gómez-Sánchez et al. analyzed cross-sectional data from 1,280 Spanish adults over 65 [2]. Those with good adherence to the Mediterranean diet showed roughly one-third lower metabolic syndrome risk (OR=0.675). Their vascular stiffness index CAVI was also significantly improved (OR=0.835). The authors suggested that the diet may improve vascular function through pathways independent of conventional metabolic mechanisms. Two limitations remain: the cross-sectional design cannot prove causality, and the study was limited to Spanish Caucasians, so extrapolation should be cautious.

A second study by the same group extended the analysis to 3,417 Spanish adults aged 35–74 [3]. Metabolic syndrome risk was 44.5% lower (OR=0.555), and fasting glucose, triglycerides, blood pressure, and waist circumference all showed consistent inverse associations. The effect size was larger and the statistical precision higher than in the first study, which strengthens the case for a multidimensional protective effect of the Mediterranean diet. Even so, the same limitations apply: cross-sectional design and a single population.

Derrick et al. ran a 16-week single-arm intervention combining a Mediterranean-style diet with whey protein supplementation and exercise [4]. Fasting glucose fell by 12.0 mg/dL in prediabetic

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patients and by 19.6 mg/dL in those with type 2 diabetes. In the type 2 diabetes group, HbA1c dropped from 6.8% to 6.0%, effectively moving patients into a better glycemic category. The sample was small and there was no control group, but the stability of glycemic markers after the intervention and the consistency of trends across groups suggest the combined regimen is reasonably robust.

Currenti et al. conducted a 16-week head-to-head non-randomized trial comparing a low-carbohydrate diet with a Mediterranean diet in 100 overweight/obese patients with type 2 diabetes [5]. The results showed that the low-carbohydrate diet achieved significantly greater improvements in BMI (-10.11% versus -8.20%), fasting glucose (-37.6% versus -21%), and HbA1c (-23.2% versus -13.5%) than the Mediterranean diet did. For patients with poor glycemic control who require rapid metabolic improvement, a low-carbohydrate diet may be the short-term priority, while the Mediterranean diet is relatively moderate in glycemic and weight control, and its traditional advantages in long-term cardiovascular protection still require validation in longer follow-up studies.

In summary, existing cross-sectional and short-term intervention evidence suggests that the Mediterranean diet has protective effects on metabolic syndrome, blood glucose, and triglycerides, and that it may improve vascular function independently of traditional metabolic pathways. However, the evidence is predominantly from Spanish populations, and intervention periods have not exceeded 16 weeks, leaving long-term safety and cross-ethnic applicability unclear. Future long-term randomized controlled trials and precision matching studies based on different metabolic phenotypes are needed.

3. DASH diet

The multiple challenges faced by patients with glucose and lipid metabolism disorders in dietary intervention practice also apply to the evaluation of the DASH diet. Unlike the Mediterranean diet, which is characterized by unsaturated fatty acids, the DASH diet was originally designed to control hypertension and emphasizes high potassium, magnesium, and calcium intake and low sodium intake, while focusing on a balanced combination of whole grains, vegetables, fruits, and low-fat dairy products. In recent years, the research scope of the DASH diet has expanded from blood pressure reduction to glucose and lipid metabolism, but whether its glucose- and lipid-lowering effects are independent of its antihypertensive action and whether they are consistently applicable across different populations still require systematic review (Table 1).

Liu et al. analyzed cross-sectional data from 8,780 adults in the US National Health and Nutrition Examination Survey (NHANES) 2005–2008 and found that the highest quintile of DASH diet adherence had a 40% lower risk of metabolic syndrome (OR = 0.60) than the lowest quintile did, with DASH scores significantly negatively correlated with waist circumference, fasting glucose, triglycerides, and systolic blood pressure [6]. This finding is highly consistent in effect direction with cross-sectional evidence for the Mediterranean diet, which suggests that different dietary patterns may exert protective effects through similar metabolic pathways. Subgroup analysis showed that the protective effect was more pronounced in women, Caucasian individuals, high-income individuals, and physically active populations, suggesting that the metabolic benefits of the DASH diet may be modified by multiple factors. However, the cross-sectional design cannot establish causality, and dietary data relied on self-reporting, which may introduce recall bias.

Konikowska et al. further validated this association based on cross-sectional data from 535 adults in Poland [7]. The study found that each 1-point increase in DASH score was associated with a 5% reduction in metabolic syndrome risk (OR = 0.95) and a 7% reduction in abdominal obesity risk

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(OR = 0.93), and that higher DASH scores were positively correlated with high-density lipoprotein (HDL) cholesterol and negatively correlated with triglycerides and waist circumference. Although the effect size was smaller than that of Liu et al. [6], the study analyzed DASH scores as a continuous variable, which revealed a dose-response relationship and corroborated the metabolic protective effects of the DASH diet from another perspective. The study also had limitations, including a cross-sectional design and limited population representation.

Valenzuela-Fuenzalida et al. conducted a systematic review and meta-analysis including 5 randomized controlled trials (RCTs) with 2,013 patients and found that the DASH diet was significantly superior to other dietary patterns in reducing systolic blood pressure (standardized mean difference [SMD] = −8.06), diastolic blood pressure (SMD = −6.38), low-density lipoprotein (LDL) cholesterol (SMD = −1.29), and increasing HDL cholesterol (SMD = 0.70) [8]. Compared with cross-sectional studies, this meta-analysis provided higher-level prospective causal evidence, but the intervention periods were generally short (4–12 weeks), and the included studies were highly heterogeneous, with overall evidence quality rated as "low" to "very low," requiring cautious interpretation.

Lv et al. conducted a network meta-analysis including 26 RCTs with 2,255 patients with metabolic syndrome and found that the DASH diet was superior to conventional diets in reducing waist circumference (mean difference [MD] = −5.72 cm) and systolic blood pressure (MD = −5.99 mmHg) [9]. The analysis also revealed differential effect profiles among different dietary patterns: the ketogenic diet was prominent in reducing blood pressure and triglycerides, the Mediterranean diet had greater advantages in improving fasting glucose, and the DASH diet had a unique position in reducing abdominal obesity and blood pressure. This finding provides direct evidence for the precision nutrition strategy of "matching dietary regimens by metabolic phenotype," but direct comparative evidence between dietary patterns is limited, with most conclusions derived from indirect comparisons.

In summary, existing evidence indicates that the DASH diet has relatively consistent improvement effects on waist circumference and blood pressure, and favorable effects on triglycerides and HDL cholesterol, but its evidence for fasting glucose improvement is relatively weaker than that of the Mediterranean diet. Network meta-analysis suggests that the DASH diet may have unique advantages in abdominal obesity and hypertension phenotypes, but this conclusion is limited by the short intervention periods and substantial heterogeneity of the original studies, with long-term follow-up and cross-ethnic validation still insufficient. Future research should further distinguish whether the antihypertensive and glucose-lowering effects of the DASH diet are independent of each other and clarify its optimal applicable population in precision nutrition strategies.

4. Ketogenic diet

The ketogenic diet is characterized by extremely low carbohydrate (<50 g/d) and high fat (70%–75%) intake, inducing ketone body production to switch the body from glucose-based to ketone-based energy supply. This pattern does not originate from traditional dietary culture but was first proposed in 1921 for the adjunctive treatment of refractory epilepsy in children. In recent years, its short-term weight loss and glucose control effects have attracted widespread attention, but the high-fat characteristics have also raised concerns about cardiovascular safety. This chapter reviews systematic evaluations and original studies on the ketogenic diet in glucose and lipid metabolism, assessing its efficacy and safety (Table 1).

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Zhou et al. conducted a meta-analysis including 8 RCTs and found that the ketogenic diet had significant benefits in reducing body weight (SMD = −5.63), waist circumference (SMD = −2.32), HbA1c (SMD = −0.38), triglycerides (SMD = −0.36), and increasing HDL cholesterol (SMD = 0.28), indicating multidimensional short-term effects in weight loss, glucose control, and lipid improvement [10]. However, the included studies were heterogeneous in intervention duration and protocol composition, and most had short follow-up periods, making long-term effects impossible to assess.

Hengist et al. conducted a 12-week RCT and found that although the ketogenic diet reduced fat mass, it decreased glucose tolerance and increased apolipoprotein B and C-reactive protein levels, suggesting deterioration of the atherogenic lipoprotein profile [11]. Notably, some effects were no longer significant at week 12, suggesting possible adaptive adjustment by the body. The study suggests that the metabolic effects of the ketogenic diet are closely related to its unique nutritional structure and ketone body production, and its early cardiovascular risk signals warrant attention, but the study population was healthy adults, and extrapolation to patient populations requires further validation.

Jing et al. conducted a network meta-analysis including 42 RCTs with 4,809 patients with type 2 diabetes and found that the ketogenic diet was significantly effective in reducing HbA1c (MD = −0.73), but was inferior to moderate-carbohydrate diets (MD = −1.30), low-glycemic index diets (MD = −1.26), and the Mediterranean diet (MD = −0.95) in reducing fasting glucose [12]. The study also found that the reductions in HbA1c and fasting glucose were significantly correlated with weight change, suggesting that the glycemic improvement effects of dietary patterns may be partially mediated by weight loss.

Table 1. Comparison of three dietary patterns on glucose and lipid metabolism

Comparison Dimension	Mediterranean Diet	DASH Diet	Ketogenic Diet
Core characteristics	High monounsaturated fatty acids, dietary fiber, polyphenols	High potassium, magnesium, calcium, low sodium	Extremely low carbohydrate (<50 g/d), high fat (70%–75%) (ketosis)
Weight loss effect	Moderate, sustainable	Moderate	Short-term significant, long-term uncertain
Glycemic control	Strong evidence (HbA1c ↓, fasting plasma glucose (FPG) ↓)	Moderate evidence	Short-term strong, long-term questionable
Lipid improvement	Triglycerides ↓, HDL ↑	Triglycerides ↓, HDL ↑	Triglycerides ↓↓, HDL ↑, LDL variable
Blood pressure improvement	Moderate evidence	Strong evidence (systolic blood pressure (SBP) −5.99 mmHg)	Short-term improvement
Waist circumference/abdominal obesity	Significant improvement	Strong evidence (−5.72 cm)	Short-term significant

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Table 1. (continued)

Recommended population	Poor glycemic control	Abdominal obesity + hypertension	Short-term rapid weight loss/glucose control, medically supervised
Main limitations	Single population, insufficient long-term data	Glycemic evidence weaker than Mediterranean diet	Long-term safety concerns, poor adherence

In summary, the ketogenic diet can effectively reduce body weight, waist circumference, HbA1c, and triglycerides in the short term, with the most prominent effects on weight loss (SMD = −5.63) and HbA1c reduction (MD = −0.73). However, its effects on LDL cholesterol and apolipoprotein B vary considerably among individuals, and cardiovascular safety remains a major concern for long-term use. Among the three dietary patterns, the ketogenic diet shows the most significant effects in rapid weight loss and short-term glucose reduction but is inferior to the Mediterranean diet in fasting glucose improvement, with long-term safety remaining uncertain. Therefore, the ketogenic diet should be regarded as a time-limited, medically supervised intervention rather than a universally applicable long-term dietary pattern.

5. Conclusion

This article systematically reviews the research progress on the effects of three representative dietary patterns—the Mediterranean diet, DASH diet, and ketogenic diet—on glucose and lipid metabolism. All three dietary patterns show potential in improving glucose and lipid metabolism, but their effect targets, evidence strength, and applicable conditions differ significantly.

The Mediterranean diet has the highest level of evidence, with advantages in comprehensive improvement of glycemic regulation and vascular function, particularly suitable for patients with metabolic syndrome and poor glycemic control. The core value of the DASH diet lies in targeted improvement of abdominal obesity and blood pressure, with unique advantages for patients presenting primarily with hypertension and central obesity. The ketogenic diet shows the most prominent effects in rapid weight loss and short-term glucose reduction, but the accompanying cardiovascular risk signals suggest it should be a short-term medically supervised intervention rather than a universally applicable long-term dietary pattern. The common pattern among the three dietary patterns is that their metabolic benefits transcend the simple summation of individual nutrients, reshaping energy metabolism and inflammatory status through overall dietary structure, with effect intensity closely related to adherence levels. Their differential effect profiles suggest that future efforts should move beyond the "one-size-fits-all" dietary recommendation model toward precision matching strategies based on patients' primary metabolic phenotypes.

Several limitations remain. Study populations are predominantly Caucasian from Europe and America, leaving cross-ethnic applicability unclear. Most intervention periods are shorter than 16 weeks, leaving long-term efficacy and safety data insufficient. Studies also vary widely in dietary protocol and outcome measures. Three questions in particular need clarification through long-term randomized controlled trials: the long-term cardiovascular safety of the ketogenic diet, the optimal timing of each approach at different disease stages, and the interaction between dietary intervention and pharmacological treatment. Future research should focus on cross-ethnic, multicenter trials; metabolic phenotype-based prediction models; and the synergistic effects of diet and medication, to support individualized clinical management.

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