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Effect of dietary patterns on cardiovascular risk factors in people with type 2 diabetes. A systematic review and network meta-analysis

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ABSTRACT

Aims: To identify the most effective dietary pattern for improving cardiovascular risk factors in people with type 2 diabetes.
Methods: PubMed, Embase, the Cochrane library, SCOPUS and Web of Science were systematically searched for randomized controlled trials comparing the effects of dietary patterns on body weight, blood pressure, HbA1c and lipids after 6 and 12 months. Treatment effects were synthesized using Bayesian network *meta*-analysis. Six-month changes in HbA1c, SBP and LDL-C were used to estimate relative risk reductions (RRR) for cardiovascular events.
Results: Seventy-three RCTs on eight different dietary patterns were included. All reduced body weight and HbA1c after 6 months, with the largest effects from the low carbohydrate (body weight −4.8 kg, 95 %credibility interval (95 %CrI) −6.5;−3.2 kg) and Mediterranean diet (HbA1c −1.0 %, 95 %CrI -15;−0.4 % *vs* usual diet). There were no significant 6-month blood pressure or lipid effects. Dietary patterns had non-statistically significant 12-months effects. The Mediterranean diet resulted in the largest expected RRR for cardiovascular events: −16 % (95 %CI -31;3.0) *vs* usual diet.
Conclusions: In patients with type 2 diabetes, all dietary patterns outperformed usual diet in improving body weight and HbA1c after 6 months and clinically relevant cardiovascular risk reduction could be achieved. There was insufficient evidence to select one optimal dietary pattern.

1. Introduction

Type 2 diabetes is an important risk factor for cardiovascular disease (CVD) and mortality [1,2] and, with its prevalence expected to exceed 10 % of the world population in 2030 [3], it imposes a major global health burden. Unhealthy dietary habits and obesity predispose for development of type 2 diabetes [4,5] and may have a detrimental effect on cardiovascular risk factors such as hypertension and dyslipidemia [6,7].

Healthy diet is a key recommendation in guidelines for the management of type 2 diabetes [8,9]. Weight loss achieved through hypocaloric diets and increased physical activity is widely recommended [8] and multiple dietary patterns (Mediterranean diet, low carbohydrate diet and plant-based diet), effectively improve glycemic control, systolic blood pressure (SBP) and low density lipoprotein (LDL) cholesterol levels [10–13]. However, it is unclear which of these dietary patterns most effectively improves glycemic control and cardiovascular risk factors and, ultimately, best prevents cardiovascular events and mortality in people with type 2 diabetes.

Ideally, evidence on effectiveness of different dietary patterns would be gathered by direct comparison in long-term randomized controlled trials (RCTs), but due to the large number of dietary patterns and time and financial constraints, this approach is not feasible. Network *meta*-analysis provides an alternative, because it uses the results from existing RCTs that directly compared two or more dietary patterns (direct evidence) to estimate the relative effects of two dietary patterns that have never been compared in a head-to-head RCT (indirect evidence) [14]. Moreover, network *meta*-analysis may improve the precision of effect estimates from RCTs and traditional pairwise *meta*-analyses by combining direct and indirect evidence [15].

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The aim of this systematic literature review and network *meta*-analysis was to compare the effectiveness of multiple dietary patterns for improving glycemic control and reducing cardiovascular risk factors in people with type 2 diabetes. Moreover, the aim was to rank dietary patterns based on their effects on cardiovascular risk factors and identify the optimal dietary pattern. Additionally, an estimate of the effects of dietary patterns on risk of cardiovascular events compared to no dietary intervention was made based on their effect on cardiovascular risk factors as found in the network *meta*-analysis.

2. Material and Methods

This systematic review and network *meta*-analysis was prospectively registered in the PROSPERO registry (CRD42021233287).

2.1. Systematic literature search and data extraction

A systematic literature search was performed from database initiation up to 31 January 2022 in PubMED, EMBASE, the Cochrane Library, Scopus and Web of Science, using search terms for diet and dietary patterns, type 2 diabetes and RCTs (Supplemental Appendix 1). RCTs comparing a dietary pattern with an alternative pattern or with no dietary intervention for at least 12 weeks in a adults with type 2 diabetes were included. RCTs with multiple lifestyle interventions, not restricted to diet, were eligible when non-dietary components were applied universally (*e.g.* both groups received the same exercise program, Table S1). The definition of type 2 diabetes was accepted from the eligible RCTs, to avoid exclusion of relevant records due to unreported data required for a specific type 2 diabetes definition. Two authors (NEB, IVD) independently performed title and abstract screening followed by full-text review of relevant articles. Discrepancies were resolved by consensus after inclusion of a third reviewer.

Data on study design, population, intervention characteristics and outcome measures were independently extracted by two authors (NEB, IVD) using a standardized report form. Included records were critically appraised using the Cochrane Risk of Bias 2 tool [16].

2.2. Dietary pattern categories

Interventions were categorized as one of eight pre-defined dietary patterns (Table S2):

(1) Low glycemic index (GI) diet: focusing on food items with a low GI and high fiber content
(2) Mediterranean diet: rich in whole grains, green vegetables, fruits, fish, lean meat and plant-based oils
(3) Plant-based diet: vegan or vegetarian diet
(4) High protein diet: ≥25 % of total energy (E%) from protein
(5) Low carbohydrate diet: <30E% from carbohydrates
(6) Low fat diet: <30E% from fat
(7) Moderate carbohydrate diet: >45E% from carbohydrates, >30E % from fat and < 25E% from protein
(8) No dietary intervention: usual diet or one-time dietary advice from treating physician without behavioural support

Categorization was based on details provided in the included articles. When a dietary intervention could be classified as either a low GI, Mediterranean or plant-based diet, this classification was preferred over the classification based on macronutrient distribution of the diet.

2.3. Outcomes

Outcome data were divided into two time points: 6 months for measurements taken after 12 weeks and before 12 months, and 12 months for measurements taken more than 12 months after diet initiation. The data available to assess other time points was insufficient or too heterogeneous to meet the assumptions underlying a network *meta*-analysis and were therefore not quantitatively synthesized. The primary outcomes were difference in 6-month change in body weight, glycosylated hemoglobin (HbA1c), SBP and LDL-cholesterol between different dietary patterns. Secondary outcomes were the 12-month change in these parameters and the 6- and 12-month change in high-density lipoprotein (HDL) cholesterol, triglyceride and C-reactive protein (CRP) levels.

When available, the mean difference from baseline and corresponding standard deviation (SD) were used in the analysis. If relevant outcomes were reported as other measures (*e.g.* standard error), the mean difference and SD were calculated in accordance with the Cochrane Handbook [17].

2.4. Statistical analyses

A random-effects network *meta*-analysis with a Bayesian framework was performed in a Monte Carlo Markov Chain simulation (4 chains, 5000 burn-in iterations, 100,000 iterations) [14,18]. The transitivity assumption was evaluated by comparing characteristics of the eligible RCTs. Convergence of the model was assessed by visual inspection of trace plots and Gelman-Rubin-Brooks plots. Model fit was assessed by checking the ratio between number of data points in each model and the residual deviance of the posterior distribution. The consistency assumption was assessed by performing node-splitting analyses to compare direct and indirect evidence. Imprecision of the model estimates was reflected by 95 % credible intervals (95 %CrI) obtained from the 2.5th and 97.5th percentile values of the simulations. Ranking probabilities were calculated for all outcomes and the hierarchy of the different dietary patterns was summarized using ranking plots and surface under the cumulative ranking curve (SUCRA) [19].

Changes in HbA1c, SBP and LDL-cholesterol at 6 months after diet initiation were used to estimate the relative risk reduction (RRR) in risk of major adverse cardiovascular events (MACE), in accordance with the methodology previously published by Berkelmans and colleagues [20]. For these analyses, the reference category was no dietary intervention. The following results from previously published *meta*-analyses were used to estimate the effect on MACE risk: 10 mmol/mol reduction in HbA1c associates with a hazard ratio (HR) of 0.91 (95 %CI 0.84; 0.99) [21], 1 mmol/l reduction in plasma LDL-C with a HR of 0.78 (95 %CI 0.76; 0.80) [22] and 10 mmHg reduction in systolic blood pressure with a HR of 0.80 (95 %CI 0.77; 0.83) [23]. A detailed description of the methodology for the calculation of MACE risk is provided in Supplemental Appendix 2.

Post-hoc sensitivity analyses were performed to explore the impact of potential sources of heterogeneity between the included studies. The first sensitivity analysis was limited to studies published from the year 2010 onwards. A second sensitivity analysis was limited to studies that selected patients with a baseline body mass index (BMI) ≥ 25 kg/m^2, with the aim of exploring whether the effects of dietary patterns were different in overweight populations. In the final sensitivity analysis, all records that were judged to be at high risk of bias were excluded.

All statistical analyses were performed using R version 4.0.4 (R Core Team, Vienna, Austria) with the gemtc package [24].

3. Results

3.1. Article selection and risk of bias assessment

The search of five different databases yielded 14,563 unique records that were screened for eligibility and 98 records, reporting on 73 unique RCTs were included (Fig. 1/ Table S3). The included studies were published between 1978 and 2022 and comprised a total of 5,753 participants. Study durations ranged from 12 weeks to 7 years, with a median of 26 weeks. Approximately half of participants were female, mean age was 58 ± 5.7 years, mean BMI was 32.5 ± 4.2 kg/m^2 and

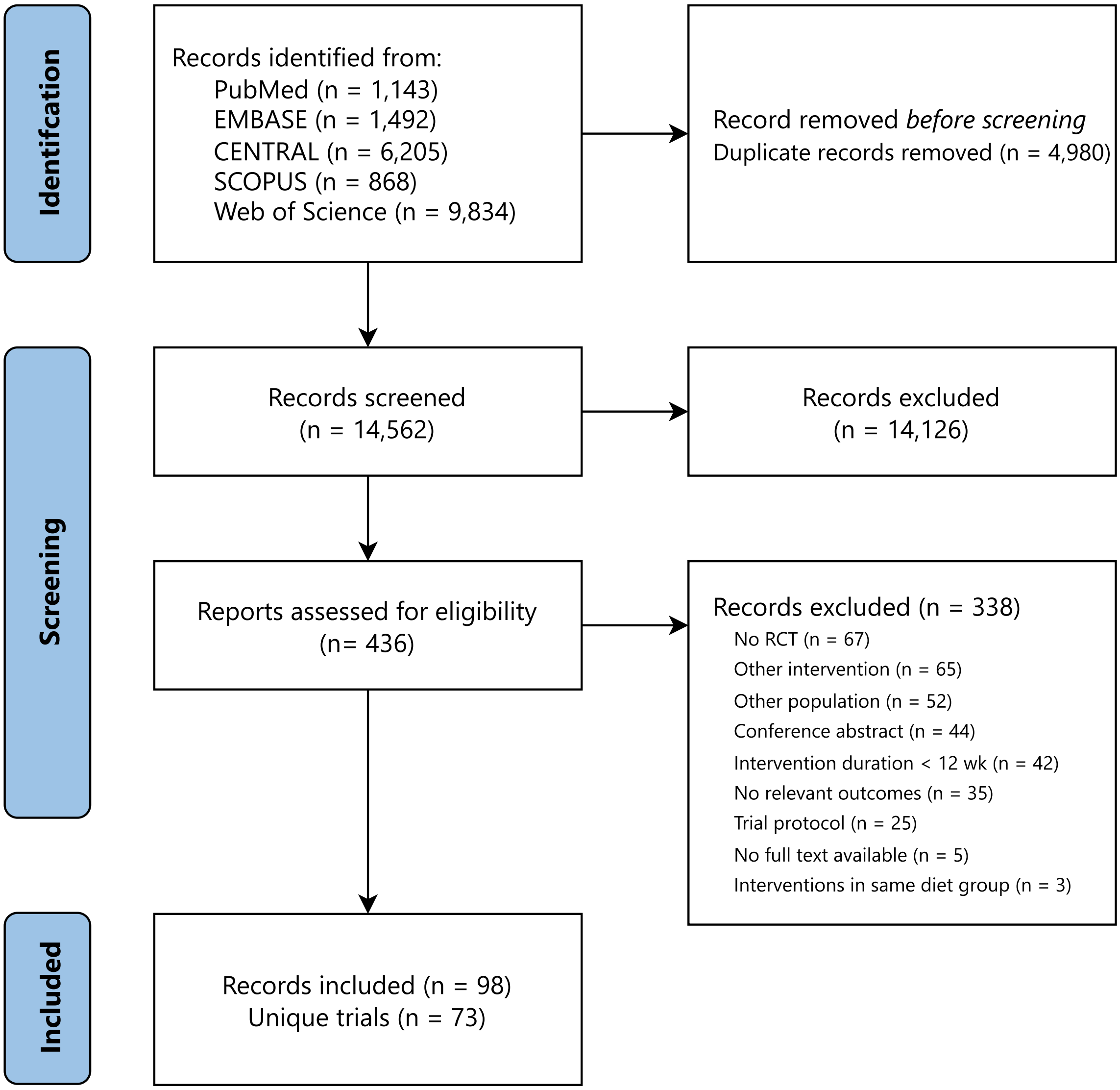

Fig. 1. Study selection flowchart. This flow diagram shows the process used to identify relevant records for the network *meta*-analysis. The systematic literature search was performed from database inception to 31 January 2022. Abbreviations: RCT: Randomized controlled trial.

median time since type 2 diabetes diagnosis was 9 [IQR 7– 10] years. Details on achieved caloric intake was available for 43 trials, of which 27 (63 %) reported a similar or lower energy intake in the intervention group.

Funding and conflict-of-interest information was fully available for 50 of the included RCTs (68 %) of whom 31 trials reported having received funding from governmental or academic sources alone and no potential conflicts of interest (Table S4). Industry sponsoring, or lack thereof, was not reported for studies on the Mediterranean diet, and reported most frequently for RCTs assessing the effectiveness of the high protein (N = 6, 55 %) and plant-based dietary patterns (N = 4, 50 %, Table S4). Twenty-four studies (35 %) were judged to be at high risk of bias (Figure S1). Risk of bias mainly arose because participants could not be blinded to the dietary intervention, and because older RCTs often did not have a pre-published protocol.

3.2. Diet categories and network

Network plots showing the number of direct comparisons between dietary patterns for each outcome are presented in Fig. 2 and S2. Most participants were randomized to either low-fat diet (N = 1,478), moderate carbohydrate diet (N = 1,011) or no dietary intervention (N = 969). The most frequent direct comparison was moderate carbohydrate *vs* low fat diet (13 RCTs), followed by low carbohydrate *vs* moderate carbohydrate and low fat *vs* no dietary intervention (both reported in 9 RCTs).

3.3. 6-month effects of dietary interventions on cardiovascular risk factors

After 6 months, all dietary patterns were more effective in reducing body weight than no dietary intervention, with changes ranging between −4.8 and −2.7 kg (Fig. 3). The largest reductions were achieved with the low carbohydrate diet (-4.8 kg, 95 %CrI-6.5;-3.2) and plant-based diet (-4.7 kg, 95 %CrI-6.8; −2.5) compared to no dietary intervention. All dietary patterns resulted in statistically significant 6-month HbA1c reductions, ranging between –1.0 % and −0.3 % (-10.5 and −2.8 mmol/mol) compared to no dietary intervention. The largest reduction was achieved by the Mediterranean diet: −1.0 %, 95 %CrI-15.8;-0.4 (−10.5 mmol/mol, 95 %CrI − 16.8;−4.1 mmol/mol). For SBP there was a non-statistically significant trend towards reduction for all dietary patterns. The estimates for SBP reduction ranged between −13.3 and −0.7 mmHg, with the largest reduction being achieved by the Mediterranean diet (-13.3 mmHg, 95 %CrI-31.7; 5.0). Six-month changes in

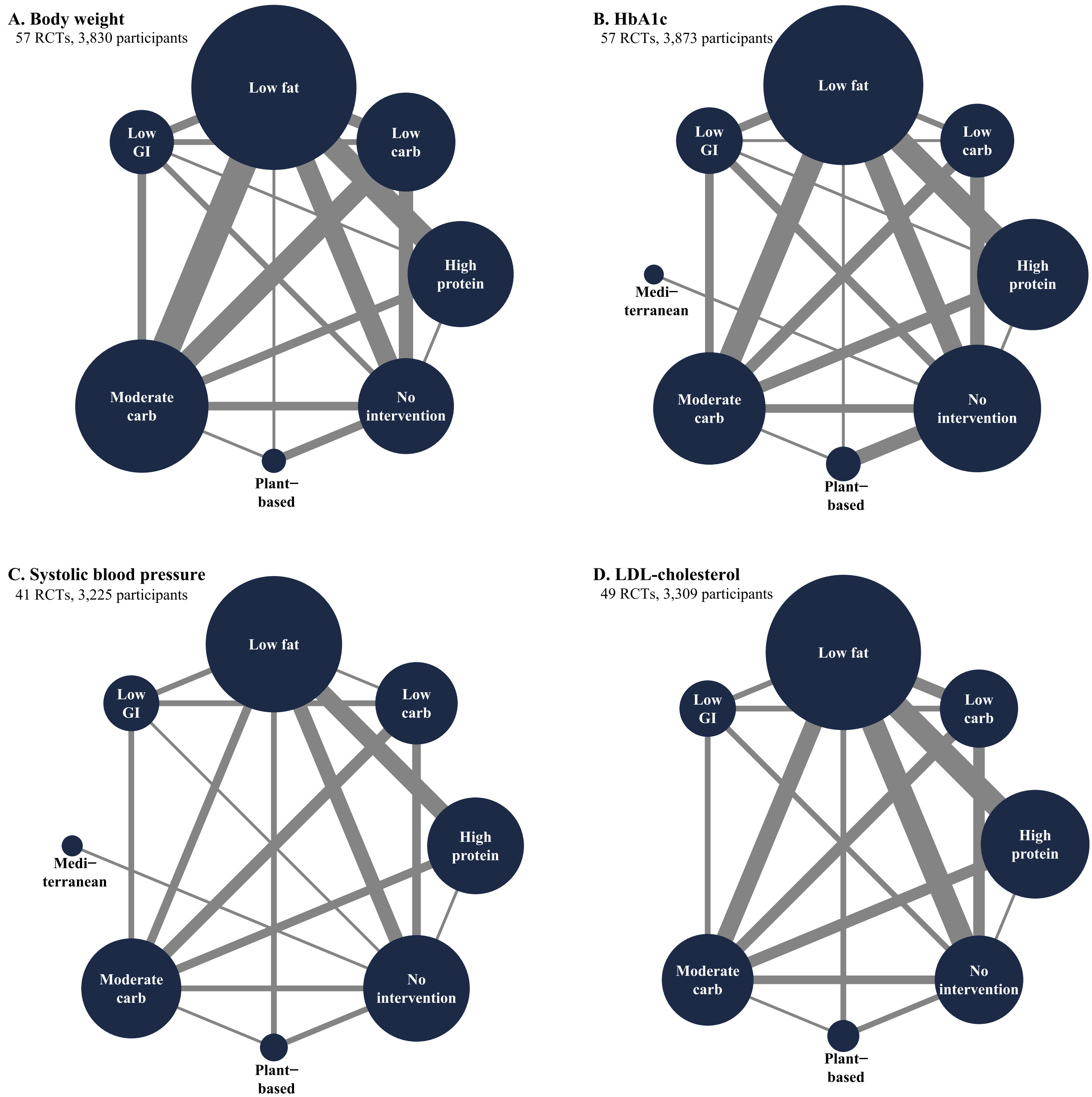

Fig. 2. Network plots of direct comparisons after 6 months. These network graphs show the direct comparisons between dietary interventions from head-to-head trials for the primary outcomes: (A) body weight, (B) HbA1c, (C) systolic blood pressure and (D) LDL-cholesterol after 6 months. The sizes of the dietary pattern nodes correspond to the number of participants randomized to that dietary pattern. The width of the edges between the nodes corresponds to the number of direct head-to-head comparisons. Abbreviations: Carb: carbohydrate GI: glycemic index, RCT: randomized controlled trial.

LDL-cholesterol compared with no dietary intervention ranged between −0.3 and −0.1 mmol/l for all dietary patterns. A statistically significant LDL-cholesterol reduction was only observed for the low GI diet: −0.3 mmol/l (95 %CrI −0.5; 0.0) compared with no dietary intervention. The studied dietary patterns had small, non-statistically significant, effects on HDL-cholesterol, triglycerides and CRP levels (Table S5).

3.4. 12-month effects of dietary patterns on cardiovascular risk factors

Twelve months after diet initiation, body weight reductions ranged between −3.3 and −1.1 kg compared with no dietary intervention, with the Mediterranean (-3.3 kg, 95 %CrI-6.4;-0.2 kg) and low-fat diet (-2.5 kg, 95 %CrI-5.2;0.0) yielding the largest reductions. Twelve-month HbA1c changes were not statistically significant and ranged between −0.2 and 0.3 % (-2.0 and 3.2 mmol/mol) compared to no dietary intervention. For SBP and LDL-cholesterol, these 12-month changes were not statistically significant, ranging from −6.8 to 0.3 mmHg and −0.1 to 0.1 mmol/l, respectively.

3.5. Ranking of dietary interventions

There was no dietary pattern that ranked best for all primary outcomes (Figure S4). The low carbohydrate diet ranked highest for body weight reduction, the Mediterranean diet for reducing HbA1c and SBP; and the low GI diet for reducing LDL-cholesterol. Usual diet performed worst for all primary outcomes. Ranking plots for the secondary

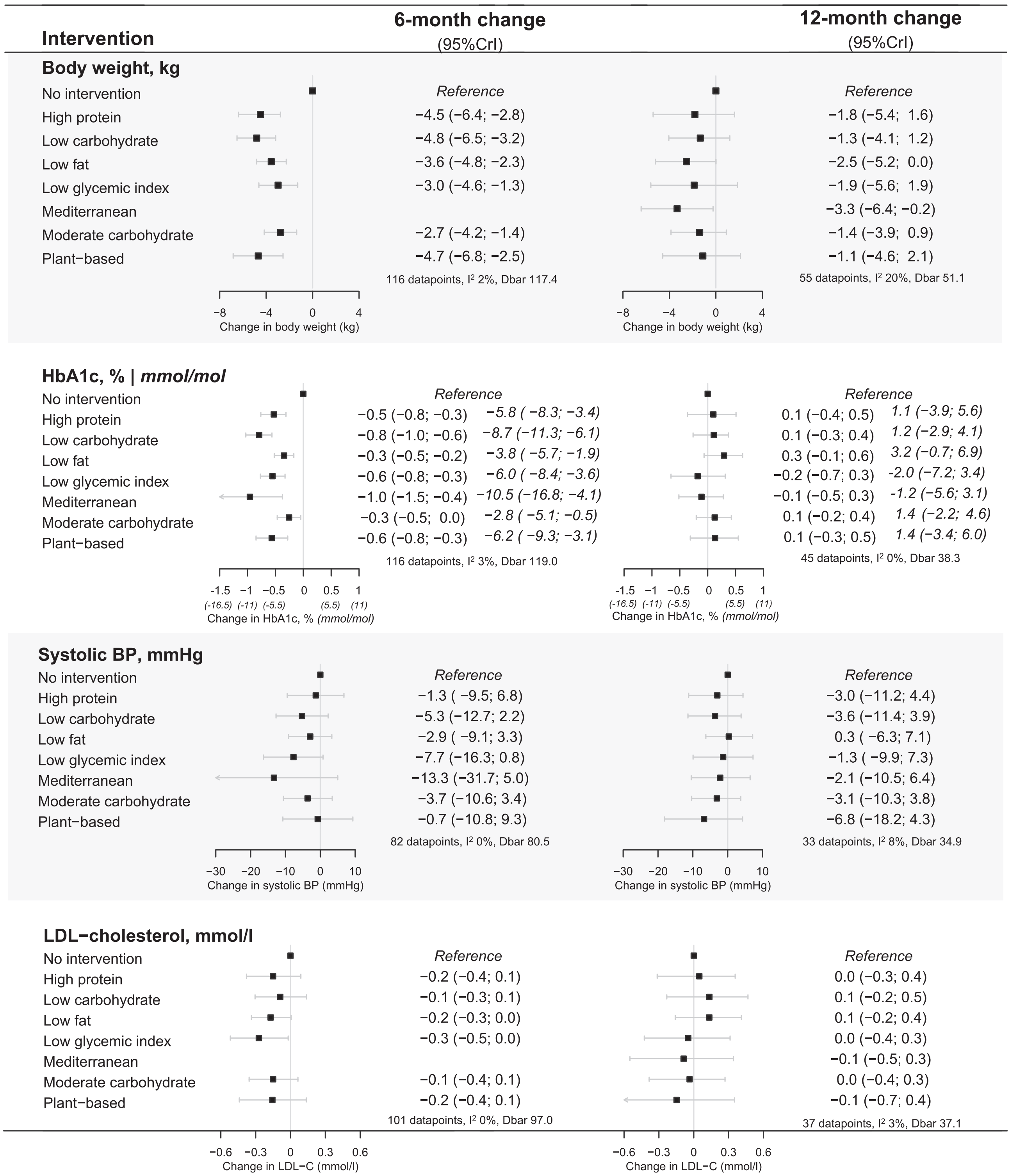

Fig. 3. The effect of dietary patterns on body weight, HbA1c, systolic blood pressure and LDL-C at 6 and 12 months after diet initiation. This figure presents the network estimates and 95 % CrI for the 6 and 12 month relative change from baseline in body weight, HbA1c, systolic blood pressure and LDL-C compared to usual diet. For each outcome, measures of model fit are provided in the figure: number of data points used for the model, I^2 and the posterior mean residual difference (Dbar). Changes in HbA1c as measured in % are presented in regular font and changes expressed in mmol/mol are presented in italic. Abbreviations: 95 %CrI: 95 % credibility interval, HbA1c – glycated hemoglobin, BP: Blood pressure, LDL-cholesterol: low-density lipoprotein cholesterol.

outcomes are provided in Figure S5.

3.6. Estimated relative reductions in MACE risk

Compared with no dietary intervention, all dietary patterns were estimated to reduce MACE risk. However, only the effect of the low GI diet was statistically significant (RRR – 12.0 %, 95 %CI −21.8;-0.9 %) (Fig. 4). The Mediterranean diet resulted in the largest RRR: −15.8 % (95 %CI-31.3;3.2 %).

Intervention	RRR (95%CI) based on changes in individual cardiovascular risk factors: Systolic BP	LDL−C	HbA1c	Combined relative risk reduction (95%CI)
No intervention	*Reference*	*Reference*	*Reference*	*Reference*
High protein	−1.3% (−8.8%; 6.8%)	−1.5% (−3.8%; 0.9%)	−2.3% (−3.4%; −1.4%)	−5.0% (−15.2%; 6.3%)
Low carbohydrate	−5.0% (−11.6%; 2.2%)	−0.9% (−3.1%; 1.4%)	−3.5% (−4.5%; −2.5%)	−9.1% (−18.2%; 1.1%)
Low fat	−2.8% (−8.5%; 3.2%)	−1.7% (−3.4%; 0.1%)	−1.5% (−2.3%; −0.8%)	−5.9% (−13.6%; 2.5%)
Low glycemic index	−7.2% (−14.6%; 0.8%)	−2.8% (−5.2%; −0.2%)	−2.4% (−3.4%; −1.5%)	−12.0% (−21.8%; −0.9%)
Mediterranean	−12.1% (−26.4%; 5.0%)	*Not available*	−4.2% (−6.7%; −1.7%)	−15.8% (−31.3%; 3.2%)
Moderate carbohydrate	−3.5% (−9.8%; 3.4%)	−1.5% (−3.6%; 0.7%)	−1.1% (−2.1%; −0.2%)	−6.0% (−14.8%; 3.8%)
Plant−based	−0.7% (−9.9%; 9.5%)	−1.6% (−4.4%; 1.4%)	−2.5% (−3.7%; −1.2%)	−4.7% (−17.1%; 9.6%)

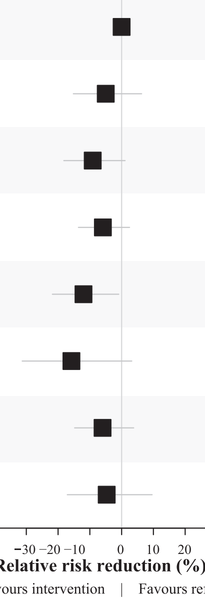

Fig. 4. Estimated relative risk reductions for MACE achieved by dietary interventions compared to no intervention. This figure presents the estimated changes in relative risk of MACE that can be achieved by different dietary interventions compared to no dietary intervention. The relative risk reduction achieved by changes in systolic blood pressure, LDL cholesterol and HbA1c were calculated by multiplying the 6-month network estimates for these cardiovascular risk factors with hazard ratios that were previously published. Note: This approach may result in an underestimation of the association between dietary pattern interventions and risk of MACE because dietary effects may manifest through other biological mechanisms. * The estimate for the Mediterranean diet is based on changes in systolic blood pressure and HbA1c, because no direct or indirect estimate for the effect on LDL-cholesterol could be obtained from the network. Abbreviations: RRR: relative risk reduction 95%CI: 95% confidence interval, Systolic BP: systolic blood pressure, LDL-C: low density lipoprotein cholesterol, HbA1c: glycated haemoglobin, carb: carbohydrate.

3.7. Sensitivity analyses

Results of studies published in or after 2010 (44/73 RCTs), were similar in size and direction to the main analysis with respect to the effects of dietary patterns on body weight, HbA1c, SBP, and LDL-cholesterol. For each outcome, the dietary pattern that resulted in the largest reduction was the same compared to the full analysis (Figure S6).

In studies excluding participants with BMI < 25 kg/m^2, all dietary patterns resulted in more weight loss compared with the main analysis (Figure S7). In this subgroup, the largest 6-month weight reduction was achieved by the high protein diet (-6.6 kg, 95 %CrI-10.8;-2.2 kg). The effects of dietary patterns on HbA1c and LDL-cholesterol were similar in the overweight population. The effects of dietary patterns on SBP compared to no dietary intervention could not be estimated, because none of the studies in this subgroup used no dietary intervention as a reference group.

In the final sensitivity analysis, excluding all studies that were judged to be at high risk of bias (n = 23), the size and direction of the network estimates was similar compared with the main analysis (Figure S8).

4. Discussion

This systematic review and network *meta*-analysis showed that dietary pattern interventions result in clinically relevant short-term reductions in body weight and HbA1c compared with no dietary intervention in people with type 2 diabetes. All effects were attenuated and not statistically significant after 12 months. When ranking dietary patterns there was no overall best option. However, for all primary outcomes, continuing usual diet was the worst option. Based on the 6-months results, dietary pattern interventions can reduce risk of MACE through their effect on CVD risk factors in patients with type 2 diabetes.

With regard to body weight, previous (network) *meta*-analyses have shown similar short- but not long-term weight loss [25,26]. A negative energy balance is the main driver for weight loss. Although the majority of comparisons between dietary patterns included in the present analyses were intended to be isocaloric, this intention was not always realized. In practice, participants that were randomized to a dietary intervention were more likely to reduce caloric intake than those that received no dietary intervention. The findings in the present study indicate that the studied dietary patterns have a similar effect on body weight and that all outperform no dietary intervention; a finding consistent with previous research [27,28].

Similar to previous research [10], the findings from this study indicate that dietary patterns reduce HbA1c, with the Mediterranean and low carbohydrate diets having the largest effects. These beneficial effects on HbA1c might be mediated through weight loss, which has been shown to reduce HbA1c [29] and even reverse type 2 diabetes [30]. In line with this, the short-term reductions in HbA1c lined up with the observed weight loss. The long-term effects on weight loss were smaller and no longer significant and, similarly, the effects on HbA1c were attenuated. Another mechanism through which diet can influence glycemic control is by reducing the quantity and improving the quality of carbohydrate intake [31]. Consumption of food items that are rich in high glycemic carbohydrates, result in fast and steep increases in blood glucose and insulin levels, especially in patients with type 2 diabetes. Frequent consumption can aggravate hyperinsulinemia and strengthen the accompanying atherogenic response [32]. The low carbohydrate dietary intervention was associated with reductions in short-term body weight and HbA1c, and therefore, might be a good dietary option for patients with type 2 diabetes, although long-term effects remain unclear.

The SBP and LDL-cholesterol effects were non-significant at both 6 and 12 months for all dietary interventions. A previous *meta*-analysis of dietary RCTs found an overall statistically significant 4 mmHg SBP reduction compared with usual diet [33]. However, that study pooled the effects of different dietary interventions in one estimate, which leads to limited options for generalization. In our analysis, a tendency towards clinically relevant 6-month reductions in SBP up to 13 mmHg was observed, but with wide CrIs, indicating insufficient power. The most important dietary factor that affects SBP is sodium salt intake [34]. Data on sodium intake was not extracted and may partially explain the findings.

The small effects of diet on LDL-cholesterol levels have been shown before [26,35] and might be explained through pathophysiologic processes leading to dyslipidemia. Genetic predisposition and low-grade inflammation are of large importance for LDL-cholesterol levels [36]. Moreover, dietary absorption and hepatic synthesis together determine serum cholesterol levels including LDL-cholesterol, and hepatic synthesis is negatively correlated to dietary adsorption [37]. Ultimately, these factors contribute to generally stable LDL-cholesterol levels that are minimally affected by dietary changes.

The present study shows that the effects of dietary patterns attenuate over time, a finding that has consistently been shown in dietary RCTs and *meta*-analyses [10,26]. A probable explanation is that adherence to prescribed dietary pattern decreases, while adherence is a strong predictor for a sustained future effects [38]. Our analyses are based on intention-to-treat results when available, meaning that the presented results are an average effect over adherent and non-adherent study participants. Especially in studies with a longer follow-up time, the proportion of non-adherent participants is expected to increase. It may be reasonable to expect larger long-term effects of the studied dietary patterns in patients that are compliant with the intervention throughout the entire follow-up period. Identifying such participants that are likely to adhere to a dietary intervention over time, is an interesting challenge for future research and may aid in targeting dietary interventions to patients that will benefit most.

To our knowledge there are no RCTs that have directly investigated the effect of dietary patterns on the occurrence of MACE in type 2 diabetes populations. Therefore, the network estimates of the effects on cardiovascular risk factors were used to calculate the expected MACE risk reduction compared to usual diet. The PREDIMED trial, performed in a population at high risk of CVD, previously showed that a Mediterranean diet reduced MACE risk by 31 % (HR 0.69, 95 %CI 0.53–0.91) [39]. The CORDIORPEV trial in patients with coronary heart disease, showed that a Mediterranean diet compared to a low fat diet led to a reduction in the risk of cardiovascular events up to 28 % (HR 0.72, 95 % CI 0.54–0. 96) [40]. The estimates for MACE risk reduction in the present study were smaller, probably because they were only based on changes in SBP, LDL-cholesterol and HbA1c. This approach therefore potentially underestimates benefits of dietary patterns when these are mediated through other mechanisms, such as inflammatory state, lipids and lipoprotein composition or quality of life [41,42].

As recommended in type 2 diabetes guidelines, adopting a healthy diet is an important part of clinical management [8,9]. This network *meta*-analysis underlines this recommendation, by showing that dietary patterns improve body weight and cardiovascular risk factors and potentially confer reductions in MACE risk. Of the included dietary patterns, there was no pattern that outperformed the others with regard to body weight, HbA1c, LDL and SBP reduction. The similarities between the studied dietary patterns should be noted. For example, in many of the included interventions it was recommended to consume fiber-rich foods and whole grain products and to limit sugar-sweetened beverages. Therefore, physicians should probably advice patients to adopt a healthy diet that suits their personal preferences. As adherence to a dietary pattern determines the success of dietary change, we recommend guiding patients towards a healthier dietary pattern they can maintain in the long-term.

Study strengths include the systematic search and analysis according to a pre-published protocol. Network *meta*-analysis techniques allowed for combining direct and indirect evidence and estimating the relative effects of dietary interventions that had not been compared in RCTs. The use of a Bayesian rather than frequentist framework allows for better modelling of the assumptions in a network *meta*-analysis, and is preferred by health care authorities [43]. Finally, multiple relevant cardiovascular risk factors were included, and an estimation of MACE risk reduction was made for all dietary patterns, which enables direct translation to clinical practice.

Limitations of the study include that the available RCTs were of low or moderate quality, although sensitivity analyses showed that the results were not impacted by studies at high risk of bias. We did not perform a GRADE assessment [44], due to its poor fit to nutrition research [45], but this means that certainty of evidence was not assessed in our analysis. A significant proportion of the included studies did not disclose funding information or was funded by advocacy groups for specific dietary patterns, which might have affected the choice of reported outcomes. Moreover, the grouping of interventions into dietary patterns inherently leads to simplification and loss of contrast. The same limitation arises for combining outcomes into two time points. However, both were necessary steps to present the available evidence in a comprehensible way and to provide sufficient power. Furthermore, the results of the ranking analyses are sensitive to the decision threshold used to determine relative effectiveness [46] and should therefore not be interpreted as definitive evidence that one dietary pattern is more effective than alternatives, but instead should be considered in light of the small differences in the estimated effect size. Our analyses focused on cardiovascular risk factors, but adverse effects, such as hypoglycemia or nutritional deficiencies, quality of life outcomes, adequacy of dietary patterns and patient dietary preferences are highly relevant for patients in deciding on the most optimal dietary pattern and should be evaluated in future research.

5. Conclusions

In conclusion, this systematic review and network *meta*-analysis showed that dietary patterns compared with no dietary intervention had beneficial effects on body weight and glycemic control in people with type 2 diabetes, especially in the first six months. These effects were attenuated and non-statistically significant after 12 months. Furthermore, the study shows that each included dietary pattern was preferable over no dietary intervention, with subtle differences between them but no particular dietary intervention being overall better than the others. Lastly, all dietary patterns resulted in reduced MACE risk mediated by their (short-term) effects on cardiovascular risk factors. These findings stress the importance of dietary interventions in the management of type 2 diabetes and their potential to reduce cardiovascular risk. There is a need to quantify the effects of dietary pattern interventions on the occurrence of cardiovascular events in a long-term randomized controlled trial. In the meantime, patients with T2DM should be advised to adopt a healthy diet, without a preference for any dietary pattern in particular.

6. Data and resource availability statement

The datasets generated during and/or analysed in the current study are available from the corresponding author upon reasonable request.

7. Dietary disclosure

The authors are not advocates or activists on specific nutrition and are not strongly committed to any of the dietary patterns assessed in this review.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Guarantor statement

FJLV is the guarantor of this work and, as such, had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.diabres.2022.110207.

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