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ORIGINAL ARTICLE

Comparative efficacy of different eating patterns in the management of type 2 diabetes and prediabetes: An arm-based Bayesian network meta-analysis

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ABSTRACT

Aims/Introduction: Diet therapy is a vital approach to manage type 2 diabetes and prediabetes. However, the comparative efficacy of different eating patterns is not clear enough. We aimed to compare the efficacy of various eating patterns for glycemic control, anthropometrics, and serum lipid profiles in the management of type 2 diabetes and prediabetes.

Materials and Methods: We conducted a network meta-analysis using arm-based Bayesian methods and random effect models, and drew the conclusions using the partially contextualized framework. We searched twelve databases and yielded 9,534 related references, where 107 studies were eligible, comprising 8,909 participants.

Results: Eleven diets were evaluated for 14 outcomes. Caloric restriction was ranked as the best pattern for weight loss (SUCRA 86.8%) and waist circumference (82.2%), low-carbohydrate diets for body mass index (81.6%), and high-density lipoprotein (84.0%), and low-glycemic-index diets for total cholesterol (87.5%) and low-density lipoprotein (86.6%). Other interventions showed some superiorities, but were imprecise due to insufficient participants and needed further investigation. The attrition rates of interventions were similar. Meta-regression suggested that macronutrients, energy intake, and weight may modify outcomes differently. The evidence was of moderate-to-low quality, and 38.2% of the evidence items met the minimal clinically important differences.

Conclusions: The selection and development of dietary strategies for diabetic/prediabetic patients should depend on their holistic conditions, i.e., serum lipid profiles, glucometabolic patterns, weight, and blood pressure. It is recommended to identify the most critical and urgent metabolic indicator to control for one specific patient, and then choose the most appropriate eating pattern accordingly.

INTRODUCTION

It was estimated that 10.5% of people aged 20–75 suffered from diabetes mellitus globally, where over 90% were type 2 diabetes (T2DM)[1]. They spend about 966 billion US dollars of health expenditure per year[1]. Since type 2 diabetes has proven to be preventable and controllable[2], the remission of a prediabetic state (PreD), or impaired glucose tolerance (IGT), was also of concern and was included in the comprehensive prevention of the incidence of type 2 diabetes.

Beyond medications, lifestyle management is the more cost-effective for type 2 diabetes/prediabetes patients with strong clinical evidence[3–5], where eating patterns play the leading role. Various patterns of different nutrients and food groups have been investigated and applied to the treatment and management of type 2 diabetes/prediabetes, from the very high-fat diet in the 18th century[6] to the pattern recommended by American

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Diabetes Association (ADA) in 2003[7]. From an evidence-based perspective, hundreds of random controlled trials (RCT), cohorts, and related systematic reviews have quantified the efficacy of popular and widely used eating patterns[8–13].

However, there are variances in the effectiveness of the diets across different outcomes, e.g., blood glucose, weight, and cardiovascular risk factors. Diabetes Canada guidelines[4] summarized the properties of dietary interventions, pointing out the differences among diets. Consequently, current guidelines strongly recommend an individualized medical nutrition therapy under the supervision of dietitians and multidisciplinary professionals[3–5]. However, how to choose and apply appropriate dietary patterns for professionals remains to be a question, due to the lack of direct evidence comparing the relative efficacy of the interventions. Whether a specific diet is suitable for an individual with specific laboratory profiles and situations is not clear enough, though high-quality evidence of several patterns has been drawn.

It is not cost-effective to carry out multi-arm trials directly comparing several diets. Thus, it is crucial to conduct a network meta-analysis to synthesize current evidence. Previous network meta-analyses[14,15] have assessed a number of patterns, but the authors only included a limited number of studies and outcomes. Furthermore, short-term trials were not considered in the analyses, but a short-term effect may be more common for some patterns[16]. Therefore, this study aimed to evaluate the relative efficacy of different eating patterns on glycemic control, anthropometrics, and serum lipid profiles in the management of patients with type 2 diabetes/prediabetes, and to conclude evidence to promote clinical decision-making.

MATERIALS AND METHODS

Study design

We conducted an arm-based Bayesian network meta-analysis of randomized controlled trials, following the Cochrane Handbook[17]. We reported results according to the Preferred Reporting Items for Systematic reviews and Meta-Analyses Incorporating Network Meta-analysis (PRISMA-NMA)[18]. A protocol was prepared and registered a priori in PROSPERO (CRD42021278268).

Eligibility criteria

We selected peer-reviewed articles and thesis according to the PICOS principle. Eligibility criteria are displayed in Table 1.

Search strategy

We conducted searches of databases and trial registers, including PubMed, Web of Science, Embase, CINAHL and Open Dissertation, ProQuest, Scopus, Global Index Medicus, Cochrane Central Register of Controlled Trials, Clinicaltrials.gov, SinoMed, WanFang Med, and CNKI. All publications from the inception to 13 October 2021 were initially retrieved. An updated search was conducted on 17 March 2022 using Scopus and Google Scholar to identify the latest relevant articles. The full search strategy can be found in File S1.

Data selection and extraction

All references identified from the search were imported into EndNote 20 (Clarivate, PA, USA) to move duplicates. After automatic exclusion by filtering title using excluding terms, the reviewers (B.-T.Z., H.-Q.P., and F.-D.L.) assessed the eligibility in the order of title, abstract, and full text. Each reference was decided upon independently by at least two reviewers, and arisen discrepancies were discussed and decided upon by the authors together.

We used MySQL 8.0 (Oracle Corporation, TX, USA) for data extraction and management, and critical information was extracted (see File S2 for fields in MySQL tables). Two authors (B.-T.Z. and Z.-Y.Y.) independently extracted the data and checked the consistency.

R 4.1.3 (R Foundation, Vienna, Austria) and Microsoft Excel 2019 (Microsoft Corporation, WA, USA) were used for data conversion and imputation. For continuous outcomes, we calculated the change from baseline and its standard deviation (SD) if not reported by the article. Correlation coefficients for changes from baseline and for crossover RCTs were estimated using reported SDs from included studies (File S3). The median and interquartile range was converted into the mean and SD using methods from Luo[19] and Wan[20] after testing for skewness using methods from Shi et al.[21]. WebPlot Digitizer[22] was applied for extracting data from figures. Ultimately, R package 'mice'[23] was used for the imputation of missing values of covariates for meta-regression.

Risk of bias assessment

The Risk of Bias 2 tool[24] and Risk of Bias 2 for crossover trials[25] were employed to assess the risk of bias (RoB) of parallel and crossover RCTs, respectively. Two reviewers (B.-T.Z. and H.-Q.P.) assessed the RoBs independently, with all arisen divergences discussed and consensuses reached.

Data synthesis

Our study synthesized evidence through an arm-based Bayesian network meta-analysis in a random effect model. We use R package 'gemtc' 1.0-1 for meta-analysis, inconsistency test, heterogeneity test, meta-regression, and sensitivity analysis[26,27]. Markov chain Monte Carlo sampling was performed using JAGS 4.3.0 via R package 'rjags' 4.12[28,29]. Comparison-adjusted funnel plots, Egger's test, and Begg's test were performed to detect publication bias under a frequentist framework and random effect model using R package 'netmeta' 2.1-0 and 'metafor' 3.4-0[30,31].

Continuous outcomes were presented as the mean difference (MD) or the difference in percentage change from baseline (Percentage MD, PMD, for fasting insulin and insulin resistance) and 95% credible intervals (95% CrI), while relative risk (RR) and 95% CrI were for dichotomous variables.

Table 1 | Eligibility criteria

Inclusion		Exclusion	
Type	Criteria	Type	Criteria
P	Adults with type 2 diabetes mellitus or prediabetes	I	Any prescribed between-group difference on exercise, antihyperglycemic medications, insulin injection, or other co-interventions; added a single supplement, or single specified food which did not provide macronutrients; or use meal replacement to provide an appreciable percentage of energy intake; or total energy intake (TEI) <800 kcal/d (3.3 MJ/d); or the adjustment of intervention during the trial
I	Contain at least one arm of the interventions as follows: caloric restriction (CR), high-fiber diet (fiber), dietary approaches to stop hypertension (DASH), high-protein diet (HPD), high-fat diet (HFD), low-carbohydrate diet (LCD), low-glycemic-index diet (LGID), Mediterranean diet (Med), Nordic diet (ND), Paleolithic diet (Paleo), Portfolio diet (PfD), and vegetarian/vegan/plant-based diet (VD). The macronutrients and food group intake can be as prescribed or as actual		
C	Contained standard diabetes diet, e.g. ADA 2003 diet[7]; *ad libitum*; general nutrition counselling; or placebo (no intervention); or contain two or more intervention arms		
O	Reported at least one outcome as follows, where fasting plasma glucose (FPG) was the primary outcome of this meta-analysis: glycemic control, including FPG, glycated hemoglobin (HbA_{1c}), fasting insulin (FIns), and insulin resistance (IR); anthropometrics, including weight, body mass index (BMI), waist circumference (WC), waist-to-hip ratio (WHR), and body fat rate (BFR), systolic blood pressure (SBP), and diastolic blood pressure (DBP); serum lipid profiles, including triacylglycerol (TG), total cholesterol (TC), low-density lipoprotein cholesterol (LDL), and high-density lipoprotein cholesterol (HDL); renal function, including serum creatinine, serum urea, serum uric acid and (estimated) glomerular filtration rate; other dichotomous outcomes, including attrition rate, remission of type 2 diabetes mellitus, incidence of hypoglycemia, incidence of drug or insulin discontinuation, incidence of type 2 diabetes mellitus from Prediabetes	Duration	less than 4 weeks or 1 month for parallel RCTs or any phase of crossover RCTs; or intermittent intervention
		S	single-arm or self-controlled trials
S	Randomized controlled trials (RCT)	Other	Data availability: trials not completed, or without data analysis and published reports; or articles with inappropriate or insufficient data
Other	Language: English or Chinese		

P, participants; I, interventions; C, comparators; O, outcomes; S, study types.

Quality of the evidence

We rated the quality of evidence of comparisons of experimental diets and control diets based on the GRADE Working Group's network meta-analysis evidence rating strategies[32] and the GRADE handbook[33]. Conclusions were drawn according to the partially contextualized framework by the GRADE workgroup[34], where minimal clinically important differences (MCID) and thresholds for moderate and large beneficial/harm effects were identified based on previous studies[13,35–37] and consensuses among reviewers.

RESULTS

We identified 9,358 publications and registrations from the initial search, and 176 from the updated search. In total, 111 publications[38–148] were eligible, where 107 independent studies were identified (Figure 1). All the items excluded via full-text screening and their reason for exclusion are listed in File S4.

Among our prescribed outcomes, data of FPG, HbA_{1c}, FIns, IR, weight, BMI, WC, SBP, DBP, TG, TC, HDL, LDL, and attrition rate were sufficient to form networks and perform a meta-analysis. However, other outcomes were not analyzed due to scarce data.

Study characteristics

The 107 included studies contained 8,909 participants for data analysis and 8,583 completers. A total of ten experimental diets and 223 arms was reported. The studies reported efficacy of CR, DASH, fiber, HFD, HPD, LCD, LGID, Med, Paleo, and VD, but ND and PfD were not included.

The characteristics of the studies are displayed in Table 2. We included 16 crossover and 91 parallel RCTs. Among them, seven were multi-arm, and six were multicenter. Four studies reported their outcomes in two or more publications. Only five studies focused on PreD population, considering that there was no significant difference among PreD and T2DM RCTs, we did not distinguish them in the meta-analysis. Fundings and conflicts of interest of the studies are listed in File S5.

Risk of bias assessment

The overall risk of bias of eligible studies was acceptable, but trials of some patterns (fiber and DASH) had a relatively high risk of bias (Table 2). 15.9% of studies were at high risk of bias (Figure 2). Notably, the risk of bias of crossover RCTs was significantly higher than the parallel ($P_{0.05/2}$ = 0.006, Mann-Whitney test), due to the period and carryover effects. Detailed risk of bias ratings of each domain are displayed in File S6.

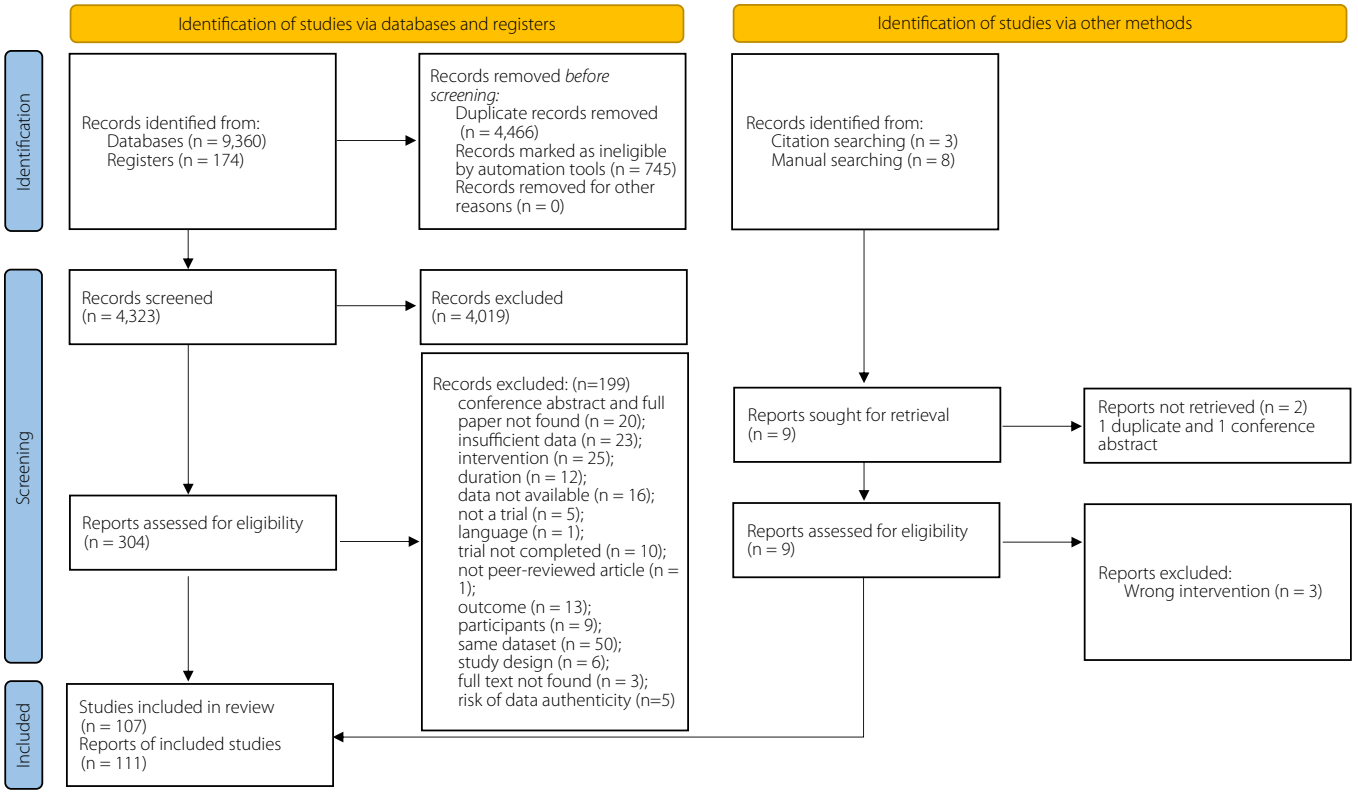

Figure 1 | PRISMA flowchart of data selection.

Table 2 | Characteristics of included studies

Study information						Intervention		Arms and characteristics										
Basic information		Type		Objective	RoB	Duration (week)	Intensity†	Arm	Size	Participants‡			Nutrition intake §					
Study ID	Origin									Sex ratio	Age (years)	BMI (kg/m^2)	TEI	Pr	Fat	CHO	GI	fiber
Al-Jazzaf 2007[38]	Kuwait	S	P	T2DM	SC	6	3	control	16	0.563	51.9 ± 12.8	34.6 ± 4.8	2270	17	33	49	73	25
								LGID	16	0.438	55.3 ± 8.9	33 ± 3	2376	17	36	47	61	25
								LGID	18	0.611	48.2 ± 8	34.4 ± 5.4	1806	18	35	51	62	26
Azadbakht 2011[39]	Iran	S	X	T2DM	H	8	2	control	31	0.581			2165	15	28	57		
								DASH	31	0.581			2189	16	29	55		
Bahado-Singh 2015[40]	Jamaica	S	P	T2DM	SC	24	3	control	24		43 ± 2.3	27.1 ± 0.8		30	32	45		25
								LGID	29		42.5 ± 2	26.11 ± 0.78		30	30	45		32
Barnard 2006/9[41,42]	USA	S	P	T2DM	SC	74	2	control	50	0.660	54.6 ± 10.2	35.9 ± 7	1422	21	34	47		18
								VD	49	0.551	56.7 ± 9.8	33.9 ± 7.8	1366	15	22	66		27
Brand 1991[43]	Australia	S	X	T2DM	SC	12	3	control	16	0.375	62 ± 9	25 ± 5	1623	19	31	46	90	26
								LGID	16	0.375	62 ± 9	25 ± 5	1654	22	30	44	77	26
Brehm 2009[44]	USA	S	P	T2DM	SC	52	3	control	52	0.673	56.5 ± 8.91	35.9 ± 3.34	1550	18	28	54		
								HFD	43	0.605	56.5 ± 8.91	35.9 ± 3.34	1550	16	38	46		
Breukelman 2019/21[45,46]	South Africa	S	P	T2DM	H	16	2	control	13	0.692	58.3 ± 5.53	38.2 ± 10.66						
								LCD	10	0.600	54.2 ± 12.67	38.9 ± 6.06				10		
Brinkworth 2004[47]	Australia	S	P	T2DM	H	64	2	control	19	0.632	62.7 ± 7.85	33.3 ± 5.67		15	30	55		30
								HPD	19	0.579	60.9 ± 7.85	33.6 ± 5.23		30	30	40		30
Brunerova 2007[48]	Czech	S	P	T2DM	H	12	3	control	13		51.2 ± 3.3	34.7 ± ± 3.6	1800	10	30	60		20
								HFD	14		54.7 ± 3.8	33.4 ± 4.5	1800	10	45	45		20
Cao 2011[49]	China	S	P	T2DM	SC	52	2	control	45	0.378	53.2 ± 6.5	35.9 ± 6.5	1860	20	32	48		
								LCD	45	0.333	54.2 ± 6.2	35.4 ± 6.2	1980	22	45	33		
Ceriello 2014[50]	Spain	S	P	T2DM	SC	12	2	control	12	0.333		29.2 ± 3.81						
								Med	12	0.250		29.8 ± 4.85						
Chandalia 2000[51]	USA	S	X	T2DM	H	6	4	control	13	0.077	61 ± 9	32.3 ± 3.9	2308	15	30	55		24
								fiber	13	0.077	61 ± 9	32.3 ± 3.9	2308	15	30	55		50
Chen 2020a[52]	China (Taiwan)	S	P	T2DM	SC	76	3	control	42	0.619	64.1 ± 7.4	26.55 ± 3.69	1469	20	41	41		
								LCD	43	0.605	63.1 ± 10.5	27.31 ± 4.53	1430	23	46	25		
Chen 2020b[53]	China	S	P	PreD	SC	12	2	control	43	0.628	51.9 ± 11.8	25.2 ± 4						
								LCD	57	0.596	54.9 ± 11.9	25.5 ± 2.9				25		
Choi 2013[54]	South Korea	S	P	T2DM	SC	12	2	control	38		56 ± 8.6	26.74 ± 2.16	1785	20	20	60		
								CR	38		55.5 ± 7	27.36 ± 3	1396	20	20	60		
Coppell 2010[55]	New Zealand	S	P	T2DM	SC	24	2	control	48	0.563	58.4 ± 8.8	34.3 ± 5.8						
								fiber	45	0.622	56.6 ± 8.8	35.1 ± 6.1		15	30	55		40
Coulston 1989[56]	USA	S	X	T2DM	SC	6	4	control	8	0.375	66 ± 8.49	25.5 ± 2.26		20	20	60		
								LCD	8	0.375	66 ± 8.49	25.5 ± 2.26		20	40	40		
Daly 2006[57]	UK	M	P	T2DM	SC	12	2	control	39	0.529	59.1 ± 10.57	36.7 ± 9	1434	21	33	45		14
								LCD	40	0.510	58.2 ± 11.07	35.4 ± 5	1290	26	40	34		10
Davis 2009[58]	USA	S	P	T2DM	SC	52	2	control	50	0.260	53 ± 7	37 ± 6	1810	19	31	50		17
								LCD	55	0.182	54 ± 6	35 ± 6	1642	23	44	33		15

Table 2. (*Continued*)

Study information						Intervention		Arms and characteristics										
Basic information		Type		Objective	RoB	Duration (week)	Intensity†	Arm	Size	Participants‡			Nutrition intake §					
Study ID	Origin									Sex ratio	Age (years)	BMI (kg/m^2)	TEI	Pr	Fat	CHO	GI	fiber
Ding 2010[59,60]	China	S	P	T2DM	H	24	2	control	37	0.725	58.7 ± 7.74	29.94 ± 3.85	2040	14	37	59		
								LGID	39	0.625	60.65 ± 6.92	30.24 ± 3.43	2012	14	30	59		
Durrer 2021[61]	Canada	S	P	T2DM	L	12	4	control	90	0.567	59 ± 8	35.1 ± 5.3	1667	22	40	40		
								LCD	98	0.561	58 ± 11	36 ± 6	984	43	31	27		
Elhayany 2010[62]	Israel	M	P	T2DM	H	52	2	control	55	0.509	56 ± 6.1	31.8 ± 3.3	2221	20	30	50		15
								Med	63	0.444	57.4 ± 6.1	31.1 ± 2.8	2221	20	30	50		30
								LCD	61	0.492	55.5 ± 6.5	31.4 ± 2.8	2221	20	45	35		30
Esposito 2009[63]	Italy	S	P	T2DM	L	208	2	control	107	0.514	51.9 ± 10.7	29.5 ± 3.6	1650					
								Med	108	0.500	52.4 ± 11.2	29.7 ± 3.4	1650					
Fabricatore 2011[64]	USA	S	P	T2DM	SC	40	3	control	39	0.795	52.5 ± 8.12	35.8 ± 4.37	1676	19	33	50	65	16
								LGID	40	0.800	52.8 ± 8.85	36.7 ± 5.06	1624	18	40	41	57	18
Fan 2010[66]	China	S	P	T2DM	SC	12	2	control	60									
								LGID	60									
Fan 2013[65]	China	S	P	T2DM	SC	12	2	control	25	0.462	69.1 ± 8.2	25.8 ± 2.5						
								LGID	26	0.462	69.3 ± 7.9	25.7 ± 2.7						
Fang 2016[68]	China	S	P	T2DM	SC	24	2	control	95	0.516	67.3 ± 9.8			15	25	60		
								LGID	105	0.495	68.2 ± 9.2			15	25	60	55	
Fang 2019[67]	China	S	P	T2DM	SC	24	2	control	283	0.481	56.78 ± 5.34		1835					
								CR	284	0.451	57.78 ± 5.14		1080					
Gannon 2003[70]	USA	S	X	T2DM	SC	5	4	control	12	0.167	61	31	2266	15	34	53		26
								HPD	12	0.167	61	31	2235	30	30	40		29
Gannon 2004[69]	USA	S	X	T2DM	H	5	4	control	8	0.000	63.3	31	2825	15	30	55		24
								LCD	8	0.000	63.3	31	2825	30	50	20		36
Goldstein 2011[71]	Israel	S	P	T2DM	SC	52	2	control	26	0.538	55 ± 8	33.3 ± 3	1937	19	40	43		
								LCD	26	0.500	57 ± 9	33.1 ± 3.6	1725	24	58	20		
Gram-Kampmann 2022[72]	Denmark	S	P	T2DM	SC	24	2	control	20	0.591	55.2 ± 12.66	35.2 ± 6.57	1600	23	28	48		30
								LCD	44	0.551	57.3 ± 6.3	32.5 ± 6.3	1642	23	63	13		16
Guldbrand 2012[73]	Sweden	M	P	T2DM	SC	104	2	control	31	0.581	62.7 ± 11	33.8 ± 5.7	1700	24	31	44		
								LCD	30	0.533	61.2 ± 9.5	31.6 ± 5	1700	20	47	31		
Guo 2014[74]	China	S	P	T2DM	SC	24	2	control	120		63.2 ± 13.1	26.98 ± 4.15						
								LGID	123		63.2 ± 13.1	26.42 ± 3.65						
Han 2021[75]	China	S	P	T2DM	SC	24	2	control	61	0.535	53.74 ± 3.48	25.39 ± 3.95	1798	17	28	55		
								LCD	60	0.333	49.13±13.06		1796	29	58	14		
Hashemi 2019[76]	Iran	S	P	T2DM	SC	12	2	control	40	0.600			1775	18	30	52		
								DASH	35	0.629			1771		27			
He 2017[77]	China	S	P	T2DM	SC	12	3	control	75	0.413		24.47 ± 3.06						
								LGID	75	0.467		24.92 ± 3.01					55	
Heilbronn 2002[78]	Australia	S	P	T2DM	SC	8	2	control	21	0.429	57.5 ± 9.6	33.4 ± 4.2	1436	22	17	61		30
								LGID	24	0.542	56 ± 9.4	34.2 ± 8.7	1442	22	18	59		29

Table 2. (*Continued*)

Study information						Intervention		Arms and characteristics										
Basic information		Type		Objective	RoB	Duration (week)	Intensity†	Arm	Size	Participants‡			Nutrition intake §					
Study ID	Origin									Sex ratio	Age (years)	BMI (kg/m^2)	TEI	Pr	Fat	CHO	GI	fiber
Hockaday 1978[79]	UK	S	P	T2DM	SC	52	2	control	39	0.487	50		1500	20	26	54		
								LCD	54	0.407	53		1500	20	40	40		
Hu 2018[80]	China	S	P	PreD	SC	24	3	control	31	0.452	50.4 ± 3.2	25.9 ± ± 2.9		15	25	60		
								LCD	29	0.517	51.9 ± 4.2	25.9 ± 4		20	40	40		
Huang 2016[81]	China	S	P	T2DM	SC	12	2	control	40	0.350	67.43 ± 8.43	25.79 ± 2.86						
								LGID	40	0.300	67.84 ± 8.71	25.92 ± 2.63						
Ikem 2007[82]	Nigeria	S	P	T2DM	SC	8	2	control	17	0.412	58.2 ± 8.8	24.5 ± 3.4		20	20	60		
								fiber	35	0.543	57.6 ± 6.3	23.8 ± 3.3		20	20	60		40+
Iqbal 2010[83]	USA	S	P	T2DM	SC	104	2	CR	74	0.054	60 ± 9.5	36.9 ± 5.3	1574	18	34	47		15
								LCD	70	0.157	60 ± 8.9	38.1 ± 5.5	1610	17	34	48		14
Itsiopoulos 2011[84]	Australia	S	X	T2DM	SC	12	4	control	27	0.407	59	30.7 ± 4.9	1787	18	32	46		
								Med	27	0.407	59	30.7 ± 4.9	2229	14	39	44		
Jenkins 2008[85]	Canada	S	P	T2DM	L	24	3	control	104	0.394	61 ± 9	31.2 ± 5.8	1690	21	31	48	84	
								LGID	106	0.387	60 ± 10	30.6 ± 6	1706	21	33	44	70	
Jimenez-Cruz 2003[86]	Mexico	S	X	T2DM	H	6	2	control	14	0.571	59 ± 9	29.6 ± 5.8	1561	18	20	64	56	25
								LGID	14	0.571	59 ± 9	29.6 ± 5.8	1422	21	23	60	44	34
Jönsson 2009[87]	Sweden	S	X	T2DM	SC	12	2	control	13	0.231	64 ± 6	30 ± 7	1878	20	34	42	55	26
								Paleo	13	0.231	64 ± 6	30 ± 7	1581	24	39	32	50	21
Kahleova 2011[88]	Czech	S	P	T2DM	SC	24	4	control	37	0.514	57.7 ± 4.9	35 ± 4.6	1795	18	37	45		21
								VD	37	0.541	54.6 ± 7.8	35.1 ± 6.1	1736	16	37	50		25
Krebs 2012[89]	New Zealand	M	P	T2DM	L	104	2	control	150	0.656	58 ± 9.2	36.7 ± 6.4	1695	20	30	48		24
								HPD	144	0.541	57.7 ± 9.9	36.6 ± 6.7	1714	21	33	46		23
Lasa 2014[90]	Spain	M	P	T2DM	SC	52	2	control	67	0.522	67.2 ± 6.8	29.8 ± 2.8	2198	17	39	41		
								Med	74	0.608	67.4 ± 6.3	29.4 ± 2.9	2463	17	42	39		
								Med	50	0.680	67.1 ± 4.8	30.1 ± 3.1	2479	17	44	37		
Lee 2016[91]	South Korea	S	P	T2DM	SC	12	2	control	47	0.745	58.3 ± 7	23.1 ± 2.4	1560	17	20	64		25
								VD	46	0.870	57.5 ± 7.7	23.9 ± 3.4	1496	15	19	72		34
Li 2011[94]	China	S	P	T2DM	SC	12	2	control	78		51.8 ± 6.2			15	25	60		
								LGID	78		51.8 ± 6.2			15	25	60		
Li 2021[92]	China	S	P	T2DM	SC	24	2	control	38	0.447	44.62 ± 1.3	35.38 ± 6.27				60		
								LCD	38	0.474	44.53 ± 1.28	35.41 ± 6.25				30		
Li 2022[93]	China	S	P	T2DM	SC	12	3	control	29		37.1 ± 14.02	29.75 ± 6.07	1500	16	12	73		
								LCD	24		36.5 ± 13.67	29.04 ± 5.81	1500	16	78	11		
Liu 2011[96]	China	S	P	T2DM	H	12	3	control	56					20	25	55		
								LGID	40								65	
Liu 2016[95]	China	S	P	T2DM	L	12	3	control	30	0.500	49.7 ± 5.48	21.17 ± 1.37	1800	17	29	54		
								control	31	0.484	50.2 ± 6.12	21.42 ± 1.34	1800	17	29	54		
								LCD	30	0.500	49.8 ± 6.02	21.72 ± 1.37	1800	28	30	40		
								LCD	31	0.516	51.9 ± 5.01	21.21 ± 1.34	1800	28	30	40		

Table 2. (*Continued*)

Study information						Intervention		Arms and characteristics									
Basic information		Type		Objective	RoB	Duration (week)	Intensity†	Arm	Size	Participants‡			Nutrition intake §				
Study ID	Origin									Sex ratio	Age (years)	BMI (kg/m^2)	TEI	Pr	Fat	CHO	GI	fiber
Liu 2020[97]	China	S	P	T2DM	SC	4	3	CR	49	0.429	66.7 ± 8.7			15	25	55		
								LCD	49	0.469	66.9 ± 8.6			20	75	5		
Lousley 1984[98]	UK	S	X	T2DM	SC	6	2	fiber	11		63.45 ± 7.17		1240	23	16	65		68
								LCD	11		63.45 ± 7.17		1240	22	44	37		13
Luger 2013[99]	Austria	S	P	T2DM	SC	12	2	control	20	0.727	63.7 ± 5.2	33.6 ± 5.3	1235	17	29	50		22
								HPD	20	0.364	61 ± 5.7	33 ± 4.2	1273	26	35	38		22
Ma 2008[100]	USA	S	P	T2DM	SC	52	2	control	21	0.476	51 ± 8.25	35.95 ± 6.75	1779	20	43	38	80	12
								LGID	19	0.579	56.31 ± 7.85	35.58 ± 7.46	1674	20	42	38	77	12
Marco-Benedí 2020[101]	Spain	S	P	PreD	L	24	3	control	32	0.657	54.6 ± 8.11	32.3 ± 3.7	1600	18	30	52		
								HPD	35	0.474	56.5 ± 8.59	33.2 ± 3.63	1600	35	30	35		
McLaughlin 2007[102]	USA	S	P	T2DM	SC	16	2	control	15	0.400	56 ± 7	31 ± 2.4		15	45	40		
								LCD	14	0.429	57 ± 7	31.4 ± 2.4		15	25	60		
Mehling 2000[103]	Canada	S	P	PreD	H	16	2	control	11	0.818	58.8 ± 13.27	29.4 ± 7.3	1714	17	28	53	83	23
								LGID	13	0.769	55.2 ± 10.82	29.7 ± 4.33	1695	19	25	55	76	36
								LCD	11	0.818	6.88 ± 13.27	30.6 ± 5.64	1894	16	36	47	82	24
Mohammadi 2017[104]	Iran	S	P	T2DM	SC	10	2	control	15	1.000	49.28 ± 7.75	32.45 ± 2.34	1787	12	40	48		
								CR	15	1.000	49.63 ± 9.57	34.57 ± 5.62	1595	14	41	45		
Mollentze 2019[105]	South Africa	S	P	T2DM	H	24	3	control	7	1.000	54.53 ± 6.48	40.1 ± 6.46	2477					
								CR	9	1.000	55.64 ± 7.72	41.3 ± 4.41	2091					
Nicholson 1999[106]	USA	S	P	T2DM	SC	12	4	control	4	0.500	60		1526	18	31	51		20
								VD	7	0.429	51		1409	14	11	75		26
Ning 2020[107]	China	S	P	T2DM	SC	52	2	control	31	0.452	57.63 ± 9.55	34.87 ± 3.25	1500			60		
								LCD	31	0.419	57.52 ± 9.13	34.82 ± 3.16	1500	20	50	30		
Parker 2002[108]	Australia	S	P	T2DM	SC	8	4	control	28	0.643	62.08		1543	16	26	55		28
								HPD	26	0.654	60.32		1587	28	28	42		24
Pavithran 2020a[109]	India	S	P	T2DM	SC	24	3	control	18	0.333	52 ± 7.7	27.25 ± 2.72						
								LGID	18	0.500	52 ± 7.7	26.81 ± 5.04					45	
Pavithran 2020b[110]	India	S	P	T2DM	H	24	3	control	40	0.325	51.93 ± 7.43	26.75 ± 3.29	1450	16	21	66		
								LGID	40	0.375	54.43 ± 7.57	26.4 ± 3.03	1511	16	24	62	45	
Pedersen 2014[111]	Australia	S	P	T2DM	SC	52	3	control	33	0.303	61	35 ± 4.6	1666	21	34	11		
								HPD	31	0.323	58	36 ± 6.12	2005	26	35	39		
Perna 2019[112]	Italy	S	P	T2DM	SC	13	3	control	9	0.556	67.78 ± 5.87	32.41 ± 2.91	1600	18	23	59		
								LCD	8	0.750	59.5 ± 9.48	30.3 ± 2.13	1600	22	46	32		
Rizkalla 2004[113]	France	S	X	T2DM	SC	4	2	control	12	0.000	54 ± 6.93	31 ± 3.46	2291	20	37	38	71	
								LGID	12	0.000	54 ± 6.93	31 ± 3.46	2222	21	37	36	39	
Rock 2014[114]	USA	M	P	T2DM	SC	52	4	control	67	0.473	55.5 ± 9.2	36.2 ± 4.3		20	20	60		
								HFD	66	0.481	57.3 ± 8.6	36.2 ± 4.7		25	30	45		

Table 2. (*Continued*)

Study information						Intervention		Arms and characteristics										
Basic information		Type		Objective	RoB	Duration (week)	Intensity†	Arm	Size	Participants‡			Nutrition intake §					
Study ID	Origin									Sex ratio	Age (years)	BMI (kg/m^2)	TEI	Pr	Fat	CHO	GI	fiber
Ruggenenti 2017[115]	Italy	S	P	T2DM	L	24	3	control	36	0.289	59.5 ± 7.1	29.6 ± 3.8	1760	18	34	48		
								CR	34	0.194	60.2 ± 7.2	30 ± 3.9	1571	20	36	44		
Ruggenenti 2022[116]	Italy	S	P	T2DM	L	104	2	control	50	0.180	62.8 ± 8.7	32.1 ± 3.1	1783	17	43	39		21
								CR	53	0.245	64.9 ± 7.5	32.3 ± 3.7	1592	18	43	39		20
Saslow 2014/7[117,118]	USA	S	P	T2DM	L	52	2	control	16	0.889	55.1 ± 13.5	36.9 ± 6.93	1681	16	40	36		
								LCD	14	0.563	64.8 ± 7.7	35.9 ± 6.84	1535	25	62	19		
Sato 2017[119]	Japan	S	P	T2DM	SC	24	2	LCD	30	0.233	60.5 ± 10.5	27.27 ± 3.9	1371	19	34	43		
								CR	32	0.250	58.4 ± 10	27.11 ± 4.27	1605	16	29	49		
Shen 2021[120]	China	S	P	T2DM	SC	8	2	control	46	0.435	61.78 ± 7.05	23.91 ± 2.12						
								LGID	46	0.391	62.11 ± 6.71	24.04 ± 2.19					55	
Shige 2000[121]	Australia	S	P	T2DM	SC	12	3	control	12		57.5 ± 11.8	32.6 ± 4.7	1541	17	9	73		
								HFD	12		58.1 ± 9	33.1 ± 2.8	1596	18	32	50		
Skytte 2019[122]	Denmark	S	X	T2DM	H	6	3	control	28	0.286	64 ± 7.7	30.1 ± 5.2		17	33	50		
								LCD	28	0.286	64 ± 7.7	30.1 ± 5.2		30	40	30		
Stentz 2016[123]	USA	S	P	PreD	H	24	4	control	12	0.019	41.1 ± 5.89	37.4 ± 5.89		15	30	55		
								HPD	12	0.250	43.1 ± 4.5	40.5 ± 6.24		30	30	40		
Sun 2007[124]	China	S	X	T2DM	SC	4	4	control	42	0.500	68.6 ± 7.3	25.32 ± 2.7	1471				77	
								LGID	42	0.500	68.6 ± 7.3	25.32 ± 2.7	1493				55	
Sun 2020[125]	China	S	P	T2DM	SC	12	3	control	30	0.500	57.9 ± 10.4			30	45	25		
								LCD	30	0.467	57.6 ± 10.3			20	25	55		
Tang 2021[126]	China	S	P	T2DM	SC	12	3	control	45	0.444	40.18 ± 6.32					60		
								LCD	45	0.467	40.25 ± 6.26		1600			30		
Tay 2015[127]	Australia	S	P	T2DM	L	52	4	control	57	0.491	58 ± 7	35.1 ± 4.1	1700	17	30	53		
								LCD	58	0.362	58 ± 7	34.2 ± 4.5	1700	28	58	14		
Thomsen 2022[128]	Denmark	S	P	T2DM	L	6	4	control	33	0.545	67 ± 8.8	33.2 ± 5.1	2044	17	33	50		48
								LCD	34	0.412	66.4 ± 6.9	33.6 ± 4.6	2058	30	40	30		36
Uusitupa 1993[129]	Finland	S	P	T2DM	SC	52	2	control	46	0.391	54.16 ± 6.45	33.21 ± 4.78	1713					
								CR	40	0.475	52.13 ± 6.61	33.88 ± 5.51	1628					
Visek 2014[130]	Czech	S	X	T2DM	H	12	2	control	20	0.400	62.7 ± 5.8	32 ± 4.2	1745	18	41	37	68	18
								LGID	20	0.400	62.7 ± 5.8	32 ± 4.2	1676	18	38	38	49	18
Walker 1995[131]	Australia	S	X	T2DM	SC	12	2	control	24	0.625	58.3 ± 10.29	29.2 ± 3.43	1506	24	23	50		34
								HFD	24	0.625	58.3 ± 10.29	29.2 ± 3.43	1554	22	36	40		25
Wang 2009a[132]	China	S	P	T2DM	SC	12	2	control	53	0.528	50.1 ± 5.2			15	25	60		
								LGID	56	0.536	49.1 ± 5.6			15	25	60	55	
Wang 2009b[135]	China	S	P	T2DM	SC	24	2	control	20		56.1 ± 1.3	30.23 ± 0.34	1800	15	25	60		
								LCD	20		57.3 ± 1.2	30.28 ± 0.39	1800	30	50	20		
Wang 2015[134]	China	S	P	T2DM	SC	24	2	control	50	0.360	71.8 ± 10.6	26.05 ± 2.82		20	25	55		
								LGID	50	0.400	70.5 ± 10.4	25.32 ± 4.01						

Table 2. (*Continued*)

Study information						Intervention		Arms and characteristics										
Basic information		Type		Objective	RoB	Duration (week)	Intensity†	Arm	Size	Participants‡			Nutrition intake §					
Study ID	Origin									Sex ratio	Age (years)	BMI (kg/m^2)	TEI	Pr	Fat	CHO	GI	fiber
Wang 2018[133]	China	S	P	T2DM	L	12	3	control	25	0.480	61.2 ± 11.71	24.62 ± 5.17	1732	18	26	56		
								LCD	24	0.458	66.79 ± 9.12	24.29 ± 3.36	1808	19	42	39		
Watson 2016[136]	Australia	S	P	T2DM	L	12	4	control	29	0.448	55 ± 8	34.4 ± 4.7	1421	21	22	50		29
								HPD	32	0.469	54 ± 8	34.3 ± 5.4	1490	29	30	35		25
Westman 2008[137]	USA	S	P	T2DM	H	24	2	LGID	29	0.793	50 ± 8.5	37.9 ± 6	1335	20	36	44		
								LCD	21	0.667	51.2 ± 6.1	37.8 ± 6.7	1550	28	59	13		
Wolever 1992[138]	Canada	S	X	T2DM	SC	6	4	control	6	0.500	63 ± 9.8	32.1 ± 5.88	1388	20	23	57	86	33
								LGID	6	0.500	63 ± 9.8	32.1 ± 5.88	1388	20	23	57	58	34
Wolever 2008[139]	Canada	S	P	T2DM	SC	52	4	control	48	0.500	60.4 ± 7.93	30.1 ± 4.33	1890	20	31	47	63	21
								LGID	55	0.661	60.6 ± 7.48	31.6 ± 4.49	1800	21	27	52	55	36
								LCD	53	0.463	58.6 ± 8.82	31.1 ± 4.41	2020	19	40	39	59	23
Wu 2020[140]	China	S	P	T2DM	SC	12	2	control	52	0.442	53.03 ± 6.74	24.28 ± 3.25	1764	17	33	53		
								LGID	52	0.462	53.16 ± 6.9	24.53 ± 3.12	1679	19	33	51		
Xue 2020[141]	China	S	P	T2DM	SC	24	3	control	40	0.475	60.01 ± 2.54	25.91 ± 1.48						
								Med	40	0.425	55.23 ± 5.99	25.98 ± 1.72		15	25	60		
Yamada 2014[142]	Japan	S	P	T2DM	SC	24	2	CR	12	0.583	63.2 ± 10.2	27 ± 3	1610	17	32	51		
								LCD	12	0.417	63.3 ± 13.5	24.5 ± 4.3	1634	25	45	30		
Ye 2021[143]	China	S	P	T2DM	SC	12	3	control	50		67 ± 1.3							
								LGID	50		68 ± 0.9							
Yu 2020[144]	China	S	P	T2DM	SC	12	3	control	150	0.387	59.98 ± 4.34	21.22 ± 3.34					83	
								LGID	150	0.407	60.01 ± 4.58	21.25 ± 3.44					69	
Zahedi 2021[145]	Iran	S	P	T2DM	SC	24	2	control	123	0.772	57.8 ± 8.9	31.21 ± 2.49						
								Med	105	0.771	56.8 ± 9.5	30.14 ± 3.21						
Zhao 2018[146]	China	S	P	T2DM	SC	8	2	control	40	0.275	60 ± 3			15	25	60		
								LGID	40	0.325	59.1 ± 3.5						55	
Zheng 2015[147]	China	S	P	T2DM	SC	8	2	control	37	0.459	59.8 ± 7.2	23.9 ± 2.7		15	25	60		
								LGID	37	0.405	60.1 ± 6.7	24.1 ± 2.9					55	
Zhou 2011[148]	China	S	P	T2DM	SC	12	3	control	31	0.581		23.47 ± 3.2						
								LGID	31	0.710		24.31 ± 3.22						

†Intensity was defined as: 1 = no intervention, 2 = only nutrition consultations or group discussion; 3 = provide detailed menus; 4 = provide prepared/prepackaged foods; 5 = metabolic wards. ‡Age and BMI were presented as mean ± standard deviation. The sex ratio was female percentage. §Macronutrients (protein, fat, and carbohydrate) are presented as the percentage of total energy intake (TEI%). The units of total energy intake and fiber were kcal/d and g/d, respectively. S, single-center; M, multicenter; P, parallel; X, crossover; T2DM, type 2 diabetes mellitus; PreD, prediabetes; RoB, risk of bias; H, high; SC, some concerns; L, low; CR, caloric restriction; DASH, Dietary Approaches to Stop Hypertension; fiber, high-fiber diet; HFD, high-fat diet; HPD, high-protein diet; LCD, low-carbohydrate diet; LGID, low-glycemic-index diet; Med, Mediterranean diet; Paleo, Paleolithic diet; VD, vegetarian, vegan or plant-based diet; BMI, body mass index; TEI, total energy intake; Pr, protein; CHO, carbohydrate; GI, glycemic index. Data of nutrition intake were either prescribed or estimated from the mean of reported values from 24 hour self-reported dietary records. A 60 kg average individual or 2000 kcal average TEI was used for nutrition intake estimation if needed.

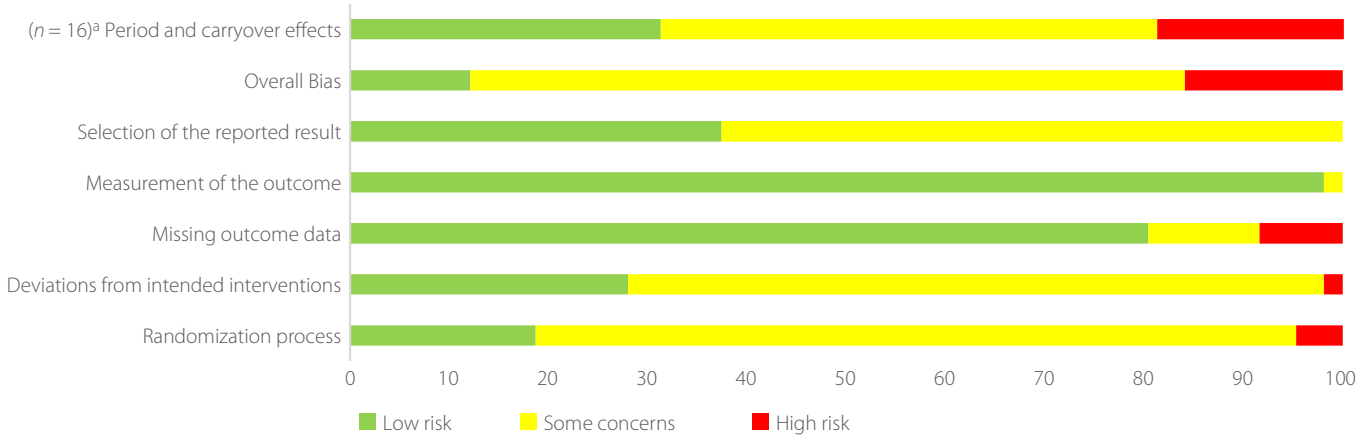

Figure 2 | Risk of bias of included studies. [a]The 'period and carryover effects' domain was only for crossover RCTs (n = 16), and other domains were for all included studies (n = 107).

Main outcomes

The number of nodes and comparisons varied among outcomes (Figure 3 and File S7). File S8 presented all league tables and cumulative ranking curves; File S9 showed forest plots with heterogeneity and inconsistency tests of all outcomes.

Glycemic control

For glycemic control, a high-fiber diet (fiber) was ranked as the best pattern for reducing FPG (MD −1.3 mmol/L, 95% CrI −2.3 to −0.22, SUCRA 82.7%) (Figure 3a). DASH (−1.2%, −2.2 to −0.23, SUCRA 90.5%) and LGID (−0.71%, −0.93 to −0.49, SUCRA 76.2%) had the highest probability of improving HbA_{1c} compared with control groups (Figure 3b). The effects on reducing FPG and HbA_{1c} were comparable.

FIns and IR were presented as PMD due to the various units reported by studies. Effects on improving insulin-related conditions were not stable and significant because of the limited sample size. High-fiber diets achieved a mean of 21% Fins reduction (95% CrI 5.2% to 46%) with a probability of 79.4% to be the best pattern (Figure 3c). IR was reported as the homeostatic model assessment (HOMA)1-IR and HOMA2-IR, among which HPD showed the best beneficial effects on improving IR (−22%, −37% to −7.0%, SUCRA 86.3%) (Figure 3d).

Anthropometrics

Calorie restriction was still one of the most effective diet patterns for weight loss (−4.1 kg, −6.1 to −2.0, SUCRA 86.8%) and WC (−4.5 cm, −7.4 to −1.8, SUCRA 82.2%), and the low carbohydrate diet was ranked as the second (−3.0 kg, −4.3 to −1.8, SUCRA 74.3%) for weight loss and the best (−1.2 kg/m^2, −1.7 to −0.74, SUCRA 81.6%) for BMI reduction (Figure 3e–g).

As for blood pressure, DASH was found to be the best pattern for lowering SBP (−7.6 mmHg, −15 to −0.29, SUCRA 87.9%) and the second for DBP (−3.7 mmHg, −10 to 2.8, SUCRA 73.7%), while HPD was the most effective for DBP (−3.0 mmHg, −5.9 to −0.068, SUCRA 74.6%) with slight superiority to DASH (Figure 3i-j).

Lipid profiles

Figure 3k–n illustrate the effects of the different interventions on lipid profiles compared with the control groups. The low-glycemic-index diet showed the most remarkable efficacy for lowering TC (−0.46 mmol/L, −0.62 to −0.30, SUCRA 87.5%) and LDL (−0.35 mmol/L, −0.47 to −0.24, SUCRA 86.6%), but were not of beneficial effect on HDL. The Paleo diet was ranked as the best pattern for improving TG (−0.50 mmol/L, −1.1 to 0.13, SUCRA 83.4%), though the outcome was not statistically significant. The low-carbohydrate diet led to an average increase of 0.12 mmol/L (95% CrI 0.073 to 0.17, SUCRA 84.0%) for HDL compared with control, thus being the best intervention with a small effect size.

Attrition

Since a considerable number of studies did not report standardized flowcharts of follow-up, we only included trials that reported a loss in at least one arm into the synthesis. An attrition rate was calculated as: the attrition number divided by the product of participant number when allocation and the duration of intervention. The meta-analysis did not find a significant difference among all patterns (Figure 3h; File S8), suggesting that the participants' tolerance for each diet be similar.

Heterogeneity and inconsistency test

Generally, the included interventions were of moderate to high heterogeneity (Figure 3, Files S9, and S10), making the results less confident. LCD-control, CR-control, LGID-control, LCD-CR, and LGID-LCD pairs were of high heterogeneity in either direct or network comparison, while Med-control and HPD-

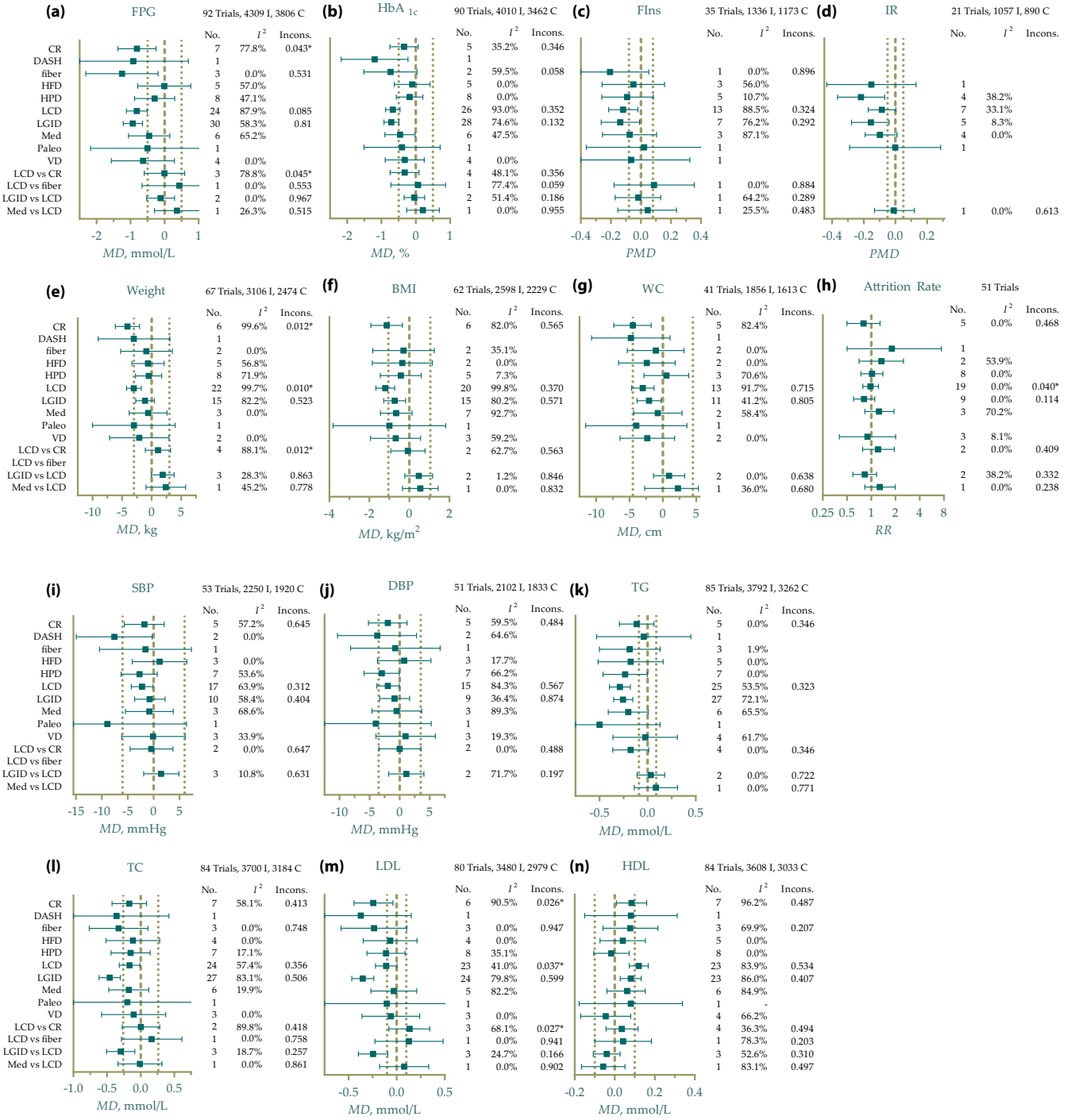

Figure 3 | Efficacy of different eating patterns on glycemic control, anthropometrics, serum lipid profiles, and comparative attrition rate. I, intervention arm; C, control arm; No., number of direct comparisons; Incons., *P* value of inconsistency test (node-splitting method); MD, mean difference; PMD, difference in percentage change from baseline; FPG, fasting plasma glucose; HbA_{1c}, glycated hemoglobin; FIns, fasting insulin; IR, insulin resistance; BMI, body mass index; WC, waist circumference; SBP, systolic blood pressure; DBP, diastolic blood pressure; TG, triacylglycerol; TC, total cholesterol; LDL, low-density lipoprotein cholesterol; HDL, high-density lipoprotein cholesterol. Thick dashes refer to the null value, and thin dashes refer to the MCID threshold. Unless otherwise specified using "vs", the effect sizes were experimental patterns vs control. I^2 values were for network heterogeneity, including both direct and indirect comparisons.

control were with mild heterogeneity in lipid profiles. Significant inconsistency was observed in LCD-CR for FPG, and CR-LCD-control loop for weight and LDL using node-splitting methods. The evidence of CR, LCD, and LGID showed severe incoherence and inconsistency and should be interpreted prudently.

Meta-regression

A random effect meta-regression model with one covariate and exchangeable coefficients was fitted for continuous outcomes. The significance of coefficients was summarized in File S11. Universally, the meta-regression denoted that weight, BMI, and macronutrient intake significantly modified the efficacy of interventions of most outcomes. On the contrary, coefficients of length, study design, medication, or insulin treatment, duration of disease, and sex ratio were not significant, implying that these factors may not contribute to the effectiveness. Another notable finding that coefficients of sample size and origin (from China or not) showed significance in FPG, weight, and lipid profiles indicated potential publication or selection biases.

Sensitivity analysis

The effect of weight, BMI, and TC showed robustness, but other outcomes were not robust enough (File S12). The exclusion of several articles[51,61,67,97,98,101,126,134,135,140,145] significantly changed the SUCRA and the 95% CrI of effect size, mainly in comparisons of CR, LCD, and Med vs. control, contributing to the severe heterogeneity. When testing for different models, i.e., fixed effect or unrelated study effect models, Med, HPD, and VD showed narrower 95% CrIs and became statistically significant for more outcome variables (see File S12). The analysis did not observe the sensitivity of relative effect and between-study heterogeneity priors, and correlation coefficients.

Publication bias

Potential publication bias of HbA_{1c}, weight and BMI existed (Egger's test $P = 0.002$; <0.001; and <0.001, respectively). P values for all outcomes and comparison-adjusted funnel plots are listed in File S13.

Quality of evidence

All MCIDs and thresholds were identified (see File S14, Figure 3, and Table 3). Of all 123 pieces of evidence comparing interventions and control groups, 49 were of moderate quality, and there was no high-quality evidence (Table 3). At the clinical level, all patterns were not significantly worse than the control diets for each outcome, but most did not show moderate to large beneficial effects. All the quality of evidence should be downgraded when applying to PreD due to the indirectness, because PreD-related trials were limited.

DISCUSSION

This review evaluated the comparative efficacy of ten experimental diets, and the results can provide guidance for diet selection of one specific patient. To manage patients with comorbidities and different levels of glycemic control, we concluded a dietary suggestion table derived from the evidence from the meta-analysis (Table 4). However, this table should be applied prudently because the evidence was not solid enough.

Quantity of macronutrients

A previous evidence basis has corroborated the efficacy of CR in weight loss, BMI and WC in patients with metabolic diseases or healthy individuals[149,150]. However, CR did not lead to a greater improvement of glycemic control, blood pressure, TG, and TC compared with standard diets. Trivial effects on these outcomes may result from weight loss but not the caloric restriction[151,152]. The median TEI of the included CR arms was 1594 kcal/d, with a 150–400 kcal negative difference compared with standard diets, significantly slighter than the prescribed (−500 kcal/d). However, the deviance did not lead to the failure of trials. The phenomena were also observed in LCD and LGID.

Carbohydrate restriction acted well in weight, HbA_{1c}, TG, and HDL, where improving HDL was the unique advantage of LCD. Nevertheless, other types of serum lipids, i.e., TC and LDL were not improved. The 75th percentile of carbohydrate intake of the included LCD arms was 40%, indicating that nearly a quarter of included trials did not meet the low-carbohydrate criteria as prescribed. Nevertheless, the effect size was similar to previous systematic reviews[13], and the strict following of the instruction as well as a more intensive intervention did not enhance the effects but may even lead to a decrease (File S11).

Increased protein intake without carbohydrate restriction (HPD) effectively improved IR, blood pressure, and TG. Compared with other reviews[153], an effectiveness of HPD on FPG, HbA_{1c}, and other lipids was not observed, mainly due to the different inclusion criteria: only HPD with protein intake of more than 30% TEI and without carbohydrate restriction was included. This implied the different efficacy of protein and carbohydrate.

As for HFD, no beneficial effect was detected, and fat intake negatively modified the lipid improvement. Despite the numerical impact on specific lipids, it remains to be evaluated whether specific types of fat improved or negatively affected the overall lipoprotein profile[154]. Unfortunately, the included trials did not provide sufficient data to draw a thorough interpretation.

Quality of carbohydrates

The low-glycemic-index diet and the high-fiber diet emphasized more the quality of the carbohydrates. The effects of LGID and high-fiber diets were similar: both showed more excellent effects on FPG, HbA_{1c}, FIns, TC, and LDL than the other patterns, but did not significantly improve weight-related outcomes, consistent with other studies[155,156]. The dietary GI and fiber of a specific single food were not well-associated[157]. However, the emphasis on lowering GI may encourage participants to

Table 3 | Summary of findings

Efficacy[†]	Intervention	Direct evidence		Indirect evidence		Network meta-analysis[‡]		
		Mean and 95% *CrI*	Quality	Mean and 95% *CrI*	Quality	Mean and 95% *CrI*	SUCRA	Quality
FPG (*MD*, mmol/L), MCID = 0.80								
Small (0.80 to 1.40)	fiber	−1.2 (−2.2, −0.057)	M[e]	−2.4 (−6.2, 1.4)	M[e]	−1.3 (−2.3, −0.22)	0.827	M
	LGID	−0.93 (−1.2, −0.64)	M[b]	−0.63 (−3.1, 1.8)	M[e]	−0.94 (−1.2, −0.65)	0.746	M
	DASH	−0.92 (−2.5, 0.70)	L[ae]			−0.92 (−2.5, 0.70)	0.639	L
	LCD	−0.72 (−1.0, −0.39)	M[bb]	−1.7 (−2.7, −0.63)		−0.82 (−1.1, −0.51)	0.651	M[g]*
	CR	−1.1 (−1.8, −0.51)	M[b]	0.15 (−0.93, 1.2)	VL[dee]	−0.81 (−1.4, −0.25)	0.645	L[g]
Trivial (0.00 to 0.80)	VD	−0.63 (−1.6, 0.29)	M[e]			−0.64 (−1.6, 0.29)	0.524	M
	Paleo	−0.50 (−2.2, 1.2)	L[ee]			−0.50 (−2.2, 1.2)	0.460	L
	Med	−0.45 (−1.1, 0.15)	L[be]			−0.45 (−1.1, 0.15)	0.405	L
	HPD	−0.29 (−0.88, 0.30)	L[ee]			−0.29 (−0.88, 0.30)	0.308	L
	HFD	−0.0078 (−0.79, 0.77)	VL[bee]			−0.0078 (−0.79, 0.77)	0.171	VL
HbA_{1c} (*MD*, %), MCID = 0.50								
Moderate (0.80 to 1.40)	DASH	−1.2 (−2.2, −0.23)	M[a]			−1.2 (−2.2, −0.23)	0.905	M
Small (0.50 to 0.90)	fiber	−0.42 (−1.3, 0.41)	L[ee]	−2.5 (−4.5, −0.53)	L[bf]	−0.74 (−1.5, 0.035)	0.712	L[g]*
	LGID	−0.73 (−0.95, −0.52)	L[bf]	0.35 (−1.1, 1.8)	VL[eef]	−0.71 (−0.93, −0.49)	0.762	L
	LCD	−0.63 (−0.85, −0.41)	L[bbf]	−0.95 (−1.6, −0.29)	M[f]	−0.67 (−0.88, −0.46)	0.721	L
Trivial (0.00 to 0.50)	Med	−0.46 (−0.90, −0.021)	L[ef]			−0.46 (−0.90, −0.021)	0.521	L
	Paleo	−0.40 (−1.5, 0.71)	L[ee]			−0.40 (−1.5, 0.71)	0.471	L
	CR	−0.51 (−1.1, 0.033)	M[e]	−0.11 (−0.74, 0.53)	VL[bee]	−0.34 (−0.76, 0.072)	0.412	M
	VD	−0.32 (−0.89, 0.25)	M[e]			−0.32 (−0.89, 0.25)	0.402	M
	HPD	−0.18 (−0.57, 0.21)	L[ee]			−0.18 (−0.57, 0.21)	0.272	L
	HFD	−0.11 (−0.63, 0.42)	L[ee]			−0.11 (−0.63, 0.42)	0.222	L
FIns (*PMD*), MCID = 0.08								
Large (>0.16)	fiber	−0.22 (−0.52, 0.084)	L[ae]	−0.18 (−0.73, 0.37)	L[ee]	−0.21 (−0.46, 0.052)	0.794	L
Moderate (0.12 to 0.16)	LGID	−0.16 (−0.30, −0.025)	M[bb]	0.041 (−0.32, 0.40)	VL[dee]	−0.14 (−0.27, −0.0098)	0.683	M
Small (0.08 to 0.12)	LCD	−0.10 (−0.21, 0.0060)	L[bbe]	−0.27 (−0.60, 0.055)	L[de]	−0.12 (−0.22, −0.02)	0.628	M[†]
	HPD	−0.09 (−0.26, 0.082)	M[e]			−0.09 (−0.26, 0.082)	0.530	M
Trivial (0.00 to 0.08)	Med	−0.075 (−0.26, 0.10)	VL[bee]			−0.075 (−0.26, 0.10)	0.476	VL
	VD	−0.065 (−0.46, 0.33)	L[ee]			−0.065 (−0.46, 0.33)	0.467	L
	HFD	−0.050 (−0.26, 0.16)	VL[bee]			−0.050 (−0.26, 0.16)	0.408	VL
	Paleo	0.021 (−0.36, 0.41)	L[ee]			0.021 (−0.36, 0.41)	0.306	L
IR (*PMD*), MCID = 0.05								
Large (>0.12)	HPD	−0.22 (−0.37, −0.07)	M[e]			−0.22 (−0.37, −0.07)	0.863	M
	LGID	−0.16 (−0.28, −0.04)	M[e]			−0.16 (−0.28, −0.04)	0.709	M
	HFD	−0.15 (−0.43, 0.13)	M[e]			−0.15 (−0.43, 0.13)	0.631	M
Moderate (0.08 to 0.12)	Med	−0.098 (−0.19, 0.01)	M[e]			−0.098 (−0.19, 0.01)	0.482	M
	LCD	−0.086 (−0.17, 0.0030)	M[e]			−0.086 (−0.17, 0.0030)	0.440	M
Trivial (0.00 to 0.05)	Paleo	−0.0010 (−0.29, 0.29)	L[ee]			−0.0010 (−0.29, 0.29)	0.257	L

Table 3. (*Continued*)

Efficacy†	Intervention	Direct evidence		Indirect evidence		Network meta-analysis‡		
		Mean and 95% *CrI*	Quality	Mean and 95% *CrI*	Quality	Mean and 95% *CrI*	SUCRA	Quality
Weight (*MD*, kg), MCID = 3.00								
Small (3.00 to 5.00)	CR	−5.9 (−8.3, −3.4)	L^{bbf}	−0.50 (−3.9, 2.9)	VL^{eef}	−4.1 (−6.1, −2.0)	0.868	L^{g}*
	LCD	−2.4 (−3.7, −1.0)	L^{bbf}	−7.3 (−11, −3.8)	L^{bf}	−3.0 (−4.3, −1.8)	0.743	L^{g}*
	DASH	−3.0 (−9.0, 3.1)	L^{ae}			−3.0 (−9.0, 3.1)	0.654	L
Trivial (0.00 to 3.00)	Paleo	−3.0 (−10, 4.0)	L^{ee}			−3.0 (−10, 4.0)	0.637	L
	VD	−2.1 (−7.1, 3.0)	L^{ee}			−2.1 (−7.1, 3.0)	0.560	L
	LGID	−1.1 (−2.8, 0.56)	VL^{bbef}	1.1 (−5.6, 7.8)	VL^{eef}	−1.1 (−2.7, 0.5)	0.435	VL
	fiber	−0.88 (−5.2, 3.5)	VL^{aee}			−0.88 (−5.2, 3.5)	0.398	VL
	HFD	−0.61 (−3.3, 2.1)	VL^{eef}			−0.61 (−3.3, 2.1)	0.343	VL
	Med	−0.58 (−3.8, 2.6)	L^{ee}			−0.58 (−3.8, 2.6)	0.342	L
	HPD	−0.50 (−3.3, 2.1)	VL^{eef}			−0.50 (−3.3, 2.1)	0.318	VL
BMI (*MD*, kg/m^2), MCID = 1.05								
Small (1.05 to 1.55)	LCD	−1.1 (−1.6, −0.59)	L^{bbf}	−1.8 (−3.3, −0.34)	L^{bf}	−1.2 (−1.7, −0.74)	0.816	L
	CR	−1.3 (−2.2, −0.35)	M^{bb}	−0.71 (−2.4, 0.95)	L^{be}	−1.1 (−1.9, −0.34)	0.756	M
Trivial (0.00 to 1.05)	Paleo	−1.0 (−3.8, 1.8)	M^{e}			−1.0 (−3.8, 1.8)	0.598	M
	LGID	−0.74 (−1.3, −0.16)	L^{bbf}	−0.022 (−2.5, 2.4)	VL^{eef}	−0.73 (−1.28, −0.18)	0.543	L
	VD	−0.69 (−1.9, 0.57)	M^{e}			−0.69 (−1.9, 0.57)	0.519	M
	Med	−0.66 (−1.4, 0.14)	VL^{bbef}			−0.66 (−1.4, 0.14)	0.504	VL
	HPD	−0.43 (−1.5, 0.59)	L^{ee}			−0.43 (−1.5, 0.59)	0.391	L
	HFD	−0.35 (−1.9, 1.1)	L^{ee}			−0.35 (−1.9, 1.1)	0.375	L
	fiber	−0.29 (−1.8, 1.2)	L^{ee}			−0.29 (−1.8, 1.2)	0.353	L
WC (*MD*, cm), MCID = 4.50								
Small (4.50 to 7.00)	DASH	−4.8 (−11, 1.1)	L^{ae}			−4.8 (−11, 1.1)	0.776	L
Trivial (0.00 to 4.50)	CR	−4.5 (−7.4, −1.8)	M^{bb}			−4.5 (−7.4, −1.8)	0.822	M
	Paleo	−4.0 (−12, 3.6)	M^{e}			−4.0 (−12, 3.6)	0.669	M
	LCD	−2.8 (−4.7, −1.0)	M^{bb}	−4.2 (−11, 2.8)	M^{e}	−3.0 (−4.7, −1.3)	0.653	M
	HFD	−2.4 (−6.6, 1.8)	M^{e}			−2.4 (−6.6, 1.8)	0.539	M
	VD	−2.3 (−6.4, 1.8)	M^{e}			−2.3 (−6.4, 1.8)	0.534	M
	LGID	−2.1 (−4.0, −0.17)	M^{e}	−1.2 (−8.0, 5.6)	VL^{dee}	−2.1 (−3.9, −0.27)	0.499	M
	fiber	−1.1 (−5.3, 3.2)	L^{ee}			−1.1 (−5.3, 3.2)	0.364	L
	Med	−0.77 (−4.4, 2.8)	L^{ee}			−0.77 (−4.4, 2.8)	0.315	L
	HPD	0.53 (−2.8, 3.9)	VL^{bee}			0.53 (−2.8, 3.9)	0.156	VL
SBP (*MD*, mmHg), MCID = 6.00								
Small (6.00 to 10.00)	Paleo	−8.9 (−24, 6.4)	M^{e}			−8.9 (−24, 6.4)	0.807	M
	DASH	−7.6 (−15, −0.29)	M^{a}			−7.6 (−15, −0.29)	0.879	M

Table 3. (*Continued*)

Efficacy†	Intervention	Direct evidence		Indirect evidence		Network meta-analysis‡		
		Mean and 95% *CrI*	Quality	Mean and 95% *CrI*	Quality	Mean and 95% *CrI*	SUCRA	Quality
Trivial (0.00 to 6.00)	HPD	−2.7 (−6.3, 0.71)	L[be]			−2.7 (−6.3, 0.71)	0.634	L
	LCD	−1.9 (−4.1, 0.38)	L[be]	−5.5 (−12, 1.3)	L[de]	−2.2 (−4.3, −0.10)	0.594	M[P]*
	CR	−2.3 (−6.8, 2.1)	L[be]	−0.12 (−8.1, 8.1)	L[ee]	−1.8 (−5.7, 2.0)	0.515	L
	fiber	−1.6 (−10, 7.3)	L[ee]			−1.6 (−10, 7.3)	0.477	L
	Med	−0.82 (−5.4, 3.8)	L[ee]			−0.82 (−5.4, 3.8)	0.401	L
	LGID	−0.92 (−4.0, 2.3)	VL[bee]	3.6 (−6.7, 14)	L[ee]	−0.76 (−3.7, 2.2)	0.385	VL
	VD	−0.11 (−6.2, 6.1)	L[ee]			−0.11 (−6.2, 6.1)	0.339	L
	HFD	1.2 (−4.1, 6.4)	L[ee]			1.2 (−4.1, 6.4)	0.211	L
DBP (*MD*, mmHg), MCID = 3.50								
Small (3.50 to 7.00)	Paleo	−4.0 (−13, 5.3)	M[e]			−4.0 (−13, 5.3)	0.708	M
	DASH	−3.7 (−10, 2.8)	VL[abe]			−3.7 (−10, 2.8)	0.737	VL
Trivial (0.00 to 3.50)	HPD	−3.0 (−5.9, −0.068)	M[b]			−3.0 (−5.9, −0.068)	0.746	M
	CR	−2.6 (−6.4, 1.1)	L[be]	0.15 (−6.7, 7.0)	L[ee]	−2.0 (−5.2, 1.2)	0.610	L
	LCD	−2.0 (−3.9, 0.033)	L[be]	−3.7 (−9.3, 1.9)	L[be]	−2.0 (−3.8, −0.069)	0.627	M[P]*
	LGID	−0.49 (−3.1, 2.1)	L[ee]	0.18 (−8.2, 8.7)	L[ee]	−0.83 (−3.3, 1.7)	0.440	L
	fiber	−0.73 (−8.2, 6.7)	L[ee]			−0.73 (−8.2, 6.7)	0.448	L
	Med	−0.48 (−4.6, 3.7)	VL[bbee]			−0.48 (−4.6, 3.7)	0.400	VL
	HFD	0.77 (−3.7, 5.2)	L[ee]			0.77 (−3.7, 5.2)	0.255	L
	VD	0.98 (−3.9, 5.9)	L[ee]			0.98 (−3.9, 5.9)	0.243	L
TG (*MD*, mmol/L), MCID = 0.09								
Large (>0.25)	Paleo	−0.50 (−1.1, 0.13)	M[e]			−0.50 (−1.1, 0.13)	0.834	M
	LCD	−0.26 (−0.38, −0.14)	M[b]	−0.45 (−0.81, −0.094)	H	−0.29 (−0.40, −0.18)	0.758	M
	LGID	−0.26 (−0.35, −0.15)	M[b]			−0.26 (−0.35, −0.15)	0.674	M
Moderate (0.15 to 0.25)	HPD	−0.23 (−0.46, −0.0030)	M[e]			−0.23 (−0.46, −0.0030)	0.615	M
	Med	−0.20 (−0.41, 0.0050)	L[be]			−0.20 (−0.41, 0.0050)	0.548	L
	fiber	−0.19 (−0.50, 0.13)	L[ae]			−0.19 (−0.50, 0.13)	0.517	L
	HFD	−0.18 (−0.52, 0.16)	M[e]			−0.18 (−0.52, 0.16)	0.499	M
Small (0.09 to 0.15)	CR	−0.18 (−0.41, 0.048)	M[e]	0.0026(−0.30, 0.31)	L[ee]	−0.11 (−0.29, 0.066)	0.361	M
Trivial (0.00 to 0.09)	DASH	−0.040 (−0.53, 0.45)	VL[aee]			−0.040 (−0.53, 0.45)	0.310	VL
	VD	−0.024 (−0.36, 0.31)	VL[bee]			−0.024 (−0.36, 0.31)	0.246	VL
TC (*MD*, mmol/L), MCID = 0.26								
Moderate (0.40 to 0.52)	LGID	−0.48 (−0.64, −0.31)	M[bb]	−0.18 (−1.0, 0.69)	L[ee]	−0.46 (−0.62, −0.30)	0.875	M
Small (0.26 to 0.40)	DASH	−0.36 (−1.1, 0.42)	VL[aee]			−0.36 (−1.1, 0.42)	0.647	VL
	fiber	−0.29 (−0.79, 0.21)	M[e]	−0.47 (−1.4, 0.51)	M[e]	−0.33 (−0.76, 0.11)	0.675	M

Table 3. (*Continued*)

Efficacy[†]	Intervention	Direct evidence		Indirect evidence		Network meta-analysis[‡]		
		Mean and 95% *CrI*	Quality	Mean and 95% *CrI*	Quality	Mean and 95% *CrI*	SUCRA	Quality
Trivial (0.00 to 0.26)	Paleo	−0.20 (−1.3, 0.87)	L^{ee}			−0.20 (−1.3, 0.87)	0.500	L
	Med	−0.18 (−0.47, 0.12)	M^{e}			−0.18 (−0.47, 0.12)	0.483	M
	CR	−0.23 (−0.53, 0.074)	L^{be}	0.027 (−0.52, 0.58)	L^{ee}	−0.17 (−0.43, 0.089)	0.472	L
	LCD	−0.12 (−0.29, 0.049)	L^{be}	−0.35 (−0.80, 0.11)	L^{de}	−0.17 (−0.32, −0.012)	0.470	M^{p}*
	HPD	−0.15 (−0.44, 0.14)	M^{e}			−0.15 (−0.44, 0.14)	0.439	M
	HFD	−0.12 (−0.52, 0.28)	L^{ee}			−0.12 (−0.52, 0.28)	0.393	L
	VD	−0.11 (−0.58, 0.37)	L^{ee}			−0.11 (−0.58, 0.37)	0.386	L
LDL (*MD*, mmol/L), MCID = 0.10								
Moderate (0.25 to 0.40)	DASH	−0.37 (−0.89, 0.15)	L^{ae}			−0.37 (−0.89, 0.15)	0.773	L
	LGID	−0.37 (−0.48, −0.25)	M^{b}	−0.19 (−0.83, 0.45)	L^{ee}	−0.35 (−0.47, −0.24)	0.866	M
Small (0.10 to 0.25)	CR	−0.39 (−0.62, −0.15)	M^{bb}	0.096 (−0.26, 0.46)	L^{ee}	−0.24 (−0.44, −0.039)	0.694	L^{g}
	fiber	−0.24 (−0.62, 0.14)	M^{e}	−0.21 (−1.1, 0.65)	L^{ee}	−0.24 (−0.35, 0.21)	0.648	M
	HPD	−0.11 (−0.31, 0.088)	M^{e}			−0.11 (−0.31, 0.088)	0.443	M
	LCD	−0.058 (−0.18, 0.062)	M^{e}	−0.43(−0.75, −0.099)	H	−0.11 (−0.22, 0.0040)	0.444	M^{g}*
	Paleo	−0.10 (−0.92, 0.72)	L^{ee}			−0.10 (−0.92, 0.72)	0.454	L
Trivial (0.00 to 0.10)	HFD	−0.067 (−0.35, 0.21)	L^{ee}			−0.067 (−0.35, 0.21)	0.361	L
	VD	−0.060 (−0.36, 0.24)	L^{ee}			−0.060 (−0.36, 0.24)	0.351	L
	Med	−0.029 (−0.27, 0.21)	VL^{bbee}			−0.029 (−0.27, 0.21)	0.284	VL
HDL (*MD*, mmol/L), MCID = 0.10								
Small (0.10 to 0.15)	LCD	0.11 (0.056, 0.16)	M^{bb}	0.15 (0.027, 0.27)	M^{b}	0.12 (0.073, 0.17)	0.840	M
Trivial (0.00 to 0.10)	CR	0.10 (0.0092, 0.19)	M^{bb}	0.044 (−0.095, 0.18)	VL^{bde}	0.084 (0.0080, 0.16)	0.657	M
	DASH	0.081 (−0.15, 0.31)	VL^{aee}			0.081 (−0.15, 0.31)	0.593	VL
	LGID	0.083 (0.028, 0.14)	M^{bb}	−0.025 (−0.28, 0.23)	L^{ee}	0.080 (0.028, 0.13)	0.640	M
	Paleo	0.080 (−0.18, 0.34)	L^{ee}			0.080 (−0.18, 0.34)	0.584	L
	fiber	0.026 (−0.13, 0.19)	VL^{aee}	0.22 (−0.041, 0.49)	L^{de}	0.077 (−0.059, 0.22)	0.609	VL
	Med	0.062 (−0.039, 0.16)	L^{bbe}			0.062 (−0.039, 0.16)	0.547	L
	HFD	0.040 (−0.074, 0.15)	M^{ee}			0.040 (−0.074, 0.15)	0.447	M
	HPD	−0.017 (−0.11, 0.072)	L^{ee}			−0.017 (−0.11, 0.072)	0.200	L
	VD	−0.045 (−0.17, 0.079)	VL^{bee}			−0.045 (−0.17, 0.079)	0.139	VL

a. limitation (risk of bias); b. inconsistency (unexplained substantial heterogeneity); bb. severe inconsistency (unexplained substantial heterogeneity, downgrade 1 level); c. indirectness (from population, intervention, or outcomes); d. indirectness (intransitivity); e. imprecision; ee. severe imprecision (downgrade 2 levels); f. publication bias; g. incoherence; g*. incoherence (same direction, no downgrading). p*. greater precision. SUCRA, surface under the cumulative ranking curve; H, high quality of evidence; M, moderate; L, low; VL, very low. [†]'Small', 'moderate' and 'large' referred to beneficial effects. [‡]We only identified limitations when more than half of the included studies providing the evidence were at high risk of bias. For inconsistency, an I^2 value of greater than 75% was considered severe inconsistent. Even if meta-regression was done, we were not confident to explain heterogeneity using covariates, so every comparison with I^2 greater than or near 50% was considered inconsistent. Indirectness from population, intervention, or outcomes was not detected for T2DM because of the aims of this study; however, if applying evidence to PreD populations, indirectness should exist. Intransitivity was determined if the effect size and the SUCRA seemed very unstable in the sensitivity analysis. Unstable SUCRA may denote differences in characteristics among studies that could modify effects in indirect comparison. Imprecision was determined if 95% CrI contained a null value, or the effect size showed statistical instability (change of significance) in the meta-regression and sensitivity analysis. Severe imprecision referred to those whose CrI was divided by the null value into two parts with a comparable ratio, or the mean was very trivial, close to null. Incoherence was determined if the comparisons showed significant inconsistency (the term in network meta-analysis). The network quality of evidence was downgraded if incoherence of different directions (i.e., positive and negative) existed. All ratings of the factors were agreed by three authors (B.-T.Z., F.-D.L., and J.-W.D.).

Table 4 | Dietary suggestions for patients with different profiles

Well-controlled glycemia	Poor-controlled glycemia	Poor insulin sensitivity	Hypertriglyceridemia	Hypercholesterolemia	Low HDL level	General obesity	Central obesity	Hypertension
Well-controlled glycemia	Only poor-controlled glycemia: LGID; fiber; DASH	HPD	LCD; Paleo[†]	LGID	LCD	CR; LCD	LCD	DASH; HPD
	Poor-controlled glycemia	LGID; fiber	LGID	LGID	LCD	DASH	DASH; LCD	DASH
		Poor insulin sensitivity	LGID	LGID	LCD	LCD	LCD[†]	HPD
			Hypertriglyceridemia	LGID	LGID	LCD	Paleo[†]	HPD
				Hypercholesterolemia	CR	CR	DASH	DASH
					Low HDL level	LCD	LCD	DASH[†]
						General obesity	CR	Paleo[†]
							Central obesity	DASH
								Hypertension

[†]The evidence is uncertain.

increase fiber intake, because the usually recommended food groups can be both low in GI and high in fiber, e.g., whole grains and nuts.

A recent high-quality meta-analysis has also denoted that dietary fiber and low-GI food were associated with a lower risk of type 2 diabetes mellitus incidence, where fiber may be a stronger protector[158]. Rather than a severe long-term restriction of carbohydrate intake which leads to higher all-cause mortality[159], LGID and increased fiber intake can be better and sustainable approaches for patients with type 2 diabetes mellitus without obesity/overweight, especially in the circumstance that most people lacked fiber intake[160].

Mediterranean diets

Even if previous cohort studies and RCTs have demonstrated the efficacy of Med in type 2 diabetes mellitus management[161], our study failed to detect a significant improvement driven by Med. Except for HbA_{1c}, IR, and TG, all other outcomes were of great imprecision and of trivial effect. The effect size was also more trivial than other meta-analyses[14,162]. A small sample size compared with other interventions could be the reason when using random effects models; different calculation of effect size, i.e., MD of change from baseline or of the endpoint may explain the numerical differences.

Moreover, heterogeneity was detected for almost all outcomes of Med-control comparisons, where the variance and bias of the definition of Med in different trials[163] can be a significant reason. Though several scales have been developed to measure the adherence to Med (e.g., MedDiet Score)[164], few trials employed it, making this problem difficult to address.

Vegan, vegetarian, or plant-based diets

The vegetarian/vegan/plant-based diet did not show any significant beneficial effects in our study. The mean differences of VD were similar to the previous studies[36], thus not affecting the conclusion but lowering the quality of the evidence. While using fixed effect models, an effectiveness of VD on BMI, WC, and HbA_{1c} was detected, but moderate heterogeneity made it unreasonable to employ fixed effect models.

Notably, the carbohydrate intake in VD trials was relatively high (mean 65.8%TEI). The sensitivity analysis also showed a slight improvement of SUCRA in TG after omitting Lee 2016[91], which contained about 72%TEI of carbohydrate in VD arms. Researchers should consider a lower carbohydrate intake when conducting a VD, and the effects would promise to be more significant.

Newly developed diets

Evidence of the efficacy of the dietary approaches to stop hypertension (DASH) and Paleo was limited and of low quality due to the sample size, and further investigation is needed. As one of the recommended healthy patterns by Dietary Guidelines for Americans (DGA 2020-2025)[165], many studies have addressed DASH's benefit in blood pressure and glycemic control[166,167]. However, related RCTs specially for type 2 diabetes mellitus/prediabetic patients were rare. Included studies also outlined the beneficial effects of DASH on blood pressure, TC, LDL, and HbA_{1c}, and DASH was the most effective intervention for HbA_{1c} with a high probability (90.5%). As for Paleolithic diets, Tommy Jönsson and his colleagues also quantified the improvement of leptin and introduced a scale (Paleolithic Diet Fraction) to measure the compliance, based on their trial[87,168], providing a basis for further study.

Limitations

This study had several limitations. First, the heterogeneity and sensitivity lowered the quality of evidence. Second, the sample size of VD, DASH, and Paleo was limited, leading to the imprecision. Third, only five prediabetic trials were included, raising the indirectness of the evidence for the prediabetic population. Moreover, there was not an adequate method to compare the longitudinal dataset of different patterns, though the data of different timepoints have been extracted.

In conclusion, energy, carbohydrate, and dietary glycemic index (GI) restriction, as well as dietary fiber intake, were the most effective approaches with solid and abundant evidence bases. Simultaneously, DASH, Paleolithic diets, and HPD were of satisfactory efficacy in limited outcomes and worth investigation. Mediterranean diets, VD, and HFD did not act well in most outcomes, mainly due to the imprecision. Heterogeneity and sensitivity should be considered when interpreting results.

This work may eliminate some barriers on how to choose the best diet on an individualized basis. Clinicians and dietitians can choose the most important outcome when there is an urgent need to control a patient to match the most appropriate dietary pattern, according to the summary of findings table and the dietary suggestions table of this review.

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DISCLOSURE

The authors declare no conflict of interest.
Approval of the research protocol: N/A.
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Registry and the registration no. of the study/trial: This network meta-analysis was registered at https://www.crd.york.ac.uk/PROSPERO as CRD42021278268.
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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

File S1 | Full search strategy

File S2 | Data extraction template

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File S4 | Reason for exclusion

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File S14 | Minimal clinically important difference and thresholds for effects