Assessing the impact of fatty diets on blood pressure: A systematic review and meta-analysis

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ABSTRACT

Background and Objectives: Hypertension is a major risk factor for cardiovascular diseases, with dietary fats playing a critical role in its regulation. While unsaturated fats are associated with blood pressure (BP) reduction, saturated and trans fats may exacerbate hypertension. This systematic review and meta-analysis aimed to evaluate the impact of various fatty diets on systolic (SBP) and diastolic blood pressure (DBP) and identify dietary patterns most effective for BP management. **Methods and Study Design:** A comprehensive search of MEDLINE and ClinicalTrials.gov (inception to February 2025) identified randomized clinical trials and observational studies assessing dietary fats' effects on BP. Twenty-five studies (n=14,522 participants) met inclusion criteria. Data were analyzed to estimate mean differences (MDs) with 95% confidence intervals (CIs). Funnel plots were generated to assess publication bias. Risk of bias was assessed using the RevMan Web tool, and sensitivity analyses were conducted. **Results:** Food-based oil diets significantly reduced SBP and DBP (MD: -18.43 and -12.90 mm Hg). Low-fat and unsaturated fat-enriched diets lowered SBP (-6.91 and -4.46 mm Hg) and DBP (-3.78 and -0.74 mm Hg). The DASH diet had moderate effects (SBP: -3.83, DBP: -2.18 mm Hg). Omega-3 and high-fat diets showed smaller reductions. Saturated fat restriction had minimal impact. **Conclusions:** Food-based fatty oil diets had the greatest BP reduction, while low-fat, unsaturated fat-enriched, and DASH diets (fat-based variation) showed moderate effects. High-fat and omega-3 diets had smaller impacts, emphasizing diet’s role in BP management.

Key Words: hypertension, fatty diets, systolic blood pressure (SBP), diastolic blood pressure (DBP), unsaturated fats

INTRODUCTION

Dietary fats play a crucial role in influencing blood pressure (BP) levels in individuals. A fatty diet refers to a dietary pattern characterized by a high intake of fats, including saturated fats, monounsaturated fats (MUFA), and polyunsaturated fats (PUFA). These diets can vary based on fat type and source, such as animal fats, plant-based oils, or omega-3 fatty acids.Research suggests that specific components of dietary fats, such as marine n−3 polyunsaturated fatty acids (PUFAs), have been associated with significant BP-lowering effects, particularly in hypertensive populations.[1,2] Conversely, the impact of other dietary fatty acids on BP remains inconclusive, with inconsistent or minor clinical effects noted.[3] Additionally, studies have shown that dietary fats obtained from seafood and dairy products

can potentially protect against abnormal BP, highlighting the importance of the fat source in BP management.[4] Furthermore, the oxidation of omega-6 fats like linoleic acid can lead to the production of reactive aldehydes that inhibit nitric oxide generation, potentially elevating BP levels and contributing to hypertension.[5] Understanding the diverse effects of different dietary fats on BP regulation are essential for developing effective dietary recommendations for hypertension prevention and management.

Different types of dietary fats have varying effects on BP. Research suggests that marine PUFAs have a notable BP lowering effect, especially in hypertensive populations, while the Dietary Approaches to Stop Hypertension (DASH) diet and Mediterranean-style diet, which are lower in saturated fatty acids, and higher in monounsaturated fats (MUFAs), are beneficial for hypertension prevention and management.6 Conversely, high intake of saturated fatty acids, MUFAs, and trans-unsaturated fatty acidshas been associated with an increased risk of hypertension, with trans fatty acidsshowing a significant positive association even after adjusting for obesity-related factors.[7] Additionally, PUFAs, including omega-3 and omega-6 PUFAs, did not show a significant association with hypertension risk in middle-aged and older women.[8] Therefore, incorporating sources of beneficial fats like marine n−3 PUFAs, MUFAs, and avoiding high saturated fatty acids and trans fatty acidsmay play a crucial role in BP regulation.

Previous studies have extensively investigated the effects of different dietary fats on BP. Replacing saturated fatty acids with unsaturated fats, particularly MUFAs, has been linked to beneficial effects on cardiometabolic profiles, such as increased HDL cholesterol and reduced aspartate aminotransferase levels.[9] Moreover, high-MUFA diets, when substituted for high-carbohydrate diets, did not demonstrate a greater reduction in BP in individuals with and without hypertension.[10] Furthermore, higher circulatory/dietary n-6 PUFAs have been associated with a lower risk of hypertension, particularly total n-6 PUFAs and linoleic acid.[10] These findings collectively emphasize the importance of considering the quality and type of dietary fats in managing BP.

Though sufficient literature exists on the effects of fatty diets on BP, it is unknown to what extent they are effective in clinical settings. The comparisons of different fatty diets and their effects on BP would greatly be helpful in understanding their role and extent of effects on systolic blood pressure (SBP) and diastolic blood pressure (DBP). This systematic review and meta-analysis aims to highlight the available literature from clinical trials and Randomized Controlled Trials (RCTs) that demonstrate the effectiveness and extent to which fatty diets can regulate blood pressure in clinical settings. Specifically, the research question is: How do

different types of high-fat diets influence SBP and DBP among individuals with any BP, regardless of age and gender? PICO framework is provided in Table 1.

MATERIALS AND METHODS

Design

This systematic review and meta-analysis followed the Cochrane Handbook for Systematic Reviews of Intervention.[11] Results were reported in accordance with the Preferred Reporting Items for SystematicReviews and Meta-Analyses (PRISMA) guidelines[12] (Supplementary Figure 1). The review protocol is registered with PRSOPERO (registration number: CRD42024546244). This article is a review of previously published literature and does not involve any studies with human participants or animals performed by the authors. Therefore, ethical approval was not required.

Search strategy

MEDLINE and Clinicaltrials.gov was searched before February 19, 2025, using criteria based on PICOS (Table 1), except that study design (S) was applied during the screening stage rather than in the initial search strategy. Manual search of references of the included studies supplemented the electronic search. However, no additional relevant studies were identified through this process. RCTs and clinical trials were identified using the relevant search terms. Search strategies for MEDLINEand Clinicaltrials.gov are provided in “Supplementary Data S1” and “Supplementary Data S2” respectively.

Study selection and inclusion/exclusion criteria

To conduct a systematic review and meta-analysis on the potential effects of different types of fatty diets in hypertensive and normotensive individuals, rigorous inclusion and exclusion criteria were established. The inclusion criteria were clearly defined to ensure the relevance and focus of the study. Included studies must involve hypertensive patients or individuals with any BP levels consuming any type of fatty diet (or where the major content of the diet is fat-based), without restrictions on age and gender groups. Only randomized controlled trials (RCTs) and clinical studies were considered for inclusion. Only dietary fat intake from whole foods was considered. The search was kept limited to articles indexed in MEDLINE and ClinicalTrials.gov.

To ensure consistency and minimize confounding factors, specific exclusion criteria were applied. Exclusion criteria encompass studies involving hypertensive patients with concurrent

diseases such as diabetes, hyperlipidemia, or metabolic syndrome. Articles that do not administer a fatty diet as an intervention, lack full-text availability, are not in English, or fully restrict the fatty diet rather than administering it as an intervention were also excluded. Fatty diets consumed through capsules or tablets (e.g., supplements) were excluded. Furthermore, review articles, animal studies, and in-vitro studies were also excluded from the analysis.

Additional exclusion measures were implemented to improve study quality and focus on primary dietary effects. No upper limit for hypertension and no lower limit for hypotension (as a result of interventions) were considered in the selection criteria of studies. Studies with previous or current anti-hypertensive medication use were excluded to eliminate potential confounding effects of pharmacological interventions. Studies without clear baseline BP measurements or lacking quantifiable effect values for outcomes were also excluded. The studies with baseline data before the diet intervention were considered as control, while the studies with isolated control and intervention groups were considered as detailed in Supplementary Table 1.

Data extraction

Data extraction was performed by two impartial reviewers using a standard proforma. Firstly, every article was entered into Endnote in order to compile research and remove duplicates. After examining the titles and abstracts, papers that did not fit the eligibility requirements were subsequently eliminated. Further, articles from which effect values could not be collected or access was restricted were omitted. The meta-analysis was finally performed on the articles that met the requirements.Relevant data included information on study authorship, publication year, study design, duration, type of fatty diet used, number of patients, age (years), gender distribution, SBP (mm Hg), DBP (mm Hg), methods used for BP measurements, study duration, BP measurement frequency during study will be extracted.

Mean differences (MDs) in end-of-treatment SBP and DBP were the main results. Review Manager, v5.3 (The Nordic Cochrane Centre, The Cochrane Collaboration, Copenhagen, Denmark) was used to analyse the data. The MDs were determined by deducting the administered fatty diet group's end-of-treatment SBP and DBP values from either the control diet group's end-of-treatment values or the pre-treatment SBP and DBP values.

The 95% CIs for the MDs were presented. A fixed-effects model was used to compare the results after the MDs ± SE (MD) from each research were combined and analyzed using the general inverse variance method with random effects model.[11,13] For MD comparisons, a 2-sided $p<0.05$ was used as the threshold of significance. All crossover study data were

subjected to paired analysis.[14] When data were unavailable, authors were contacted, and studies were considered irretrievable if no answer was received after three attempts.[15]

Risk of bias assessment

Using the RevMan Web Risk of Bias Assessment tool, two independent reviewers evaluated each study for bias. Sequence generation, allocation concealment, blinding, outcome data, and reporting were among the assessment domains.[11] Trials were classified as "unclear risk" if insufficient information was provided to identify the danger, "low risk" if methodological problems were thought to be insignificant, and "high risk" if they had flaws that could have affected the results. Disputes were settled by agreement.

Publication bias and sensitivity analysis

Publication bias and sensitivity analysis were assessed using RevMan Web tool. $p<0.05$ was regarded as evidence of small-study effects. Publication bias was quantitatively tested using the Egger's and Begg's tests and visually examined using funnel plots. Sensitivity tests were carried out, whereby each trial was eliminated from the meta-analysis and the effect size was recalculated using the remaining trials, in order to ascertain whether any one trial had a particularly significant impact on the overall results. Additionally, sensitivity assessments were conducted using leave-one-out technique16in Open metanalyst software.

Statistical analysis

We assessed heterogeneity among the included studies using the I^2 statistic and presented the data as standardized mean differences (SMDs) and 95% confidence intervals (CIs). Fixed-effects models were applied throughout the analysis, as this approach assumes a common effect size across studies and provides more precise estimates when heterogeneity is minimal.[17] A sensitivity analysis was performed to evaluate the stability of the results. Begg's and Egger's tests were used to detect publication bias. $p < 0.05$ was set as the significance level. Data analysis was performed using RevMan Web.[18]

RESULTS

Study Selection

A total of 25518 articles were found through search strategy (supplementary data S1) in MEDLINEand clinicaltrials.gov databases. The selection process is detailed in the PRISMA flowchart (Figure 1). After careful screening of titles and abstracts of these articles by two

independent researchers, 3157 articles were selected for a comprehensive full-text review. A total of 3,132 articles were excluded after full-text assessment due to not meeting eligibility criteria. The most common reasons for exclusion included irrelevant study methodology, administration of diets other than fatty diets, and absence of blood pressure measurement as a study parameter. After this rigorous screening process, 25 articles met the inclusion/exclusion criteria and were selected for assessment.

Characteristics of the included studies

The characteristics of the included trials are summarized in Supplementary Table 1.[19-43] The analysis was based on 25 trials selected according to predefined inclusion and exclusion criteria. Among these, 19 trials were explicitly described as RCTs, while two each were categorized as clinical trials, crossover control trials, and observational studies. A total of 14,522 participants were included across the studies, with sample sizes ranging from 12 to 12,279 individuals. The age of participants varied widely, from as young as 8 months to 75 years, with both genders well represented across the trials. Both SBP and DBP were assessed as outcomes in 24 trials, whereas one trial measured only SBP. Most studies utilized automated devices for BP measurement, while three studies used mercury sphygmomanometers.

The interventions involved various dietary modifications focused on fat intake. Two studies implemented High-Fat Diets, while six studies administered Omega-3 Fatty Acid Diets. Two studies investigated the effects of Food-Based Oil Diets, while five examined Saturated Fat Restriction Diets. Three studies administered DASH Diets (fat-based variation of the DASH diet), and six studies involved Unsaturated Fat-Enriched Diets (MUFA/PUFA-enriched diets), while three studies involved Low-Fat Diets. Study durations ranged from 3 weeks to 15.8 years, with BP measurement frequencies varying from daily assessments to annual evaluations, depending on the trial design and intervention period.

Effect on SBP and DBP

Figure 2 and Figure 3 depict the effects of various dietary interventions on SBP and DBP, respectively. The food-based oil diet, specifically the sesame oil blend38, exhibited the most substantial reductions in both SBP and DBP, with MD of -21.40 mm Hg [-25.27, -17.75] and -14.00 mm Hg [-15.53, -12.47], respectively. Diets rich in unsaturated fats28 also demonstrated significant reductions in SBP (-15.80 mm Hg [-18.59, -13.01]). High MUFA44 intake and long-chain omega-3 polyunsaturated fatty acids (LC n-3 PUFA)[41] markedly

reduced SBP by -7.00 mm Hg [-8.41, -5.59] and -7.60 mm Hg [-13.63, -1.57], respectively, with corresponding reductions in DBP of -6.00 mm Hg [-7.52, -4.48] and -2.70 mm Hg [-6.43, -1.03]. Low-fat diets19,27,30 were associated with moderate decreases in SBP (-6.91 mm Hg [-8.44, -5.39]) and DBP (-3.78 mm Hg [-4.64, -2.91]). Similarly, the DASH diet rich in fat contents21,33,45exhibited modest reductions in SBP (-3.83 mm Hg [-4.19, -3.47]) and DBP (-2.18 mm Hg [-2.41, -1.96]). In comparison, diets high in omega-3 content [35,36,39,43,46] and overall high-fat intake[27,32] yielded smaller reductions in both SBP and DBP. Restriction of saturated fat intake[22,24-26] had minimal effects on BP parameters when compared to control groups.

Sensitivity analyses

Systematic removal of individual trials did not alter the results. Sensitivity analyses using leave-one-out forest plot shows that no one study was responsible for these findings when each trial was systematically excluded from analysis. This represented a pattern of overall combined association between the administration of fatty diets and SBP and DBP (Supplementary Figure 2A and 2B).

Risk of bias

Using the Cochrane Risk of Bias Tool (supplementary figure 3A and 3B), individual trials were judged as having a high, low, or unclear risk of bias for the domains measured. Trials were judged in (A) Random sequence generation (selection bias) (B) Allocation concealment (selection bias) (C) Blinding of participants and personnel (performance bias) (D) Blinding of outcome assessment (detection bias) (E) Incomplete outcome data (attrition bias) (F) Selective reporting (reporting bias) (G) Other bias domains. Seven studies showed “high risk” and three reveal “unclear risk” in blinding process, probably due to obvious BP readings on display during measurement process. One study manifested “unclear risk” in allocation concealment. The remaining studies showed low risk of bias in remaining parameters.

Publication bias

Visual inspection of the funnel plot (Supplementary Figure 4A) revealed a generally symmetrical distribution of studies around the mean effect size, suggesting a low likelihood of publication bias. Studies across various dietary interventions—such as high-fat diets, omega-3 fatty acid diets, food-based oil diets, and unsaturated fat-enriched diets—are evenly dispersed along both sides of the mean difference (MD) axis. The distribution of studies falls within the

expected confidence limits (represented by the dashed lines), indicating no significant asymmetry. This visual assessment was further supported by Egger's test and Begg's test, both of which showed no significant small-study effects for systolic blood pressure (SBP). These findings confirm that the results of this meta-analysis are unlikely to be influenced by publication bias.

DISCUSSION

The primary objective of this meta-analysis was to quantify the effects of various fatty diet interventions on SBP and DBP. The main findings suggest that higher intake of unsaturated fats and low-fat diets significantly reduces SBP, while diets high in saturated fatty acids, low-fat diets, and saturated fatty acids with low PUFA content are more effective in reducing DBP. This research provides preliminary insights into dietary fat intervention strategies that can help optimize blood pressure control in both hypertensive and normotensive patients. The analysis was based on data from 14,522 participants across 25 trials, encompassing 27 different fatty diet interventions in diverse age groups and populations.

In comparison to previous meta-analyses[47,48], this study extends the understanding of fatty diet associations with BP by analyzing a broader spectrum of dietary interventions. The findings indicate that unsaturated fats and low-fat diets are particularly effective in reducing both SBP and DBP when compared to diets high in SFAs or total fat intake.

Saturated fatty acids have been implicated in influencing BP through several mechanisms. One plausible mechanism is their impact on endothelial function, where SFAs can impair endothelial-dependent vasodilation by promoting inflammation and oxidative stress, thereby increasing BP[49,50]. Additionally, SFAs contribute to increased arterial stiffness and elevate circulating low-density lipoprotein (LDL) cholesterol levels, both of which are associated with higher BP51. Experimental studies suggest that high-SFA diets can lead to a progressive rise in BP due to increased vascular resistance[51]. Moreover, genetic factors such as variants in the fat mass and obesity-associated gene (FTO) may modulate the BP response to saturated fatty acids, with some individuals displaying reduced SBP and DBP regardless of body mass index. Conversely, circulating very-long-chain saturated fatty acids, like arachidic and behenic acids, have been linked to a lower risk of hypertension, illustrating the complexity of SFAs' influence on BP[52].

Our analysis demonstrated that restricting saturated fatty acids intake led to modest reductions in SBP and more substantial decreases in DBP. Notably, saturated fatty acids with

low PUFA content showed more significant reductions in both SBP and DBP. These results highlight the nuanced effects of different types of saturated fatty acids on BP regulation.

Increased intake of unsaturated fats, particularly PUFAs and monounsaturated fatty acids (MUFAs), demonstrated significant BP-lowering effects[53]. PUFAs, especially marine-derived n-3 fatty acids, may lower BP through mechanisms such as improving endothelial function, enhancing nitric oxide production, and exerting anti-inflammatory effects53. Similarly, MUFAs, primarily oleic acid from vegetable oils, have been associated with reductions in DBP, likely due to their favorable effects on lipid profiles and vascular reactivity[54]. Our findings support these mechanisms, showing that high intake of unsaturated fats led to the most substantial BP reductions among all dietary interventions analyzed. However, diets high in PUFAs alone showed minimal effects on BP, indicating potential differences in BP-lowering efficacy between n-3 and n-6 fatty acids[55].

Low-fat diets, including those resembling the DASH diet, also showed significant BP-lowering effects[31,56]. These diets likely reduce BP through mechanisms involving improved sodium-potassium balance, enhanced vascular function, and reductions in arterial stiffness[57]. Our analysis revealed that low-fat diets were effective in lowering SBP and DBP. DASH diets, rich in fruits, vegetables, and low-fat dairy, further supported these findings with modest reductions in both SBP and DBP.

Furthermore, specific dietary interventions such as food-based oil diets (e.g., sesame oil blends) exhibited the most pronounced effects, with reductions in SBP and DBP. These results suggest that targeted dietary modifications, particularly those enriched with bioactive compounds, may offer additional BP-lowering benefits.

In conclusion, this meta-analysis highlights the differential effects of various fatty diet interventions on BP regulation. While unsaturated fat intake demonstrated the most significant benefits, low-fat and certain saturated fatty acids-restricted diets also contributed to BP reduction. The findings underscore the importance of dietary fat composition in hypertension management and provide a foundation for future research to explore the underlying mechanisms and long-term effects of these dietary strategies.

Limitations

The study aimed to include the participants without upper or lower limits of BP that may or may include hypertensive state. This limits the analysis as it is unclear what the data would have implied if only hypertensive patients were included in the analysis. Similarly, age and

gender considerations were also not undertaken as the goal of the study was to analyze the effects of fatty diets on BP.

Conclusion

This systematic review and meta-analysis highlight the diverse and nuanced effects of various fatty diets on blood pressure regulation. The findings demonstrate that food-based oil diets, particularly those enriched with sesame oil, and diets high in unsaturated fats produced the most significant reductions in both SBP and DBP. High intake of MUFA and PUFA, as well as omega-3 fatty acid diets, also exhibited notable reductions in SBP and DBP, though to a lesser extent. Low-fat diets and fat-rich adaptations of the DASH diet showed moderate effects in lowering both SBP and DBP. Conversely, diets focused on saturated fat restriction showed minimal impact on blood pressure reduction when compared to control groups. The subgroup analysis underscores the importance of dietary composition in influencing cardiovascular outcomes, particularly highlighting the benefits of unsaturated fat-enriched diets. These findings provide valuable insights that can inform future clinical guidelines and dietary recommendations. Nonetheless, further large-scale, long-term trials with diverse dietary interventions are necessary to validate and strengthen these conclusions.

SUPPLEMENTARY MATERIALS

All supplementary tables and figures are available upon request from the editorial office.

CONFLICT OF INTEREST AND FUNDING DISCLOSURE

The authors declare no competing interests related to this review. The authors have no financial or personal relationships with organizations or individuals that could have influenced the content or outcomes of this work.

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Table 1. PICOS

Criteria	Description
Participant(s)	Individuals with any blood pressure without restrictions on age and gender
Intervention(s)	Any type of fatty diets
Comparison(s)	Comparison between types of high-fat diets
Outcome(s)	SBP and DBP
Study design	RCTs and clinical trials

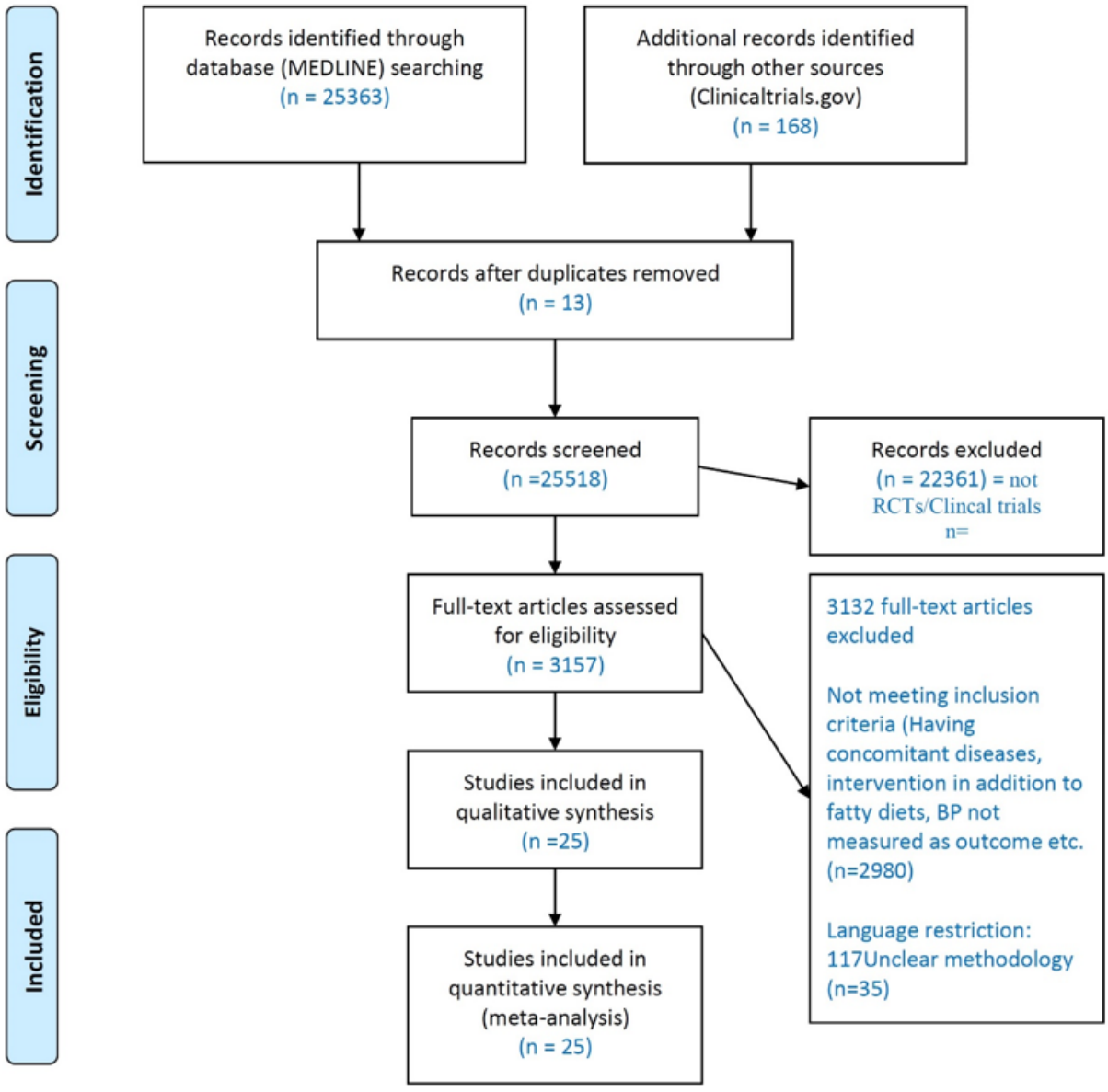

Figure 1. PRISMA flowchart depicting the study selection process, outlining the number of studies identified, screened, and included in the systematic review and meta-analysis.

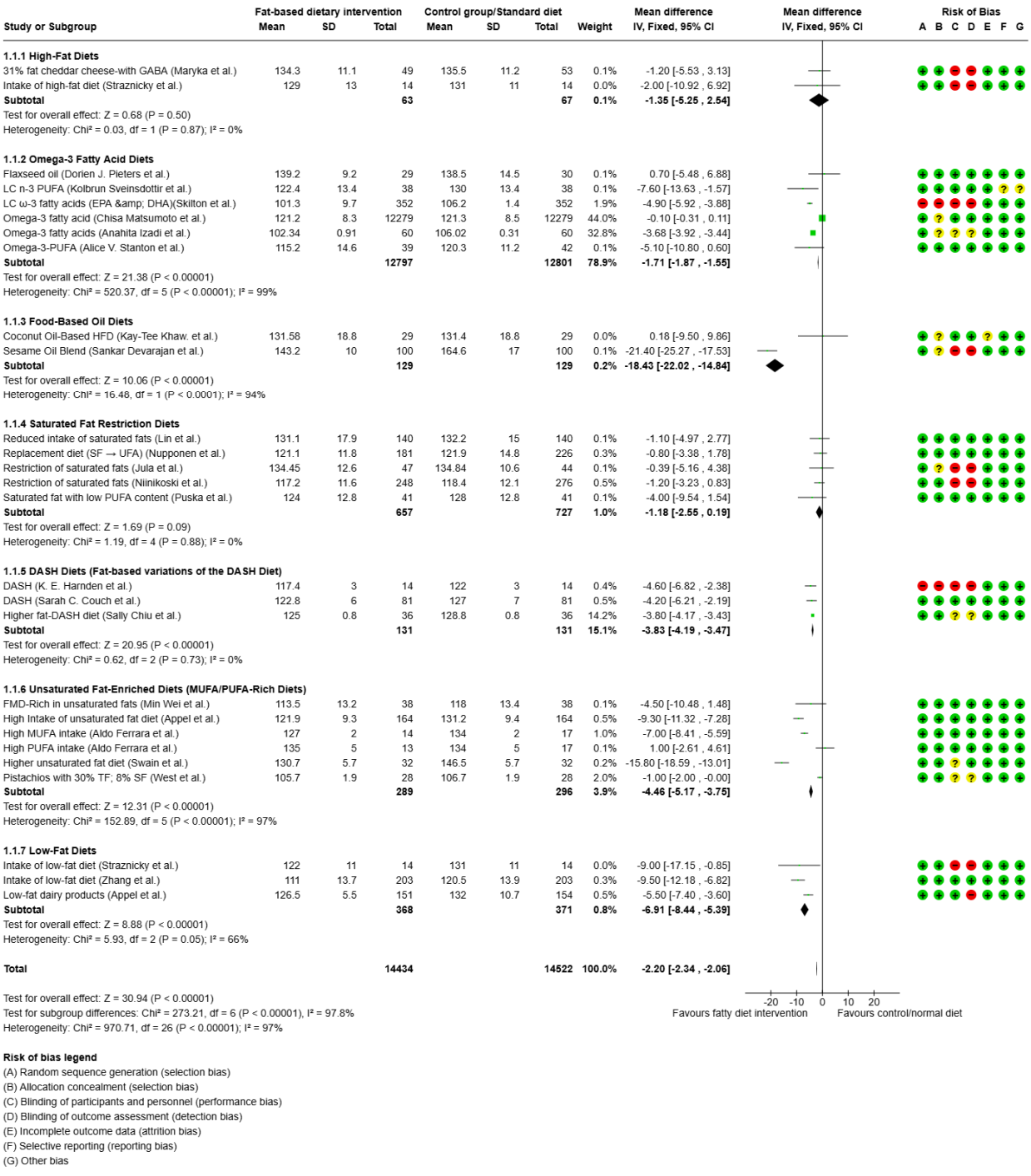

Figure 2. Effect of various fatty diets on systolic blood pressure (SBP). The graph illustrates the significant reductions in SBP associated with higher intake of unsaturated fats and low-fat diets, compared to the modest effects observed with high-fat and saturated fat diets

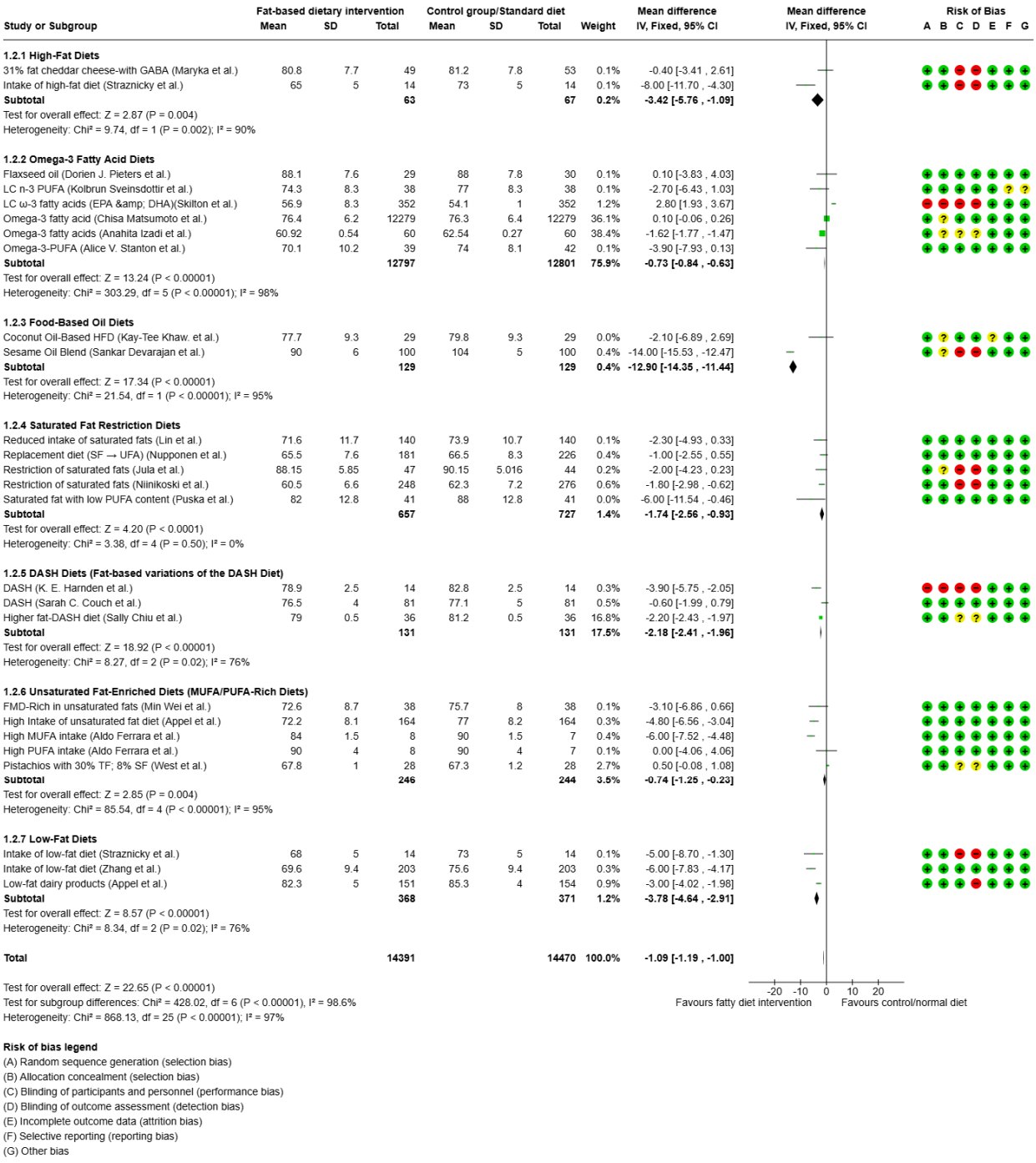

Figure 3. Effect of various fatty diets on diastolic blood pressure (DBP). The graph highlights the most significant reductions in DBP achieved by high-fat diets, low-fat diets, and saturated fats with low polyunsaturated fatty acid (PUFA) content, with limited effects observed for other dietary interventions