Review the current evidence on the durability of type 2 diabetes remission achieved through intensive lifestyle and dietary interventions, specifically comparing low-carbohydrate diets to severe caloric restriction. Synthesize the physiological mechanisms and long-term (≥3 years) relapse rates.

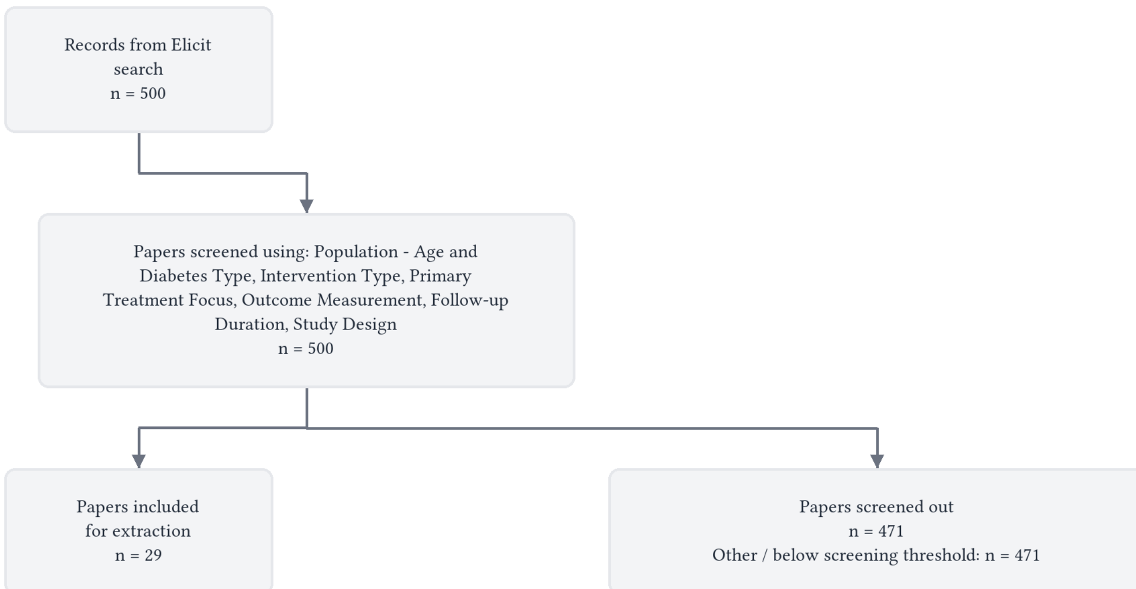
Both low-carbohydrate diets and severe caloric restriction can achieve type 2 diabetes remission in up to 62% of participants at one year—primarily by reducing ectopic pancreatic and hepatic fat to restore beta-cell function—but neither approach demonstrates superior long-term durability, with remission rates declining to approximately 13% by five years due to weight regain and progressive beta-cell loss.

Abstract

Intensive dietary interventions—including low-carbohydrate diets, ketogenic diets, and very-low-calorie diets—can achieve type 2 diabetes remission in up to 62% of participants at one year [1], with remission defined as HbA1c <6.5% off glucose-lowering medications [1, 2]. However, remission durability is poor: rates decline to approximately 13% by five years, accompanied by partial weight regain and HbA1c levels rising above baseline [1]. Remission odds are roughly six times greater when follow-up is limited to 12 months or less [3], and HbA1c benefits of low-carbohydrate diets become non-significant beyond 12 months [4]. Direct comparisons between low-carbohydrate diets and severe caloric restriction are limited, but available evidence indicates no clear superiority of either approach at 12 or 24 months [5], with sustained weight loss—rather than specific macronutrient composition—identified as the primary driver of remission [5]. Both strategies appear to operate through reduction of ectopic pancreatic and hepatic fat, restoring beta-cell function and insulin sensitivity [1, 5], a mechanism more effective in recently diagnosed patients [2].

Ketogenic diets produce larger short-term HbA1c reductions than moderate low-carbohydrate diets (SMD -1.45% vs. -0.27%) [6], and VLCDs achieve the greatest initial weight loss (mean 13.2 kg) [7], but both face substantial adherence challenges—ketogenic diet attrition reaches 45% at six months [8], and VLCD dropout rates increase during follow-up compared with active intervention phases [7]. Long-term relapse is driven primarily by weight regain [9, 10] and progressive beta-cell decline [2], factors that no current dietary strategy has reliably overcome beyond three years. The evidence base for remission durability specifically is constrained by few studies with follow-up exceeding three years, high attrition, and heterogeneous remission definitions across studies.

Flow Diagram



Paper search

We performed a semantic search across over 138 million academic papers from the Elicit search engine, which includes all of Semantic Scholar and OpenAlex.

We ran this query: "Review the current evidence on the durability of type 2 diabetes remission achieved through intensive lifestyle and dietary interventions, specifically comparing low-carbohydrate diets to severe caloric restriction. Synthesize the physiological mechanisms and long-term (≥3 years) relapse rates."

The search returned 500 total results from Elicit.

We retrieved 500 papers most relevant to the query for screening.

Screening

We screened in sources based on their abstracts that met these criteria:

- **Population - Age and Diabetes Type**: Does this study include adults (≥18 years) with confirmed type 2 diabetes mellitus, and exclude participants with type 1 diabetes, gestational diabetes, secondary diabetes, or pre-diabetes only?
- **Intervention Type**: Does this study examine intensive lifestyle interventions (low-carbohydrate diets ≤130g carbohydrates/day or ≤26% total energy, OR severe caloric restriction ≤800 kcal/day) as the primary intervention, rather than bariatric surgery as the primary intervention?

- **Primary Treatment Focus**: Is this study focused on lifestyle interventions rather than pharmacological interventions as the primary treatment? (Note: studies combining lifestyle with standard medications are acceptable)
- **Outcome Measurement**: Does this study report diabetes remission rates using standardized criteria (HbA1c <6.5% or <48 mmol/mol without glucose-lowering medications for ≥3 months) and/or relapse rates?
- **Follow-up Duration**: Does this study provide a minimum of 3 years of follow-up data?
- **Study Design**: Is this study a randomized controlled trial, prospective cohort study, systematic review, or meta-analysis (rather than a case report, case series, cross-sectional study, or conference abstract)?

We considered all screening questions together and made a holistic judgement about whether to screen in each paper.

At abstract screening, the number of papers excluded for each primary reason was:

- **Other / below screening threshold**: n = 471

Data extraction

We asked a large language model to extract each data column below from each paper. We gave the model the extraction instructions shown below for each column.

- **Study Design**:

  Extract study design, sample size, participant demographics (age, diabetes duration, baseline HbA1c), and inclusion/exclusion criteria specifically relevant to type 2 diabetes remission studies. Include diabetes medication status at baseline and any relevant comorbidities that might affect remission durability.

- **Intervention Type**:

  Classify and extract detailed intervention characteristics for type 2 diabetes remission, specifically identifying:

- Low-carbohydrate diet (specify carb percentage/grams per day, ketogenic vs moderate low-carb)
- Severe caloric restriction/VLCD (specify calorie limits, meal replacement protocols)
- Combined interventions (diet plus exercise, behavioral support)
- Duration of active intervention phase
- Any maintenance phase protocols

- **Remission Definition**:

  Extract the specific definition of type 2 diabetes remission used in each study, including:

- HbA1c thresholds (e.g., <6.5%, <7.0%)
- Fasting glucose criteria
- Medication status requirements (off meds vs reduced meds)
- Duration criteria for sustained remission
- Whether partial vs complete remission was distinguished

- **Initial Remission**:

  Extract remission achievement data at the end of active intervention, including:

- Percentage of participants achieving remission by intervention type
- Time to remission achievement
- Magnitude of HbA1c reduction

- Weight loss associated with remission
- Medication discontinuation rates

- **Long-term Follow-up**:

  Extract all follow-up data for diabetes remission durability, with special focus on studies with ≥3 years follow-up:

- Total follow-up duration
- Remission maintenance rates at each follow-up timepoint
- Relapse rates and timing of relapse
- Patterns of HbA1c change over time
- Weight regain patterns
- Medication resumption rates and timing

- **Physiological Mechanisms**:

  Extract all reported physiological mechanisms explaining diabetes remission durability or relapse, including:

- Beta cell function recovery (C-peptide, HOMA-β)
- Insulin sensitivity changes (HOMA-IR, glucose clamp data)
- Metabolic changes (ketone levels, fat oxidation, muscle insulin sensitivity)
- Hormonal changes (GLP-1, leptin, adiponectin)
- Inflammatory markers
- Pancreatic fat content or liver fat changes
- Any proposed mechanistic pathways for intervention differences

- **Comparative Effectiveness**:

  Extract direct or indirect comparison data between low-carbohydrate diets and severe caloric restriction for diabetes remission durability:

- Head-to-head comparison results if available
- Differential relapse rates between intervention types
- Sustainability differences (adherence, tolerability)
- Subgroup analyses by intervention type
- Authors' conclusions about relative effectiveness for long-term remission
- Any moderating factors affecting intervention success

- **Quality Factors**:

  Extract study quality factors that affect interpretation of remission durability evidence:

- Dropout rates and reasons, especially during long-term follow-up
- Adherence measurement and rates for each intervention type
- Blinding status and control group comparisons
- Statistical analysis approach for time-to-event data
- Missing data handling for long-term outcomes
- Funding source and potential conflicts of interest

Results

Characteristics of Included Studies

This review encompasses 29 sources, the majority of which are systematic reviews and/or meta-analyses of randomized controlled trials examining dietary and lifestyle interventions for type 2 diabetes mellitus (T2DM). The sources vary considerably in their focus: some address diabetes remission directly, while others report on glycemic control, weight loss, and cardiometabolic outcomes as surrogate endpoints. Only a minority of studies explicitly defined or measured T2DM remission, and fewer still reported long-term follow-up data of three or more years. The table below summarizes the characteristics of all included sources.

Study	Full text retrieved?	Study Type	Primary Focus	Intervention(s) Examined	No. of Primary Studies / Participants	Follow-up Duration
Rajib Das et al., 2025	Yes	Systematic review [1]	T2DM remission via LCD/KD [1]	LCD (<130 g/d), KD, caloric restriction [1]	6 studies [1]	1–8 years [1]
Yating Zhang et al., 2022	Yes	Systematic review and meta-analysis [3]	Lifestyle interventions for diabetes remission [3]	Diet-only, diet + physical activity [3]	12 studies, 3,997 participants [3]	Up to 6 years [3]
A. P. Nicholas et al., 2021	Yes	Systematic review [5]	LCD vs. LED for T2D remission [5]	LCD (<130 g/d), LED (<1200 kcal/d), meal replacements [5]	15 studies [5]	Up to 24 months [5]
P. McArdle et al., 2019	Yes	Systematic review and meta-analysis [11]	Carbohydrate restriction and glycemic control [11]	Very low-carb (<50 g/d), low-carb (50–130 g/d) [11]	2,132 participants [11]	12–208 weeks [11]
Henny-Kristine Korsmo-Haugen et al., 2018	Yes	Systematic review and meta-analysis [12]	Carbohydrate quantity and T2DM management [12]	Moderate LCD (32–40 E%) [12]	Multiple RCTs (e.g., n=13 to 259) [12]	3–24 months [12]
C. Terranova et al., 2015	Yes	Systematic review and meta-analysis [9]	Lifestyle-based weight loss in T2DM [9]	Diet, exercise, behavioral support, VLCD [9]	27–5,145 participants per study [9]	16 weeks to 10 years [9]

Study	Full text retrieved?	Study Type	Primary Focus	Intervention(s) Examined	No. of Primary Studies / Participants	Follow-up Duration
Aditi Panditrao, 2025	Yes	Systematic review [8]	KD as adjunct therapy for T2DM [8]	KD (<50 g carbs/d) [8]	25 studies (15 clinical, 10 preclinical) [8]	12 weeks to 12 months [8]
L. Sellahewa et al., 2016	No	Systematic review [7]	VLCD in T2DM [7]	VLCD (5 days to 6 months) [7]	17 studies [7]	Up to 5 years [7]
Delphyne Anyang Kaakyire et al., 2025	Yes	Systematic review of RCTs [13]	LCD vs. LFD for glycemic control [13]	Very low-carb ketogenic (<10% carbs), moderate LCD (30–45%) [13]	7 RCTs [13]	Not specified [13]
Yaofu Fan et al., 2016	No	Systematic review and meta-analysis [14]	LCD effects on T2DM [14]	LCD (not further specified) [14]	Not specified [14]	Not specified [14]
Amber Parry-Strong et al., 2022	Yes	Systematic review and meta-analysis of RCTs [15]	VLC/KD in T2D [15]	VLC/KD (≤50 g carbs/d or ≤10% TE) [15]	13–144 participants per study [15]	3–24 months [15]
D. Sherifali et al., 2025	Yes	Systematic review and meta-analysis of RCTs [2]	Nonsurgical T2DM remission [2]	VLCD (600–853 kcal/d), multi-component nonpharma-cological [2]	18 studies; 6,433 (nonpharma-cological) + 1,488 (phar-macological) [2]	Not specified beyond intervention [2]
Hany A. Zaki et al., 2022	Yes	Systematic review and meta-analysis [6]	KD vs. LCD for glycemic/weight control [6]	KD (<50 g/d, >75% fat), LCD [6]	15 studies [6]	Not specified [6]
Gloria Hernández Alcántara et al., 2015	Yes	Systematic review of RCTs [16]	LCD and weight loss/HbA1c in T2DM [16]	LCD (<130 g/d or <26% TE) [16]	4 studies, 444 participants [16]	10–24 months [16]
Bhupesh Gupta et al., 2025	Yes	Systematic review and meta-analysis [17]	Low/very-low-calorie and special diets in DM [17]	LCD, VLCD (<800 kcal/d), low-calorie (<1200 kcal/d) [17]	16 RCTs, 1,232 participants [17]	Not specified [17]

Study	Full text retrieved?	Study Type	Primary Focus	Intervention(s) Examined	No. of Primary Studies / Participants	Follow-up Duration
Xiaojie Yuan et al., 2020	Yes	Meta-analysis [18]	KD and glycemic/lipid metabolism in T2DM [18]	KD (<55 g/d carbs) [18]	13 studies, 567 subjects [18]	Not specified [18]
M. V. Beretta et al., 2024	No	Overview of systematic reviews [19]	LC diets for metabolic control in T2DM [19]	LC (not further specified) [19]	Not specified [19]	Up to >12 months [19]
H. Mozaffari et al., 2024	No	Systematic review [20]	Food-based dietary strategies for T2D remission [20]	LCMD, low-calorie, plant-based [20]	52 original studies [20]	Not specified [20]
Junya Hironaka et al., 2024	Yes	Systematic review and meta-analysis of RCTs [21]	LCD in East Asians with T2DM [21]	LCD (<50–130 g/d) [21]	6 studies, 24–134 patients each [21]	3–18 months [21]
Yukmin Rotama Panjaitan et al., 2025	No	Systematic review [4]	Lifestyle modifications for blood sugar control in T2DM [4]	Diet, exercise, DSME, digital tools [4]	80 studies [4]	6–24 months (DSME) [4]
J. Hartmann-Boyce et al., 2023	Yes	Systematic review and meta-analysis of RCTs [10]	Long-term effects of weight regain after BWMPs [10]	Behavioral weight management programs [10]	124 trials; 4,202 participants (diabetes incidence) [10]	Median 28 months post-program [10]
Jessica Amerkamp et al., 2024	Yes	Systematic review of RCTs [22]	Combined diet-and-exercise in T2DM [22]	LC diets (HF or HP) + exercise [22]	11 RCTs [22]	8 weeks to 24 months [22]
Jie Yang et al., 2023	No	Systematic review and meta-analysis of RCTs [23]	Ethnic differences in lifestyle weight-loss interventions [23]	Lifestyle weight-loss interventions [23]	30 studies, 7,580 subjects [23]	Not specified [23]

Study	Full text retrieved?	Study Type	Primary Focus	Intervention(s) Examined	No. of Primary Studies / Participants	Follow-up Duration
Joshua Chadwick et al., 2024	No	Systematic review and meta-analysis [24]	Intermittent fasting for T2DM [24]	Intermittent fasting [24]	9 identified, 4 in meta-analysis (238 participants) [24]	Not specified [24]
S. Abrar et al., 2025	No	Systematic review and meta-analysis [25]	Lifestyle and pharmacological interventions in T2DM [25]	Lifestyle, pharmacological, and combined [25]	8 studies (qualitative), 5 in meta-analysis (>20,000 participants) [25]	Not specified [25]
Yi Liu et al., 2025	Yes	Network meta-analysis of RCTs [26]	12 nutritional interventions for T2DM [26]	MNT, LGI, LGI+LGL, digital dietary models, LCD (33% TE) [26]	18 RCTs, 1,687 patients [26]	Not specified [26]
Abdulmohsin Almuaiqel et al., 2025	No	Systematic review [27]	Lifestyle interventions in primary care T2DM [27]	Diet, physical activity, behavioral therapy [27]	7 studies, >9,000 people [27]	Not specified [27]
Shelly Juliska et al., 2024	Yes	Systematic review [28]	KD in obese T2DM patients [28]	KD (20–50 g carbs/d) [28]	Not specified [28]	Not specified [28]
Anya Francheska Salazar Supe et al., 2025	No	Systematic review and meta-analysis of RCTs [29]	KD effects on LDL-C and metabolic parameters [29]	KD (≤10% carbs), ≥3 months [29]	9 studies, 658 participants [29]	3–24 months [29]

The included sources span publication years from 2015 to 2025 and collectively synthesize evidence from hundreds of primary studies. The majority are systematic reviews with meta-analyses of RCTs, though several are reviews of reviews or narrative systematic reviews. Notably, only a small subset of sources—Rajib Das et al. (2025), Yating Zhang et al. (2022), C. Terranova et al. (2015), L. Sellahewa et al. (2016), and D. Sherifali et al. (2025)—report follow-up periods extending to three or more years, which is directly relevant to the question of remission durability. Full texts were available for 20 of the 29 sources. The interventions studied are heterogeneous, ranging from ketogenic diets to very-low-calorie diets, combined diet-and-exercise programs, behavioral weight management, and other nutritional strategies. This heterogeneity limits direct head-to-head comparisons but allows for a broad assessment of the evidence landscape.

Effects

Remission Rates and Definitions

Only a handful of studies explicitly reported T2DM remission as a primary outcome. Remission was most commonly defined as HbA1c <6.5% without glucose-lowering medications for at least three consecutive months [1, 2]. Nicholas et al. (2021) further distinguished partial remission (HbA1c 5.7–6.4%) from complete remission (HbA1c <5.7%), both requiring cessation of diabetes medications for at least one year [5]. Korsmo-Haugen et al. (2018) added a fasting glucose criterion of <5.6 mmol/L for complete remission and required maintenance of remission criteria for at least 12 months for sustained remission [12]. The vast majority of included sources (22 of 29) did not define or report on T2DM remission per se, instead reporting surrogate glycemic and anthropometric outcomes [6, 8, 9, 11, 14–18, 21, 22, 24, 26, 28, 29].

The table below summarizes remission and glycemic outcomes across studies where these were reported.

Source	Intervention	Remission Rate	HbA1c Reduction	Weight Loss	Medication Changes	Timepoint
Rajib Das et al., 2025	LCD/KD	62% at 1 year, 13% at 5 years [1, 1]	Improved initially, rose above baseline by year 5 [1]	12.1 kg average [1]	87% off glucose-lowering meds at 1 year [1]	1–8 years [1]
Yating Zhang et al., 2022	Diet-only, diet + exercise	Higher at ≤12 months (OR 6.09) [3]	Not reported [3]	-7.09 kg vs. control [3]	Implied by remission definition [3]	Up to 6 years [3]
D. Sherifali et al., 2025	Nonpharmacological multicomponent	RR 5.80 vs. control [2]	-0.98% post-intervention; -1.16% change from baseline [2]	-5.05 kg (nonpharmacological) [2]	Fewer medications reported in one study [2]	Not specified [2]
Aditi Panditrao, 2025	KD + metformin	12% [8]	-0.9% (general KD effect) [8]	-5.4 kg [8]	Not reported [8]	12–24 weeks to 12 months [8]
Yukmin Rotama Panjaitan et al., 2025	Intensive lifestyle	7–12% [4]	-0.51% to -0.63% (multi-component) [4]	Not specified [4]	Reduced requirements reported [4]	6–24 months [4]
M. V. Beretta et al., 2024	LC diets	Not reported [19]	-0.42% overall; -0.28% at ≤3 mo, -0.40% at ≤6 mo, -0.32% at 6–12 mo, -0.31% at >12 mo [19]	Not reported [19]	Not reported [19]	Up to >12 months [19]

Source	Intervention	Remission Rate	HbA1c Reduction	Weight Loss	Medication Changes	Timepoint
P. McArdle et al., 2019	LCD (various)	Not reported [11]	Not reported (meta-analysis pooled) [11]	Not reported [11]	Not reported [11]	12–208 weeks [11]
L. Sellahewa et al., 2016	VLCD	Not reported [7]	-1.4% mean (range 0.1–3.1%) [7]	-13.2 kg mean (range 4.1–24 kg) [7]	Reduced insulin doses in 3 studies [7]	Up to 5 years [7]
Xiaojie Yuan et al., 2020	KD	Not reported [18]	-1.07% [18]	-8.66 kg; BMI -3.13; waist -9.17 cm [18]	Not reported [18]	Not specified [18]
Bhupesh Gupta et al., 2025	Low/very-low-calorie, special diets	Not reported [17]	SMD -0.67 (95% CI -0.94 to -0.40) [17]	SMD -0.59 (weight); SMD -0.93 (BMI) [17]	Not reported [17]	Not specified [17]
Yaofu Fan et al., 2016	LCD	Not reported [14]	Significant decrease [14]	WMD -2.356 kg [14]	Not reported [14]	Not specified [14]
Hany A. Zaki et al., 2022	KD vs. LCD	Not reported [6]	KD: SMD -1.45%; LCD: SMD -0.27% [6]	Significant with KD [6]	Not reported [6]	Not specified [6]
S. Abrar et al., 2025	Lifestyle ± pharmacological	Not reported [25]	-0.61% (lifestyle); additional -0.32% (with pharmacotherapy) [25]	Not reported [25]	Not reported [25]	Not specified [25]
Delphyne Anyang Kaakyire et al., 2025	LCD vs. LFD	Not reported [13]	Greater HbA1c reduction with LCD [13]	Superior weight loss with LCD [13]	Significant medication reduction with LCD [13]	Not specified [13]
Anya Francheska Salazar Supe et al., 2025	KD (≤10% carbs)	Not reported [29]	Short-term HbA1c improvement [29]	Not reported [29]	Not reported [29]	3–24 months [29]
Gloria Hernández Alcántara et al., 2015	LCD (<130 g/d)	Not reported [16]	No significant difference vs. other diets [16]	3 of 4 studies showed weight loss [16]	Not reported [16]	10–24 months [16]

Source	Intervention	Remission Rate	HbA1c Reduction	Weight Loss	Medication Changes	Timepoint
A. P. Nicholas et al., 2021	LCD and LED	Not reported specifically [5]	Clinically significant reductions at 12 and 24 months [5]	Clinically significant [5]	Medication changes in 12/15 trials [5]	Up to 24 months [5]
Joshua Chadwick et al., 2024	Intermittent fasting	Not reported [24]	-1.27% (not significant vs. regular diet) [24]	-0.26 kg (not significant) [24]	Similar hypo-glycemia frequency [24]	Not specified [24]
Jie Yang et al., 2023	Lifestyle weight-loss	Not reported [23]	WMD -0.59% (Caucasians); -0.48% (Asians) [23]	Not reported [23]	Not reported [23]	Not specified [23]
J. Hartmann-Boyce et al., 2023	BWMPs	Imprecise evidence of lower T2D incidence for ≥5 years [10]	-0.38% at 1 and 5 years post-program [10]	Not reported [10]	Not reported [10]	Median 28 months post-program [10]
Junya Hironaka et al., 2024	LCD in East Asians	Not reported [21]	Baseline HbA1c 7.3–8.6% [21]	Not reported [21]	Medication changes in 4/6 studies [21]	3–18 months [21]
Jessica Amerkamp et al., 2024	LC diet + exercise	Not reported [22]	Few additional benefits from exercise on glycemic control [22]	Not reported [22]	LC + exercise superior for medication reduction [22]	8 weeks to 24 months [22]
Yi Liu et al., 2025	MNT, LGI, digital, LGI+LGL	Not reported [26]	MNT: SMD -0.75 (FPG); digital: SMD -1.06 (HbA1c) [26]	LGI+LGL most effective for BMI (SUCRA 99.8%) [26]	Not reported [26]	Not specified [26]
Amber Parry-Strong et al., 2022	VLC/KD	Not reported [15]	Varied (baseline 7.3–9.0%) [15]	Not reported [15]	Not reported [15]	3–24 months [15]
Korsmo-Haugen et al., 2018	LCD (32–40 E%)	Not reported [12]	Not reported in extracted data [12]	Not reported [12]	Not reported [12]	3–24 months [12]
C. Terranova et al., 2015	Lifestyle weight loss (incl. VLCD)	Not reported specifically [9]	Improvements attenuated over time [9]	Weight regain observed [9]	Not reported [9]	Up to 10 years (Look AHEAD) [9]

Source	Intervention	Remission Rate	HbA1c Reduction	Weight Loss	Medication Changes	Timepoint
Abdulmohsin Almuaiqel et al., 2025	Structured lifestyle programs	Not reported [27]	Improved in most studies [27]	Improved in most studies [27]	Not reported [27]	Not specified [27]
Shelly Juliska et al., 2024	KD (20–50 g carbs/d)	Not reported [28]	Significant decrease ($p<0.001$) [28]	Significant decrease [28]	Not reported [28]	Not specified [28]
H. Mozaffari et al., 2024	LCMD, low-calorie, plant-based	Not explicitly quantified [20]	Not reported [20]	6–8 kg needed for remission [20]	Not reported [20]	Not specified [20]

Several key findings emerge from this table. Initial HbA1c reductions are robust across most dietary and lifestyle interventions, ranging from approximately -0.3% to -1.4% depending on intervention intensity. The largest HbA1c reductions were observed with ketogenic diets (mean -1.07% [18] to -1.45% [6]) and very-low-calorie diets (mean -1.4% [7]), while moderate low-carbohydrate diets produced more modest reductions in the range of -0.27% to -0.42% [6, 19]. Weight loss similarly scaled with intervention intensity, with VLCDs producing the greatest losses (mean 13.2 kg [7]) and ketogenic diets producing intermediate losses (5.4–8.66 kg [8, 18]).

Remission rates, where reported, were highest at one year—up to 62% in LCD/KD interventions with concurrent caloric restriction [1] —and declined sharply thereafter to 13% by year five [1]. Nonpharmacological multimodal interventions showed a risk ratio of 5.80 (95% CI 4.28–7.87) for remission compared with controls [2], while intensive lifestyle interventions achieved remission in only 7–12% of participants [4]. The wide range in remission rates across studies reflects differences in remission definitions, intervention intensity, participant selection (particularly diabetes duration and baseline glycemia), and follow-up length.

Long-term Durability and Relapse

Evidence on remission durability beyond three years is sparse. The most informative source on this topic, Rajib Das et al. (2025), reported a dramatic decline in remission rates from 62% at one year to 13% at five years, accompanied by partial weight regain and HbA1c levels that rose slightly above baseline by year five [1]. This pattern of glycemic relapse despite initially successful intervention was echoed by the Look AHEAD trial data summarized by Terranova et al. (2015), where HbA1c improvements attenuated and weight regain occurred even with continued intervention contact over up to 10 years of follow-up [9]. Zhang et al. (2022) found that remission odds were substantially higher when follow-up was ≤12 months (OR 6.09, 95% CI 3.14–11.79), suggesting a clear time-dependent attenuation of remission [3].

Sellahewa et al. (2016) observed that cardiovascular risk improvements from VLCDs were maintained at follow-up in most studies, though they noted that dropout rates increased during follow-up periods compared with active intervention phases (overall 4.7–33%) [7]. Beretta et al. (2024) reported that HbA1c reductions with low-carbohydrate diets diminished over time but remained statistically significant at >12 months of follow-up (-0.31%) [19]. Hartmann-Boyce et al. (2023) reported that HbA1c reductions of 0.38% persisted at both one and five years after behavioral weight management program completion, despite progressive weight regain [10]. Salazar Supe et al. (2025) noted that ketogenic diet effects on LDL-C, HbA1c, and triglycerides were significant in the short term (3–4 months) but diminished at longer follow-up of 6–24 months [29]. Panjaitan et al. (2025) specifically noted that long-term low-carbohydrate diet effects (≥12 months) on HbA1c were non-significant (SMD -0.11, p=0.32) [4].

Comparative Effectiveness: Low-Carbohydrate Diets vs. Severe Caloric Restriction

Direct head-to-head comparisons between low-carbohydrate diets and severe caloric restriction for long-term diabetes remission are lacking in the reviewed literature. Nicholas et al. (2021) provided the most relevant comparison, finding that both LCDs and LEDs (<1200 kcal/d) produced clinically significant weight loss and HbA1c reductions, with trials restricting energy intake not being superior to those permitting ad libitum low-carbohydrate feeding at 12 and 24 months [5]. The most effective single intervention at both 12 and 24 months in their review was an ad libitum ketogenic diet [5]. A key observation across studies was a strong association between average weight loss and HbA1c reduction at 6, 12, and 24 months, suggesting that sustained weight loss—regardless of dietary mechanism—is central to T2D remission [5].

Rajib Das et al. (2025) noted that LCD interventions combining carbohydrate restriction with concurrent caloric restriction (e.g., 800 kcal/day maximum) reported higher remission rates than those without caloric restriction [1]. Hernández Alcántara et al. (2015) found no significant differences in weight loss or HbA1c between LCDs and comparator diets over 10–24 months [16]. Amerkamp et al. (2024) reported that low-carbohydrate diets combined with regular exercise showed superior effects on medication use, lipid profiles, and wellbeing compared with conventional diets [22].

Adherence emerged as a critical moderating factor across both intervention types. Ketogenic diet adherence was notably poor, with attrition rates of 45% at six months [8] and up to 48% in some RCTs [15]. Juliska et al. (2024) characterized adherence to ketogenic diets as "low for long-term persistence" [28]. VLCD dropout rates ranged from 4.7% to 33% and were lower during the active intervention phase compared to follow-up [7]. McArdle et al. (2019) noted that adherence to prescribed carbohydrate targets was observed more frequently in moderate (rather than very low) carbohydrate groups [11].

Physiological Mechanisms

Several sources addressed the physiological mechanisms underlying remission and relapse. The Twin Cycle Hypothesis, cited by Nicholas et al. (2021), posits that weight loss reverses ectopic fat accumulation in the pancreas and liver, restoring beta-cell function [5]. Rajib Das et al. (2025) similarly reported that reductions in pancreatic and hepatic fat improve both beta-cell function and insulin sensitivity [1], with concomitant reductions in inflammatory markers (ALT, GGT, CRP) [1]. Sherifali et al. (2025) noted that the pathophysiological effect on beta-cell capacity is more pronounced in early stages of T2DM diagnosis, supporting the clinical observation that shorter diabetes duration predicts greater remission success [2].

Ketogenic diet-specific mechanisms include suppression of hepatic gluconeogenesis, enhanced mitochondrial efficiency, and reduced oxidative stress [8]. Panditrao (2025) reported that ketosis activates PPAR-alpha via increased free fatty acids, while ketone-mediated pathways inhibit histone deacetylases and enhance antioxidant responses through FOXO1 activation [8]. Yuan et al. (2020) described improvements in insulin receptor sensitivity during ketogenesis, with HOMA-IR reductions of -0.4 to -3.4 across studies [18]. Liu et al. (2025) identified low-glycemic-index diets as particularly effective for improving HOMA-IR (SUCRA 96.9%) through slowing carbohydrate digestion, reducing postprandial glucose excursions, and enhancing insulin signaling efficiency [26].

Panjaitan et al. (2025) emphasized that weight loss is an important but not sole mediator of glycemic improvement; direct improvements in skeletal muscle glucose uptake, reduced postprandial carbohydrate load, and enhanced insulin sensitivity contribute independently [4]. Hironaka et al. (2024) noted that East Asians have higher insulin sensitivity but lower insulin secretory capacity compared with Western populations, suggesting carbohydrate restriction may be differentially effective across ethnic groups [21] —an observation consistent with Yang et al. (2023), who found significant HbA1c benefits in Caucasians and Asians but not in Black/African or Hispanic groups [23].

Study Quality Considerations

Several quality factors affect interpretation. Blinding is inherently difficult in dietary trials [11], and the lack of participant or researcher blinding was noted across multiple reviews [3, 13, 21]. High dropout rates, particularly in long-term follow-up of restrictive diets, introduce attrition bias and likely inflate the apparent durability of remission in completers [5, 15]. Adherence was predominantly self-reported [1, 13], introducing measurement error. Heterogeneity in remission definitions across studies further complicates synthesis. Most meta-analyses reported moderate to high statistical heterogeneity (I-squared >50%) [17], warranting cautious interpretation of pooled estimates.

Synthesis

The central tension in this evidence base is the contrast between impressive short-term remission rates and the consistent attrition of these benefits over time. This pattern—62% remission at one year declining to 13% at five years [1], or remission odds six times greater at ≤12 months than at longer follow-up [3] —is not unique to any single dietary approach but appears to be a general feature of lifestyle-induced T2DM remission.

The apparent equivalence between low-carbohydrate diets and severe caloric restriction at 12 and 24 months [5] is best explained by the primacy of weight loss as the mediating mechanism. The Twin Cycle Hypothesis provides a unifying framework: regardless of whether caloric deficit is achieved through carbohydrate restriction or overall energy restriction, the resulting loss of ectopic fat from the pancreas and liver restores beta-cell function and hepatic insulin sensitivity [1, 5]. This explains why Nicholas et al. (2021) observed a consistent association between weight loss magnitude and HbA1c reduction across studies using different dietary approaches [5], and why Mozaffari et al. (2024) found that less weight loss was needed to achieve remission on plant-based diets than on low-calorie or low-carbohydrate diets, presumably reflecting additional weight-independent metabolic benefits [20].

The time-dependent attenuation of remission can be attributed to two interacting factors. First, weight regain is the norm following intensive dietary interventions: Terranova et al. (2015) documented weight regain in the Look AHEAD trial even with sustained intervention contact [9], and Hartmann-Boyce et al. (2023) found that cardiometabolic benefits dwindled in proportion to weight regain [10]. Second, the natural progressive loss of beta-cell function in T2DM imposes a ceiling on remission durability, particularly in patients with longer disease duration [2]. This explains why Sherifali et al. (2025) found that remission interventions were most effective in "newly diagnosed" T2DM [2], and why Mozaffari et al. (2024) noted that greater weight loss was required to achieve remission in patients with diabetes duration exceeding two years [20].

Ketogenic diets appear to produce larger short-term HbA1c reductions than moderate LCDs (SMD -1.45% vs. -0.27% [6]), consistent with both greater carbohydrate restriction and the additional metabolic effects of ketosis, including suppressed hepatic gluconeogenesis and enhanced insulin receptor sensitivity [8, 18]. However, this advantage does not appear to translate into superior long-term outcomes, as ketogenic diet adherence is poor beyond six months [8, 28] and metabolic effects diminish at later timepoints [4, 29]. VLCDs produce the largest initial weight losses (mean 13.2 kg [7]) but face similar adherence challenges during follow-up [7].

The differential ethnic response to lifestyle interventions identified by Yang et al. (2023)—significant HbA1c benefits in Caucasians (WMD -0.59%) and Asians (WMD -0.48%) but not in Black/African or Hispanic populations [23] —may reflect underlying differences in insulin secretory capacity and sensitivity [21], suggesting that the mechanisms of remission may operate differently across populations. Combined interventions incorporating exercise alongside dietary modification may offer incremental benefits through weight-independent pathways such as improved skeletal muscle glucose uptake [4] and physical fitness [22], though the evidence for additive glycemic effects beyond those of diet alone is inconsistent [22].

In summary, intensive dietary interventions—whether through carbohydrate restriction or caloric restriction—can achieve T2DM remission in a substantial proportion of participants at one year, particularly those with shorter diabetes duration and greater weight loss. Both approaches appear to operate primarily through reduction of ectopic fat and restoration of beta-cell function. However, remission durability beyond three years is poor, with relapse driven predominantly by weight regain and progressive beta-cell decline. No dietary approach has demonstrated clear superiority for sustained long-term remission, and the critical determinants of durability appear to be the magnitude and maintenance of weight loss, baseline beta-cell reserve (proxied by diabetes duration), and ongoing adherence support, rather than the specific macronutrient composition of the diet.

References

1. Das R, Mohammad N, Islam Md, et al (2025) Long-Term Efficacy and Safety of a Low-Carbohydrate Diet in Type 2 Diabetes Remission: A Systematic Review. Cureus. https://doi.org/10.7759/cureus.93340

2. Sherifali D, Racey M, Greenway M, et al (2025) Type 2 Diabetes Remission: A Systematic Review and Meta-analysis of Nonsurgical Randomized Controlled Trials. Diabetes Care. https://doi.org/10.2337/dc25-0562

3. Zhang Y, Yang Y, Huang Q, et al (2022) The effectiveness of lifestyle interventions for diabetes remission on patients with type 2 diabetes mellitus: A systematic review and meta-analysis. Worldviews on Evidence-Based Nursing. https://doi.org/10.1111/wvn.12608

4. Panjaitan YR, Sari RDI, Lase KY (2025) Effectiveness of Lifestyle Modifications on Blood Sugar Control in Type 2 Diabetes Mellitus Patients : A Systematic Review. International journal of medical science and health research. https://doi.org/10.70070/ehg2p341

5. Nicholas AP, Soto-Mota A, Lambert H, Collins A (2021) Restricting carbohydrates and calories in the treatment of type 2 diabetes: a systematic review of the effectiveness of 'low-carbohydrate' interventions with differing energy levels. Journal of Nutritional Science. https://doi.org/10.1017/jns.2021.67

6. Zaki HA, Iftikhar H, Bashir K, et al (2022) A Comparative Study Evaluating the Effectiveness Between Ketogenic and Low-Carbohydrate Diets on Glycemic and Weight Control in Patients With Type 2 Diabetes Mellitus: A Systematic Review and Meta-Analysis. Cureus. https://doi.org/10.7759/cureus.25528

7. Sellahewa L, Khan C, Lakkunarajah S, Idris I (2016) A Systematic Review of Evidence on the Use of Very Low Calorie Diets in People with Diabetes. Current Diabetes Reviews. https://doi.org/10.2174/1573399812666151005123431

8. Panditrao A (2025) Ketogenic Diet as an Adjunct Therapy for Type 2 Diabetes Mellitus: A Systematic Review. International Journal of Pharmaceutical Quality Assurance. https://doi.org/10.25258/ijpqa.16.3.16

9. Terranova C, Brakenridge CL, Lawler SP, et al (2015) Effectiveness of lifestyle-based weight loss interventions for adults with type 2 diabetes: a systematic review and meta-analysis. Diabetes, obesity and metabolism. https://doi.org/10.1111/dom.12430

10. Hartmann-Boyce J, Theodoulou A, Oke J, et al (2023) Long-Term Effect of Weight Regain Following Behavioral Weight Management Programs on Cardiometabolic Disease Incidence and Risk: Systematic Review and Meta-Analysis. Circulation Cardiovascular Quality and Outcomes. https://doi.org/10.1161/CIRCOUTCOMES.122.009348

11. McArdle P, Greenfield S, Rilstone S, et al (2019) Carbohydrate restriction for glycaemic control in Type 2 diabetes: a systematic review and meta-analysis. Diabetic Medicine. https://doi.org/10.1111/dme.13862

12. Korsmo-Haugen H-K, Brurberg KG, Mann J, Aas A-M (2018) Carbohydrate quantity in the dietary management of type 2 diabetes: A systematic review and meta-analysis. Diabetes, obesity and metabolism. https://doi.org/10.1111/dom.13499

13. Kaakyire DA, Abdelfattah O, Kumar A, Qadeer S (2025) Efficacy of Low-Carbohydrate Diets Versus Low-Fat Diets in Glycemic Control Among Patients With Type 2 Diabetes: A Systematic Review. Cureus. https://doi.org/10.7759/cureus.77004

14. Fan Y, Di H, Chen G, et al (2016) Effects of low carbohydrate diets in individuals with type 2 diabetes : systematic review and meta-analysis

15. Parry-Strong A, Wright-McNaughten M, Weatherall M, et al (2022) Very low carbohydrate (ketogenic) diets in type 2 diabetes: A systematic review and meta-analysis of randomized controlled trials. Diabetes, obesity and metabolism. https://doi.org/10.1111/dom.14837

16. Alcántara GH, Cruz AJ, Gascón MB (2015) EFECTO DE LAS DIETAS BAJAS EN CARBOHIDRATOS SOBRE LA PÉRDIDA DE PESO Y HEMOGLOBINA GLUCOSILADA EN PERSONAS CON DIABETES TIPO 2: REVISIÓN SISTEMÁTICA. Nutricion Hospitalaria. https://doi.org/10.3305/NH.2015.32.5.9695

17. Gupta B, Singh R, Verma N, et al (2025) Effect of Low/Very Low-Calorie and Other Special Diets on Anthropometric and Cardio-Metabolic Parameters of Diabetes Mellitus Patients: A Systematic Review and Meta-Analysis. National Journal of Community Medicine. https://doi.org/10.55489/njcm.161020255875

18. Yuan X, Wang J, Yang S, et al (2020) Effect of the ketogenic diet on glycemic control, insulin resistance, and lipid metabolism in patients with T2DM: a systematic review and meta-analysis. Nutrition & Diabetes. https://doi.org/10.1038/s41387-020-00142-z

19. Beretta MV, Flores CA, Colameo GF, et al (2024) Low-Carbohydrate Dietary Interventions for Metabolic Control in Individuals With Type 2 Diabetes Mellitus: An Overview of Systematic Reviews. Nutrition reviews. https://doi.org/10.1093/nutrit/nuae123

20. Mozaffari H, Civi RM, Askari M, et al (2024) The impact of food-based dietary strategies on achieving type 2 diabetes remission: A systematic review. Diabetes & metabolic syndrome. https://doi.org/10.1016/j.dsx.2024.103096

21. Hironaka J, Hamaguchi M, Ichikawa T, et al (2024) Low-carbohydrate diets in East Asians with type 2 diabetes: A systematic review and meta-analysis of randomized controlled trials. Journal of Diabetes Investigation. https://doi.org/10.1111/jdi.14326

22. Amerkamp J, Benli S, Isenmann E, Brinkmann C (2024) Optimizing the lifestyle of patients with type 2 diabetes mellitus - Systematic review on the effects of combined diet-and-exercise interventions. NMCD Nutrition Metabolism and Cardiovascular Diseases. https://doi.org/10.1016/j.numecd.2024.09.016

23. Yang J, Xia Y, Sun Y, et al (2023) Effect of lifestyle intervention on HbA1c levels in overweight and obese adults with type 2 diabetes across ethnicities: a systematic review and meta-analysis of randomized controlled trials. Diabetes Research and Clinical Practice. https://doi.org/10.1016/j.diabres.2023.110662

24. Chadwick J, Ayyasamy L, Kalyanasundaram M, et al (2024) Efficacy and safety of intermittent fasting for type 2 diabetes mellitus: A systematic review and meta-analysis of randomized trials. Diabetes Epidemiology and Management. https://doi.org/10.1016/j.deman.2024.100249

25. Abrar S, Ahsan S, Abrar[1] A, et al (2025) Effectiveness of Lifestyle and Pharmacological Interventions in Managing Type 2 Diabetes Mellitus – A Systematic Review. Journal of Health, Wellness and Community Research. https://doi.org/10.61919/f6867e87

26. Liu Y, Li H, Zhao Q, Cui W (2025) Effects of 12 nutritional interventions on type 2 diabetes: a systematic review with network meta-analysis of randomized trials. Nutrition and Metabolism. https://doi.org/10.1186/s12986-025-00968-3

27. Almuaiqel A, Ammar R, Ammar S, et al (2025) Effectiveness of lifestyle interventions in managing type 2 diabetes in primary care settings: systematic review. International Journal of Medicine in Developing Countries. https://doi.org/10.24911/ijmdc.51-1752097675

28. Juliska S, Rahmiwati A, Novrikasari (2024) Effect of Ketogenic Diet In Obese Patients With Type 2 Diabetes. Jambi Medical Journal : Jurnal Kedokteran dan Kesehatan. https://doi.org/10.22437/jmj.v12i1.29416

29. Supe AFS, Juan ASS, Sy R, Chiu HH (2025) Abstract 4363699: The Effect and Safety of Ketogenic Diets on LDL-C and other metabolic parameters compared with non-ketogenic diets among Adults with BMI Greater than 25 with Type 2 Diabetes Mellitus: A Systematic Review and Meta-Analysis. Circulation. https://doi.org/10.1161/circ.152.suppl_3.4363699