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Review Paper

Integrative Therapies for Type 2 Diabetes Mellitus: A Systematic Review of Ayurvedic Interventions, Allopathic Standards and Novel Synergies

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ABSTRACT

Background: Long-term care is necessary for Type 2 Diabetes Mellitus (T2DM), a growing global health burden. Ayurvedic treatments provide supplementary methods that target underlying pathophysiology, but allopathic standards continue to be the primary line of treatment. The evidence supporting integrative management techniques is assessed in this systematic review. **Goal:** By contrasting Ayurvedic treatments with allopathic norms and investigating new synergies, this systematic review assesses the clinical evidence for integrative therapy in type 2 diabetes. **Techniques/ Method:** We examined clinical research that has been published thus far, contrasting allopathic therapies with traditional Ayurvedic phototherapy, single or compound formulations, and lifestyle practices. Glycemic control, insulin sensitivity, lipid profile, and safety were among the results. From modern therapeutic techniques to conventional Yoga practices, AI- assessed assessment can facilitate a comprehensive and synergistic approach to therapy. **Result:** When used in conjunction, Ayurvedic treatments such as *Momordica charantia*, *Gymnema sylvestre*, and *Curcuma longa* significantly reduced Glycated Hemoglobin (or hemoglobin A 1 c) HbA1c. In certain groups, combined treatments decreased the need for allopathic doses and increased insulin sensitivity. In oxidative stress pathways and gut- microbiome regulation, new synergies have emerged. The majority of the adverse events were gastrointestinal in nature. **Conclusion:** Integrative Ayurvedic-allopathic treatment for type 2 diabetes shows encouraging Glycemic improvements and safety. To create evidence-based synergistic regimens, standardized formulations, larger Randomized Controlled Trials (RCTs), and mechanistic research are required.

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INTRODUCTION

In recent decades, a several chronic illnesses have become significant worldwide health issues, with diabetes mellitus being one of the most common. The word 'Diabetes' originates from an ancient Greek term meaning 'siphon' or 'to pass through' (dia meaning "through" and bainein mean "to go or to walk") . The Latin root 'mellitus' means 'sweetened with honey' or "honey sweet," which is derived from Mel (honey). British physician Thomas Willis added it in 1675 after tasting patients' urine and discovering that it was sweet because of excessive glucose.

Chronic hyperglycemia brought on by deficiencies in insulin secretion, action, or both is the hallmark of diabetes, a metabolic disease. Lifestyle modifications, urbanization, sedentary behaviors, obesity, and genetic predisposition are all strongly associated with the increasing incidence of diabetes.

It can be broadly categorized into four major forms and several additional forms.

Major / Primary Forms:

1. Type 1 diabetes mellitus: Patients with this autoimmune disease produce little to no insulin and need daily insulin therapy because the body's immune system targets and kills the pancreatic cells that make insulin.
2. Type 2 diabetes mellitus: Insulin cannot function correctly because the body either produces insufficient amounts of it or resists it. Oral drugs, lifestyle modifications, and occasionally insulin are used to manage it.
3. Gestational diabetes mellitus (GDM): Some pregnant women get this condition. However, it normally goes away after childbirth.
4. Type 3C diabetes mellitus: Caused by illness, injury, or pancreatic removal due to cystic fibrosis or chronic pancreatitis.

Other / Additional Forms:

1. Latent Autoimmune Diabetes in Adults (LADA): It is a slow developing form of autoimmune diabetes that starts in adulthood and share features of both Type 1 and Type 2 diabetes.
2. Maturity-Onset Diabetes of the Young (MODY): It is an inherited type of diabetes is a rare and caused by a genetic mutation. Typically diagnosed before the age of 25, though this is relatively uncommon.

3. Prediabetes: This is defined as blood sugar levels that are elevated but not high enough to be classified as Type 2 diabetes.

Over 90% of instances of diabetes are type 2, which is the most prevalent type and has reached epidemic proportions, particularly in developing nations like India.

Serious long-term consequences of uncontrolled diabetes include renal failure, cardiovascular disease, nerve damage, visual problems, and an elevated risk of infections. Diabetes has become a major global public health burden due to its effects on healthcare systems and quality of life.

Therefore, it is crucial to comprehend the pathophysiology, etiology, risk factors, and management of diabetes. For millions of patients with this chronic illness, early detection, lifestyle changes, appropriate medication, and patient education are essential to reducing complications and improving outcomes.

The risk of hypoglycemia, weight gain, high expense, and difficulties with long-term patient adherence restrict the effectiveness of current allopathic therapy in lowering blood glucose. These drawbacks emphasize the need for lifestyle intervention and alternative therapies as well as safer, more economical, and patient-friendly treatment methods.

Harsha Suryawanshi et al ^[1] summarized nanotechnology for improvement in diagnosis and treatment of diabetes.



The transition from "disease management" to "holistic health management" is seen in the increasing interest in integrative and AYUSH systems for diabetes. Integrative care seeks to address the diabetes epidemic with safer, more cost-effective, and long-lasting solutions by fusing the best aspects of contemporary treatment with ancient knowledge.

This review's main goals are to examine the mechanisms of action, evaluate safety and tolerability, assess efficacy, and investigate the potential for integration.

With an emphasis on how effectively they function, how safe they are, and how they might be combined to create safer, more inexpensive

diabetic treatment, this review attempts to present a thorough, evidence-based comparison of allopathic and integrative/AYUSH systems for diabetes.

PATHOPHYSIOLOGY of Diabetes Mellitus

Pathophysiology includes etiology i.e. causes, mechanism, signs and symptoms, diagnosis, treatment and prevention of disease.

Classification of diabetes and its pathophysiology including that of its various types is very well explained by Banday MZ et al [2].

Insulin deficiency vs. Insulin resistance

Features	Insulin Deficiency	Insulin Resistance
	Type 1 DM	Type 2 DM
Root Cause	Not enough insulin produced	Insulin produced but tissues are resistant
Pancreatic β -cells	Destroyed by autoimmune	Present, but exhausted/
attack		overworked over time
Insulin Levels	Very low/ absent	↑High initially, then ↓ later
Onset	Sudden, usually young age	Gradual, usually adults 30+
Body Weight	Normal or thin	Overweight/Obese common
Glucose Uptake	Can't enter cells at all	Cells ignore insulin uptake
Liver	↑↑ Gluconeogenesis uncontrolled	↑↑ Gluconeogenesis despite insulin
Ketosis/DKA Risk	High	Low, except in severe stress
Main Cause	Autoimmune + Genetic	Obesity, lifestyle, genetics, inflammation
Treatment	Insulin is mandatory	Lifestyle + Oral drugs → Insulin later if needed.

Simple analogy

➤ Insulin Deficiency = No key

The door is fine, but you don't have the key to open it. Glucose stays outside cells → *Type 1*

➤ Insulin Resistance = Rusty lock

You have the key, but the lock is jammed. You need more and more keys. Eventually you run out of keys too → *Type 2*

OUTCOME: Both lead to CHRONIC HYPERGLYCEMIA

1. Glucose can't get into muscle/fat.
2. Liver keeps making more glucose.

3. Over time → Micro vascular + Macro vascular complications.

It matters for Treatment

- Deficiency : You replace insulin
- Resistance : You sensitize tissues with metformin, Thiazolidinediones (TZDs), exercise, Ayurvedic herbs and minerals, weight loss, yoga, diet and reduce glucose production



Role of Pancreas, Liver, Muscle, Adipose tissue are given in the table below

Organs	Routine Function	What Goes Wrong in DM
Pancreas	Make insulin and glucagon	↓ Insulin, ↑ glucagon
Liver	Store glucose, Stop production	Keeps making glucose
Muscle	Take up glucose for use/storage	Can't take up glucose
Adipose hormones	Store fat, release anti-inflammatory	Leaks Free Fatty Acid (FFA) , causes inflammation

Hence, Type 2 treatment targets all 4 organs e.g;
Metformin → Liver, TZDs/ Exercise → Muscle &
Fat, Glucagon – like Peptide – 1 (GLP-1/
Sulfonylurea's (SU) → Pancreas.

Type 2 isn't just "high sugar". It's 4 organs
miscommunicating. That's why the best
management hits all 4 at once.

The 4 Organ Treatment Map is well explained
below

1) PANCREAS: Make enough insulin at the right
time + stop excess glucagon.

Drug / Class	How it works	Example
Sulfonylureas	Force β -cells to release more insulin	Glimepiride, Glizalide
GLP-1 RA	Glucose dependent insulin release + ↓ glucagon + delays gastric emptying	Semaglutide, Liraglutide Dulaglutide
DPP-4 Inhibitors	↑ your own GLP-1 → ↑ insulin, glucagon	Sitagliptin, Vildagliptin
Insulin	Replace when β -cells fail	Basal/Bolus
AYUSH - Bitter melon, Gymnema, Fenugreek and so on. YOGA - Claimed to support β -cell function and insulin secretion.		

2) LIVER: Turn off Gluconeogenesis and
glycogen breakdown.

Drug / Class	How it works	Example
Metformin	# 1 drug ↓ hepatic Gluconeogenesis + Improves insulin signaling	Metformin
GLP-1RA	Indirectly ↓ glucagon → ↓ liver glucose output	
SGLT2 Inhibitors	Mild effect via ↓ glucose load	
AYUSH - Turmeric/ Curcumin, Berberine, Amla, Intermittent fasting YOGA - ↓ hepatic glucose production, improve insulin sensitivity.		

3) SKELETAL MUSCLE -Make muscle listen to
insulin again.

Drug / Class	How it works	Example
TZDs	Activate PPAR- γ → ↓ GLUT-4 in muscle	Pioglitazone
Metformin	↑ AMPK → ↑ glucose uptake	
Exercise	Insulin-independent GLUT-4 translocation. Most powerful "drug"	
SGLT2 inhibitors	↓ glucose toxicity → muscle works better	
AYUSH : Ashwagandha → ↑ insulin sensitivity, ↑ GLUT-4 YOGA : Resistance Training, Surya Namaskar, Pranayama		



4) ADIPOSE TISSUE - Stop fat from leaking FFA

+ fix hormones.

Drug / Class	How it works	Example
TZDs Subcutaneous + ↑ adiponectin	Redistribute fat from visceral to	Pioglitazone
GLP-1RA/SGLT2i	Weight loss → ↓ visceral fat → ↓ FFA	
Metformin	Mild ↓ appetite + ↓ inflammation	
AYUSH : Weight loss, Low carb/ keto diet - Guggul, Triphala, MEDITATION → ↓ visceral fat, ↑ adiponectin, ↓ inflammation.		

Combination therapy works better

ORGAN	ALLOPATHY	AYUSH/ Lifestyle
Pancreas	GLP-1 RA, DPP-4i	Gymnema, Yoga, Stress reduction
Liver	Metformin	Berberine, Amla, Fasting
Muscle	TZDs, Exercise	Resistance training, Yoga asanas
Adipose	GLP-1 RA, TZDs, Weight loss	Diet, Guggul, Meditation, Sleep

Integration Model for Type 2 DM

To put it briefly, allopath quickly corrects the flaw. Long-term sensitivity is restored by AYUSH + Lifestyle.

The "hidden drivers" that link fat, insulin resistance, β -cell failure, and comorbidities are

oxidative stress, inflammation, and gut macrobiotic.

Synopsis of Integrative Therapy

Factor	Allopathy
AYUSH = Lifestyle	
Oxidative Stress	Statins, ACEi
Curcumin, Amla, Antioxidant-rich diet, Yoga	
Inflammation	GLP-1 RA, SGLT2i, TZDs
Turmeric, Ginger, Omega-3, Meditation, Sleep	
Gut microbiome	Metformin
High fiber diet, Probiotics, Triphala, Fasting	

The causes of oxidative stress, inflammation, and gut health are the focus of integrative therapy.

Type 2 diabetes complications

Over time, high blood sugar affects blood vessels, which are divided into two categories: micro-vascular and macro-vascular.

Chronic hyperglycemia and oxidative stress are major causes of micro-vascular problems because they harm capillaries, which are tiny blood vessels. For instance, the involvement of end-stage kidneys, nerves, and eyes. On the other hand, damage to big blood vessels, or arteries, like the

heart, brain, or legs, is known as macro-vascular problems. Insulin resistance, dyslipidemia, hypertension, inflammation, and oxidative stress are major causes of this condition.

In their discussion of DM consequences, Ohiagu FO et al^[3] noted that hyperglycemia activates polyol, hexosamine, Protein Kinase C (PKC), Advanced Glycation End-products (AGEs), Cyclooxygenase (COX) and Lipoxygenase (LOX) pathways, which causes nephropathy, retinopathy, and neuropathy. Thus, inhibiting these enzymes helps avoid issues.



ALLOPATHIC MANAGEMENT:

There are various classes of allopathic drugs which act upon different vital organs such as pancreas, liver, muscle, adipose, kidney, gut:

1. Drugs that elevate Insulin or lower Glucagon:

Drug Class:

- i. Sulfonylureas, such as gliclazide and glimepiride
- ii. Meglitinidines, such as Repaglinide
- iii. Dipeptidyl Peptidase- 4 inhibitors (DPP-4i), such as Sitagliptin and Vildagliptin
- iv. Glucagon- like Peptide- 1 Receptor Agonists (GLP-1 RA), such as Semaglutide, Liraglutide, and Dulaglutide

2. Drugs that decrease hepatic glucose production and raise sensitivity:

Drug Class:

- i. Biguanides - example - Metformin
 - ii. Thiazolidinediones - Pioglitazone
- ### 3. Drugs that increase Urinary Glucose Excretion :

Examples: Empagliflozin, Dapagliflozin, Canagliflozin

4. Drugs that impede the absorption of carbohydrate :

Drug Class - .Alpha-glucosidase inhibitors, such as Acarbose, and Voglibose

5. Insulin :

Type: Basal – examples include Degludec and Glargine

Prandial - Lispro, Aspart

Premix - Combo basal + Prandial, such as 30/70, 50/50

ORGAN TARGET DRUG CLASSES

1. Pancreas – SU, GLP-1 RA, DPP-4i, Insulin
2. Liver - Metformin, GLP-1 RA
3. Muscle - Metformin, TZDs, Exercise
4. Adipose -TZDs, GLP-1 RA, SGLT2i
5. Kidney - SGLT2i
6. Gut / Brain - GLP-1 RA, DPP-4i, α -glucosidase inhibitors

The treatment algorithm can be summed up as follows:

1. Metformin + All T2DM Lifestyle
2. Regardless of HbA1c, add GLP-1RA or SGLT2i if you have Atherosclerotic cardiovascular Disease (ASCVD), Chronic Kidney Disease (CKD) or Heart Failure (HF).
3. If the goal is not reached, add a second or third medication from a different class, such as SU, DPP-4i, TZD, α -glucosidase, insulin.

Insulin and Analogs:

When β -cells fail or other drugs aren't enough, insulin replaces the hormone.

Reasons for using Insulin in Type 2 DM:

1. After five to ten years, β -cell failure
2. Symptomatic hyperglycemia or HbA1c > 10% at diagnosis
3. Acute sickness, surgery, DKA, Hyperglycemic Hyperosmolar State (HHS) and pregnancy
4. Uncontrolled on two to three oral agents plus GLP-1 RA/SGLT2i

Insulin Types and Analogs:

1. Rapid-acting analogs: onset in 10 to 15 minutes, peak in 1 to 2 hours
2. Short-acting analogs: onset in 30 minutes, peak in 2 to 4 hours
3. Intermediate-acting analogs: onset in 2 to 4 hours, peak in 4 to 12 hours
4. Long-acting analogs: flat, no peak, one to two hours of onset
5. Ultra long analogs with a flat peak and an onset of one to two hours
6. Premixed: onset, two peaks, 10 to 30 minutes

More Recent Developments:

1. Ultra-rapid analogs that are closer to meals, such as Lispro-aabc and Faster Aspart
2. Intelligent insulin pens that monitor dosage, timing, and remind.



3. Weekly baseline injections of Icodec-1
4. Oral insulin is still undergoing testing and has not yet received approval.

Choosing Insulin vs. GLP-1 RA: Depending on the circumstances, a better option may be suggested as

1. HbA1c >10% + symptoms: Insulin
2. GLP-1 RA obesity
3. ASCVD/CKD: GLP-1 RA or SGLT2i initially.
4. The cost of human insulin
5. Fear of weekly GLP-1 RA injections

The deficit is treated with insulin. However, resistance is not resolved by it. Therefore, insulin + sensitizer + weight loss medication is the current T2DM treatment.

Efficacy and Clinical Guidelines:

Guidelines focus on three things i.e. HbA1c, weight and organ protection

Efficacy depends on baseline HbA1c. Higher starting HbA1c is equal to bigger drop.

Situation	Recommended start
Fasting glucose high	Basal insulin 10U or 0.2 U/kg at bedtime. Titrate + 2U every 3 days till Fasting Blood glucose (FBG) 80-130.
Post - meal high despite basal	Add 1 rapid analog with largest meal, then 2, then 3
HbA1c > 10%	Basal-Bolus from start OR Premix 2x/day
Titration	Treat-to-target. Goal FBG 80-130mg/dL

Significant changes to the 2024 Guidelines

1. Prioritize organ protection by selecting SGLT2i/GLP-1 RA for the kidney and heart rather than just sugar.
2. Weight is a target: in obesity, GLP-1 RA and SGLT2i are favored
3. Early Combo: Don't wait for metformin to stop working. If HbA1c is greater than 7.5%, start two medications.
4. De-intensification: To prevent hypoxia in the elderly and fragile, loosen the HbA1c target.
5. Continuous Monitoring: If on insulin or at low risk, CGM is advised.

Efficacy summary:

The American Diabetes Association (ADA), the American Association of Clinical Endocrinology (AACE), the Research Society for the Study of Diabetes in India (RSSDI) (2024 guidelines customized for India), and many other clinical guidelines are available.

The RSSDI-India 2024 Guidelines, which have been modified for India, are as follows:

1. First line: Metformin + Lifestyle + Early usage of DPP-4i, SGLT2i, GLP-1 RA
2. Cost and Access: Pioglitazone and SU are still commonly used.
3. Emphasis: At diagnosis, look for complications. Utilize FDCs to ensure compliance
4. Integrative: Recognize AYUSH, yoga, and diet as supplements.

Insulin-specific guidelines are advised in various circumstances when a patient is on insulin.

For example,

- i) Maximum glucose reduction: Insulin + GLP-1 RA. SU. Metformin
- ii) Maximum weight loss: GLP-1 RA > SGLT2i > Metformin
- iii) Heart protection with metformin, SGLT2i, and GLP-1 RA
- iv) SGLT2i, GLP-1RA, and ACEi/ARB kidney protection
- v) Metformin, DPP-4i, SGLT2i, GLP-1 RA, and Lowest hypoglycemia.
- vi) Metformin, SU, and human insulin are the least expensive.

No single medication is the best. Therefore, guidelines need to be both organ-centered and patient-centered.



Regular health examinations should be performed on all patients. The following Monitoring Schedule should be followed for the primary required check-up:

1. HbA1c should be checked every three months until the goal is reached, then every six months after that.
2. Kidney: Estimated Glomerular Filtration Rate (eGFR), Urine Albumin – to- Creatinine Ratio (UACR) at diagnosis, followed by annual.
3. Eye Exam: Each visit.
4. Blood pressure and cholesterol: at diagnosis, then annually.

5. Body Mass Index (BMI) and weight: Each visit.
The preferred allopathic treatment for keeping a diabetic patient's general health in good condition. Allopathic preferable medication for maintaining the overall health of diabetic patient in good condition -

1. Organ Protection from Excess Glucose: Start SGLT2i/GLP-1 RA in ASCVD/HF even if HbA1c is 6.8%. This is the preferred allopathic treatment for keeping the general health of a diabetic patient in good shape.

2. Early Combination: If HbA1c > 7.5%, start two medications instead than waiting for metformin to fail.

3. Target weight: GLP-1 RA is favored in obesity

4. CGM: Suggested for anyone using SU or insulin
The latest allopathic clinical guidelines for diabetes management emphasize a holistic Cardiovascular, Kidney and Metabolic (CKM) risk-reduction model rather than focusing solely on blood glucose control.

Gawde S. et al.^[4] created a pulsatile pellet-based Teneligliptin formulation that showed acceptable physicochemical characteristics and was able to accomplish time-controlled drug release.

Limitations and Adverse Effects:

Since no drug is flawless and has no side effects, the class-specific side effects and limitations are described.

Drug Class	Key Adverse Effects	Limitations/ Drug resistance
Metformin	GI, Nausea, Metallic taste. Rare: Lactic acidosis	Lactic acidosis - Risk increases in CKD eGFR<30, Liver disease, sepsis, contrast B12 deficiency with long use. No weight loss after 1-2 yrs, GI limits dose
Sulfonylureas Glibenclamide	Hypoglycemia- esp 5-10 years. Secondary failure common	Drug resistance β -cell exhaustion over
Weight gain 2-3kg	Limitation : Doesn't protect heart/kidney	
Meglitinides	Hypoglycemia: If meal skipped Weight gain	Short acting - need 3x/day. Costly
TZDs- Pioglitazone	Weight gain 2-4kg. Fluid retention Fractures, in women, Bladder cancer risk not for HF patients	Slow onset 8 - 12 weeks. Limitation : CHF risk,
DPP-4 Inhibitors	Generally well tolerated Nasopharyngitis Rare: Pancreatitis, joint pain	Modest efficacy HbA1c: 0.6 - 0.8% Limitation- Weight neutral, no organ protection
GLP-1 RA	GI, Nausea, vomiting, diarrhea Rare- Pancreatitis, Gallbladder Disease.	Cost Rs5000-15000/month Injection barrier. Oral sema has GI too. Limitation Contraindicated in MEN2, History of pancreatitis.
SGLT2i	Genital UTI, Mycotic infections Volume depletion, Hypotension Rare : DKA, Fournier's gangrene	Cost Rs.2000-5000/month. Less effective if eGFR < 45 Limitation : Increases LDL slightly



α -glucosidase Inhibitors	GI: Flatulence, diarrhea, Abdominal pain	GI limits use . Need to take with 1 st bite Modest efficacy : HbA1c : 0.5 - 0.8%
Insulin	Hypoglycemia Weight gain 2-4kg	Cost, needles, Monitoring Limitation doesn't fix insulin resistance
Lipohypertrophy at injection site	Dose. Keeps increasing over time Psychological barrier for patients.	

In his research on diabetic retinopathy (DR), Bloomgarden Zachary ^[5] has demonstrated the advantages of blood pressure control and glucose control as well as the potential benefits of fenofibrate, RASi, and SGLT2i in improving DR. There are five major issues to focus on:

A. Hypoglycemia - Low blood sugar

High-risk drugs: meglitinides, insulin, and SU.

Symptoms include tremor and sweating. Seizures and confusion

It is important because of adverse cardiovascular events, falls in the elderly, fear, and low compliance.

Mitigation: Instead, use GLP-1 RA, SGLT2i, DPP-4i, and Metformin. CGM + Education.

B. GI Effects

High risk drugs -Metformin, GLP-1 RA, α -glucosidase inhibitors. Metformin - Lactate in gut
GLP-1 - delayed gastric emptying. Mitigation: Start low, go slow. Take with food. Extended - Release metformin

C. Lactic Acidosis

Medication: 3–10 metformin per 100,000 patient-years. Quite uncommon.

Risk factors include contrast, alcohol, sepsis, liver failure, and eGFR < 30.

Action: Stop 48h before/after contrast. Stop if creatinine increases.

D. Cost

Metformin costs Rs. 50 per month, SU costs Rs. 100 per month, and human insulin costs Rs. 500

per month. Mid: SGLT2i Rs. 2000–3000/month, TZD Rs. 300/month, DPP-4i Rs. 800–1500/month. GLP-1RA costs between Rs. 5000 and Rs. 15000 a month, while analogs cost between Rs. 3000 and Rs. 6000 per month.

Low serum vitamin B12 level is associated with longer duration and higher dose of metformin use as reported by Akinlade KS et al ^[6]

A. Over time Drug Resistance

What occurs: In T2DM, β -cell function decreases by 4-6% annually.

Drug: SU: Causes β -cell exhaustion. 5–10 years of secondary failure Metformin is a medication that can't stop insulin resistance from getting worse. TZD: Stopped weight gain and fluid intake. Insulin medication: resistance rises, dose continues to rise.

Early combination therapy, weight loss, and the medication GLP-1RA, which preserves β -cells, are the solutions.

Additional long-term restrictions include:

1. Gaining weight exacerbates insulin resistance due to SU, TZD, and insulin
2. Organ toxicity: none significant, however canagliflozin increases the likelihood of TZD-bone and SGLT2-ampulation.
3. Doesn't reverse the disease: All medications address hyperglycemia rather than the underlying cause of insulin resistance.
4. Polypharmacy: The majority of patients take three to four medications, a statin, and an ACE Inhibitor.

Choosing medications that provide efficacy, safety, organ protection, and weight loss with the



fewest possible adverse effects is the modern strategy in 2026. For high-risk patients, metformin, GLP-1 RA, and SGLT2i are thereby becoming the standard.

Under its Global Diabetes Compact and five Global Diabetes Targets for 2030, WHO is monitoring diabetes. According to the WHO, diabetes is one of the main causes of death and shortened life expectancy. The largest groups that WHO emphasizes

1. Increasing cases: four times higher
2. Significant undiagnosed burden: 1 in 2 individuals are unaware that they have it
3. Inequity: Low-income nations are more severely affected.
4. Urgent action on diagnosis, treatment, and prevention is required by 2030.

Old DM drugs like insulin, metformin, tolbutamide, glipizide are being replaced by newer, more potent drugs with longer action, fewer side effects and better glucose control. This is detailed by Elkhalfi et al^[7]

AYURVEDIC PERSPECTIVE ON DIABETES

In Ayurveda, Diabetes is referred as "Madhumeha," which means "honey-like urine."

1. Root cause in Ayurveda :

In Ayurveda, diabetes is correlated with "Prameha," specifically Madhumeha.

Principal causes:

- a) Diet: Overindulgence in processed, sugary, fatty, dairy, and grain foods
- b) Lifestyle: Stress, inactivity, sleeping during the day, and sitting all day.
- c) Dosha imbalance: In chronic situations, Kapha predominates first, followed by Pitta and Vata.
- d) Weak Jatharagni, poor digestion, the production of Ama toxins, and blocked channels

According to Ayurveda, Modern Type 1DM is Vata Madhumeha and Modern Type 2DM is Kapha + Pitta + Prameha.

2. Ayurvedic Therapy :

"Nidan Parivarjan" is an Ayurvedic treatment that eliminates causes, balances doshas, enhances agni, and detoxifies.

- A. Diet:** For diabetic patients "Eating the Right food in Right amount and Right times" is important. Following are the recommended Diet but not limited:

Fibrous food recommended to diabetic patients;

Fiber is the best medicine from food - It slows glucose absorption, improves insulin sensitivity and feeds good gut bacteria.

- Best Cereals:- Yava / Barley 17g fiber/100g, Oats-Beta-glucan fiber, Ragi, Jowar Bajra, Brown Rice, Dalia, Whole wheat with bran.
- Fiber rich Pulses: - Chana- 17g, Rajma-13g, Whole Moong- 12g, whole Masoor Kulthi/ Horse gram, Lobia.
- Vegetables (300-400g daily):- Highest Fiber - Karavellaka/ bitter gourd, Bhindi, Lauki, Patola, Methi bhaji, Broccoli, Cabbage, Cauliflower, Drumstick leaves.
- Fruits (With skin):- Guava- 5.4g, Pear, Apple, Orange, Papaya, Jamun, Ber, Pomegranate, Avocado.(Always eat with skin where possible). Avoid fruit juice as fiber is removed.
- Seeds / Nuts :- Flax-seed / Alsi -27g fiber - Roast - 1 Spoon daily, Chia seeds - Soak 1 spoon in water, Methi seeds - Soaked overnight water, Sesame, Pumpkin seeds, Almonds, Walnuts.
- Eating salad 15min BEFORE meal- reduces post-meal glucose spike by 30-40%- It is proven in Foodomics studies.



Curd known as Yogurt : Since unsweetened plain curd has low Glycemic Index - Between 14 to 36, it digests slowly and prevents rapid spikes in blood sugar after meals. The high content of protein in curd slows down absorption of carbohydrates, preventing sudden spikes in blood sugar, feel full for longer while maintaining stable energy levels. It is rich in Calcium and contains healthy fat. It supports weight management, improves digestion and boosts immunity

As per the write-up dated 5th December 2024 in DIABETIC AND ENDOCRINOLOGY Most diabetic individuals can safely enjoy ½ to 1 cup (approximately 100–200 grams) of curd daily, depending on calorie intake and blood sugar control. Always monitor your post-meal sugar levels and make dietary adjustments as needed.

Avoid high- carbohydrate, starchy foods and sugary drinks. Also, limit fried foods, food high in sodium, and alcohol.

Maqsood S et al^[8] reported A new Approach Foodomics in Diabetes management. Foodomics integrates genomics, proteomics and metabolomics to study interaction of food bioactives with human metabolism in T2DM. It helps identify biomarkers, dysregulated pathways and role of gut microbiota in insulin resistance. This enables personalized, nutrition-based interventions for better glycemic control and prevention of complications. Polyphenols and dietary fibers show therapeutic potential for improving insulin sensitivity.

B. Lifestyle - (Vihara) :

"Exercise: Surya Namaskar, Ardha Matsyendrasana, Mandukasana for pancreas, and a daily 45-minute walk or yoga are the greatest remedies for overall health. Sleep: Go to bed early and don't sleep during the day. Stress: Pranayama and meditation.

C. Herbs - (Dravya) :

Common herbs improve insulin sensitivity, slow down carbohydrate digestion, and boost pancreatic function to help control blood sugar levels.

While spices and other herbs like Cinnamon, Haldi, Garlic and Ginger, Amla, and Vijaysar are antioxidants and support the pancreas, the main anti-diabetic herbs include Jamun, Karela, Methi, Gurmar, and Neem.

Modak Manisha et al ^[9] summarized various Indian herbs and herbal formulations for the treatment of Diabetes, whereas, Tarle R et al^[10] designed, developed In-Vitro characterization and highlighted the importance of standardization of products. Tran N et al. ^[11] examined the pharmacological properties and active ingredients of plants used to treat diabetes in order to guarantee the quality. Additionally, morphological information from each species' V-herb database was used to identify plants.

Many natural herbs and spices show anti-diabetic activity, hence can be used in the formulation in appropriate proportion to get positive results.

1. **Jamun (*Syzygium cumini*):** The pulp and seeds of Jamun can help reduce blood sugar. Jamboline, which is found in seeds, prevents starch from rapidly becoming sugar. The fruit has a low glycemic index of roughly 25, which means it raises blood sugar very slowly. High anthocyanin and polyphenol levels shield cells from harm caused by high glucose. Active substances help the body use insulin more effectively.



Fig 1. Jamun

2. **Karela - Bitter Melon (*Momordica charantia*):** helps the cells absorb glucose by acting as insulin. It has active ingredients including vicine, charantin, and p-insulin, an insulin-like peptide that increases insulin production, improves glucose uptake, and slows carbohydrate absorption in the gut's. Aids in preventing harm to pancreatic beta cells.



Fig 2. Karela

3. **Methi - Fenugreek (*Trigonella foenum-graecum*):** packed with soluble fiber. The seeds help decrease fasting blood sugar and slow down the digestion of carbohydrates. Soluble fiber and bio-active substances such as trigonelline and 4-hydroxyisoleucine are responsible for the anti-diabetic action. It decreases blood lipids, enhances insulin sensitivity, and lowers blood sugar enables the appropriate utilization of glucose by body cells by activating signaling pathways such as PI3K/Akt. Reduces oxidative stress and protects pancreatic beta cells from harm.



Fig 3. Methi

4. **Gurmar - (*Gymnema sylvestre*):** Known as the "sugar destroyer." Its leaves may promote the synthesis of insulin and aid in blocking sweet taste receptors. Gymnemic acids temporarily block sweet taste perceptions and lessen sugar cravings by binding to sweet receptors on taste buds. It prevents abrupt rises in blood sugar following a meal by slowing down the small intestine's absorption of glucose. It may aid in the regeneration or repair of insulin-producing beta cells and stimulate the pancreas to release more insulin. It enhances the body's cells' utilization of glucose and fat processing. Bhatt S and Sharma N ^[12] in their article have discussed possible mechanism on how gurmarin helps manage diabetes and also discussed the plant tissue culture methods to enhance gymnemic acid production.



Fig 4. Gurmar

5. **Neem (*Azadirachta indica*):** Compounds in neem leaves, bark, and seeds can improve insulin sensitivity, reduce oxidative stress, and help the body use glucose better. It helps the pancreas release more insulin. Helps body tissues take in sugar from the blood. Lowers cell damage from high sugar levels using antioxidants. Active compounds like nimbin, nimbidin, and quercetin play a major role.



Fig 5. Neem

6. **Chirayata (*Swertia chirata*):** Swerchirin, mangiferin, and swertiamarin are among the active phytochemicals that give Chirayata its notable antidiabetic and antihyperglycemic properties. According to research, it improves insulin signaling, lowers blood glucose, and increases glucose tolerance. Swerchirin is a strong xanthone that has been extracted from the plant and is known to directly decrease blood sugar. Dey Pinaki et al ^[13] have explained all valuable constituents and therapeutic potential of *Swertia chirata* along with associated pharmacological property.



Fig 6. Chirayata

7. **Bichu buti (stinging nettle or *Urtica dioica*):** It has the potential to prevent diabetes by lowering blood sugar, simulating the effects of insulin, and promoting the health of pancreatic cells. Plant compounds may enhance the absorption of glucose and lessen metabolic stress in general. Plant extracts have the potential to lower high blood glucose levels. Insulin Support: Active substances can boost

the body's natural synthesis of insulin. It helps lower oxidative stress linked to diabetic complications.



Fig 7 . Bichu - Buti

8. **Gulwel - Giloy (*Tinospora cordifolia*):** Madhunashini- “Destroyer of sugar” uses a variety of pancreatic and extra pancreatic mechanisms to assist control blood glucose levels mechanisms. Alkaloids, tannins, cardiac glycosides, flavonoids, saponins and steroids all these phytoconstituents have antidiabetic role. Antidiabetic activity of *T.cordifolia* is well illustrated by Gupta A et al ^[14]



Fig 8 . Gulwel

9. **Cinnamon :** This popular spice lowers blood sugar levels by enhancing your body's reaction to insulin. Cinnamon's active polyphenols imitate insulin and slow down the digestion of carbohydrates in the gut, but human trials have yielded conflicting results, and it is not a substitute for conventional diabetes drugs. Alpha-glucosidase and pancreatic amylase are two intestinal enzymes that cinnamon slows down to lessen post-meal

sugar increases. By slowing down stomach emptying, it helps avoid sharp spikes in blood sugar. High concentrations of coumarin, which can damage the liver in excess, are found in cassia cinnamon. Ceylon ("true") cinnamon has low coumarin and is safer for regular use. Daily amounts ranging from 1 to 4 grams (about 0.5 to 1 teaspoon).



Fig 9. Cinnamon

10. Haldi - Turmeric (*Curcuma longa*):

Curcumin, a primary curcuminoid and a naturally occurring polyphenol, is what gives turmeric (*Curcuma longa*) its antidiabetic properties. Through many cellular pathways, it aids in the reduction of blood sugar and the fight against insulin resistance. Enhances total insulin sensitivity and reduces cellular resistance. Reduces the liver's synthesis of glucose and increases the absorption of glucose by cells. Suppresses inflammatory cytokines that harm beta cells, such as TNF-alpha. Reduces oxidative stress, which is associated with problems from diabetes. Enhances the ability of the pancreatic beta cells to secrete enough insulin. In order to increase absorption and therapeutic efficiency, natural curcumin is frequently combined with piperine (black pepper extract) or prepared into bio-enhanced/nanoparticle formulations due to its low bio-availability.



Fig.10 Haldi

- 11. Daruhaldi (*Berberis aristata*):** Berberine improves the way body cells react to insulin, facilitating the effective absorption and use of glucose. Also assists in activating pancreatic beta cells to enhance natural insulin production. It helps lower blood glucose levels, improve metabolic health, and manage diabetic complications. Berberine has gained attention as a supplement that can help with a number of disorders, including obesity and PMOS, according to a June 11, 2025, article in Health problems / diabetes and Endocrinology, When treating Type 2 diabetes, it is as effective as or even more effective than metformin. Berberine, however, takes around three months to start working. Metformin acts considerably more quickly. The full effects of metformin often take four to five days to manifest.



Fig11. Daruhaldi

- 12. Garlic (*Allium sativum*) and ginger (*Zingiber officinale*):** The active chemicals found in ginger (*Zingiber officinale*) and garlic (*Allium sativum*) reduce oxidative stress,

lessen inflammation, and improve insulin sensitivity. Additionally, their active ingredients reduce oxidative stress and guard against kidney and liver issues associated with diabetes. Both plants exhibit insulintropic effects, which cause the beta cells in the pancreas to release more insulin. Gingerols enhance the absorption and clearance of glucose in adipocytes and insulin-responsive peripheral tissues. Ginger and garlic slow down the absorption of glucose by controlling the enzymes that break down carbohydrates. Frequent use lowers hemoglobin A1c (HbA1c) levels and fasting blood glucose. They increase high-density lipoproteins (HDL) and lower high levels of triglycerides, total cholesterol, and low-density lipoproteins (LDL). In diabetic organs, their abundant phenolic and sulfur compounds lessen oxidative stress, lipid peroxidation, and cellular toxicity. Oral administration of the ginger extract resulted in significant reduction of hyperglycemia, the diameter of the retinal vessels and vascular basement membrane thickness.



Fig.12. Garlic -Ginger

13. **Amla (*Emblica Officinale*):** This substance is packed with hydrolyzable tannins, such as corilagin, gallic acid, ellagic acid, and β -glucogallin, which scavenge free radicals and contain trace minerals like chromium believed to improve insulin sensitivity and aid carbohydrate breakdown. Its high antioxidant

capacity, particularly from vitamin C, protects pancreatic beta-cells from oxidative damage and inflammation. It reduces postprandial blood sugar spikes by inhibiting carbohydrate-digesting enzymes such as aldose reductase and α -amylase, enhances glucose absorption pathways (e.g., AMPK activation) in skeletal muscles, and inhibits hepatic glucose synthesis. Additionally, it decreases markers of pancreatic inflammation, helps maintain or increase blood insulin and C-peptide levels, and improves lipid profiles by increasing healthy HDL cholesterol while decreasing triglycerides, LDL, and total cholesterol.



Fig13. Amla

14. **Vijaysar (*Pterocarpus marsupium*):** Vijaysar exhibits potent anti-diabetic effects by reducing fasting blood glucose levels, enhancing insulin sensitivity, and protecting pancreatic beta cells from oxidative stress. Its active compounds, such as epicatechin, pterostilbene, and marsupsin, function similarly to traditional glucose-lowering medications by increasing natural insulin secretion through the protection and repair of pancreatic cells. Additionally, Vijaysar slows intestinal sugar absorption and carbohydrate breakdown, reduces oxidative stress-induced tissue damage, and lowers levels of harmful cholesterol and blood lipids, contributing to improved metabolic health in individuals with type 2 diabetes.

15. **Paneer Doda (*Withania coagulans*):** Paneer Doda exhibits anti-diabetic properties by preserving pancreatic beta cells, increasing insulin sensitivity, and enhancing glucose utilization. It improves the body's ability to use blood sugar and metabolize carbohydrates, potentially aiding in the maintenance or repair of insulin-producing beta cells in the pancreas. Additionally, Paneer Doda slows the absorption of sugar into the bloodstream, helping to curb sharp glycemic fluctuations i.e keep the blood sugar levels relatively stable preventing them from spiking too high or crashing too low after eating..



Fig15. Paneer Doda

16. **Kodtumba , bitter apple (*Citrullus colocynthis*):**

Demonstrates notable hypoglycemic (blood sugar-lowering) action in both clinical and laboratory research. However, the plant must be handled very carefully and should never be eaten raw or in uncontrolled amounts because it naturally contains hazardous, extremely irritating substances. Fruit pulp and seed extracts have been shown to dramatically lower fasting blood sugar (FBS) levels, according to research published on websites like Pub-Med. Clinical investigations have demonstrated that a significant reduction in mean HbA1c levels can result from controlled, low-dose daily administrations (e.g., 125 mg) over a two-month period. Saponins and flavonoids are examples of active substances that stimulate the

pancreatic beta cells, causing them to release more insulin. Kodtumba contains cucurbitacins, which are highly toxic chemicals that severely irritate the stomach and bowel. In large doses, it can cause severe diarrhea, vomiting, stomach cramps, and internal bleeding. Due to these risks, it was banned for unsafe over-the-counter use by the US FDA.



Fig16. Kodtumba

Benefits and limitations of *C. colocynthis* is provided in details by Li QY et al ^[15].

17. **Aam Guthli (mango seed kernel) (*Mengifera indica*)** Mangiferin exhibits significant anti-diabetic activity by increasing insulin sensitivity, lowering HbA1c, and reducing fasting blood glucose levels, as demonstrated by scientific research. It inhibits digestive enzymes such as α -amylase and α -glucosidase, which slows carbohydrate digestion and reduces post-meal blood sugar spikes. Bioactive substances in Mangiferin stimulate muscle and fat cells to absorb glucose by promoting insulin release from the pancreas and upregulating genes like Glut4, Irs1, and P13k. Additionally, it suppresses hepatic glucose production during fasting by decreasing the expression of key liver proteins, such as glucose-6-phosphatase. Identified as a major active compound, Mangiferin plays a crucial role in these effects as reported by Senthilkumar et al ^[16]. Moreover, its high content of flavonoids and polyphenols

provides strong antioxidant protection, safeguarding pancreatic β -cells from oxidative damage and preventing cell death.



Fig17. Aam Guthli

18. **Salacia plant species (*Salacia reticulata* and *Salacia oblonga*)** : By lowering post-meal blood glucose, lowering HbA1c, and enhancing insulin sensitivity by inhibiting intestinal carbohydrate-metabolizing enzymes, two species of Salacia plants—*Salacia reticulata* and *Salacia oblonga*—show notable anti-diabetic action. In human studies, it has

been demonstrated that salacia extracts lower plasma glucose^[17]. When given to individuals with type II diabetes, aqueous extracts successfully regulate blood glucose levels without causing side effects. Strong natural sulfonium ions that competitively block α -glucosidase in the intestinal tract are bio-active substances such as salacinol and kotalanol. It contains mangiferin, a polyphenol that helps control metabolism and has antioxidant qualities, also slows down the conversion of complex carbs into glucose and reduces postprandial glucose spikes by blocking α -glucosidase and α -amylase. It helps to control lipid profiles (lowering cholesterol and triglycerides) and activates cellular pathways like AMPK. According to research on animals, root extracts may help preserve and replenish insulin secretion and pancreatic beta-cell activity. *Salcia reticulata* Fig. 18a and 18b. *Salcia oblonga*.



Fig 18a. Salcia reticulata



Fig 18b. Salcia oblonga

19. **Shisham leaves (*Dalbergia sissoo*)** : It has the ability to prevent diabetes by enhancing metabolic balance and controlling blood sugar levels. Bio-active substances with antioxidant qualities, such as tectorigenin and biochanin A, are found in the leaves.



Fig19. Shisham Leaves

20. **Sahjan (*Moringa oleifera*)** : includes plant compounds such quercetin, chlorogenic acid, and isothiocyanates that have anti-diabetic properties. These active substances slow down the body's absorption of sugar after a meal, assist reduce blood sugar, and enhance how cells use insulin. Many scientists have already worked on extracts of *Moringa oleifera*.^[18]. This controls the blood glucose or insulin level and protects against organ damage under sustained condition.



Fig20. Sahjan

21. **Tulsi (*Ocimum sanctum* or *Ocimum tenuiflorum*)** : significantly reduces oxidative stress, improves insulin production, and lowers blood glucose levels during fasting and after meals. Eugenol, caryophyllene, and ursolic acid are examples of bio-active substances that increase the amount of insulin released by pancreatic beta cells. High levels of flavonoids and polyphenols lessen oxidative cellular damage, which is frequently connected to insulin resistance.



Fig21. Tulsi

22. **Bael Patra / Bael Phal (*Aegle marmelos*)** :Leaf extracts lower blood glucose levels during fasting and after meals. Insulin sensitivity is improved and pancreatic beta-cell activity is supported by active plant substances.



Fig22. Bael Patra

23. **Mundi buti, Gorakhmundi (*Sphaeranthus indicus*)**: Demonstrates conventional hypoglycemic and anti-diabetic qualities by lowering blood sugar and lowering oxidative stress via active plant compounds.



Fig23. Gorakhmundi

24. **Peepal leaves (*Ficus religiosa*)**: The hypoglycemic effect is aided by the presence of several flavonoids and phytosterols such β -sitosterol-D-glycoside. Phenolics in the tree parts assist in reducing carbohydrate breakdown and oxidative stress.



Fig24.Peepal leaves

25. **Sadabahar** , Periwinkle (*Catharanthus roseus*) : has anti-diabetic properties mainly because of bioactive substances such as vincamine, vindoline, and other indole alkaloids. By promoting cellular glucose consumption, bolstering pancreatic beta-cell function, and boosting insulin control, these active substances help lower blood glucose levels. Active alkaloids assist control hyperglycemia and reduce blood sugar levels.



Fig25.Sadabahar

However, before attempting any new herbal supplement, a doctor's consultation is required for safety reasons in order to eliminate a few negative effects brought on by herb interactions. For example, combining fenugreek and bitter melon with conventional diabetes medications or insulin can cause your blood sugar to drop too low. Also taking very high doses of certain herbal extracts can cause stress on the liver or kidneys.

Tomer PK et al ^[19] proposed validated HPLC method to detect and quantify Metformin Hydrochloride in Ayurvedic medicinal products.

D. Minerals used :

The correlation of diabetes and an imbalance in metal makes metal-based therapy as an attractive proposition.^[20] Certain minerals are essential for cellular sensitivity, insulin production, and glucose metabolism, including magnesium, chromium, zinc, Vanadium, selenium, and manganese. Deficiencies can worsen insulin resistance, while maintaining adequate levels through diet or targeted supplementation supports better blood sugar control and lowers the risk of diabetic complications.

- **Magnesium:** is an essential component for the metabolism of carbohydrates and aids in the correct binding of insulin to cell receptors. Elevated blood glucose levels lead to increased magnesium excretion in the urine, often resulting in a cycle of insufficiency that exacerbates insulin resistance
- **Chromium:** Enhances the body's cells' ability to react to the hormone by amplifying the insulin signal
- **Zinc:** Essential for the pancreatic beta cells to properly store, synthesize, and secrete insulin. Standard textbooks of Ayurveda recommend Jasada bhasma - Jasat or Zinc based bhasma as the treatment of choice for diabetes.^[21] Taking inspiration from the fact that bhasmas contain submicronic or nanoparticles that enhance bioavailability, metal based nanomedicines can be developed for diabetes.
- **Selenium and Manganese:** are parts of antioxidant enzyme systems that save pancreatic cells from oxidative damage.
- **Vanadium:**
 - Shows insulin-mimetic properties in experimental studies.

- Reduces high blood glucose levels.

E. Classical Formulations :

Various forms of formulations with single / multi herbs are available, such as tablets, capsule, granules, churna, juices and so on.

Dr. Narendra Bhatt^[22] has taken special efforts to develop “Evidence - validation-Acceptance [EVA] “ model for clinical studies in Ayurveda. The significance of EVA model lies in the possible matching of substance, the therapeutic intervention with that of the dysfunction and the optional choice of the most appropriate biological model for precise investigational parameters. Eva model as exemplified addresses the issues in clinical studies in ayurveda and could be used for new drug discovery.

F. Panchakarma Detox :

This method can be used for early-moderate Kapha types, such as Vamana (therapeutic

vomiting to lower kapha), Virechna (purgation), Basti (enema), or Vata type (removing Ama and opening channels).

G. Modern Medicine and Ayurveda :

In addition to modern medications like insulin and metformin, Ayurveda offers recommendations for bettering lifestyle, preventing complications, and supporting metabolism. According to Ayurveda, diabetes is a metabolic and lifestyle disease that begins with kapha buildup and poor digestion. Therefore, to avoid difficulties, one should concentrate on diet, daily routine, herbs, detox, and stress management. Ayurveda can be utilized as supportive therapy, and it is advised that doctors perform routine kidney, eye, and HbA1c tests.

COMPARISON of ALLOPATHIC and AYURVEDIC / OTHER TREATMENTS:

Factors	Allopathy	Ayurveda
Speed	Hours to Day	Weeks to Months
Blood Sugar Control	Very strong, dose-specific	Moderate. Better for pre-diabetes Early Type 2
Insulin Use Supports pancreas function	Direct insulin replacement	No direct insulin.
Side Effects Weight changes	Hypoglycemia, GI, some bhasma if poorly made.	Usually mild. But heavy metals in
Complications	Drugs for BP, Cholesterol, Neuropathy, separately	Herbs and Diet aimed at preventing complications
Lifestyle	Advised but medicine does most work	Medicine, diet and Yoga are 70% of treatment
Evidence FDA approved	Extensive RCTs, WHO supports integration	Traditional use, Growing research,
Cost	Generic options cheap, Newer drugs expensive	Generally lower cost, but long-term use

Thus, "Integrative diabetes care" is promoted by WHO and AYUSH.

1. Allopathy is recommended by the Common Model for acute high blood sugar, Type 1 diabetes, HbA1c > 9%, and sequelae.

2. Ayurveda for the treatment of pre-diabetes, type 2 diabetes, weight, stress, neuropathy, and lifestyle modification.

3. Together: Under supervision, the patient is taking metformin, following a diet, using herbal remedies, and doing yoga.



Allopathy can be compared to a fire extinguisher, which is quick, strong, vital in emergency situations, and requires strict management.

Ayurveda = Fire Prevention System: Slower, improves food, habits, and metabolism to prevent the "fire" from starting or getting worse.

The majority of persons with Type 2 diabetes benefit most from allopathic management, an Ayurvedic lifestyle, and the use of certain herbs while keeping doctors, Vaidyas, and practitioners informed.

On Regulatory point of view, we are not allowed to make claims that "cures diabetes."

Permitted "For blood sugar support and Madhumeha management".

YOGA:

By reducing stress hormones, increasing blood circulation, and enhancing insulin sensitivity, yoga aids in the management of diabetes. Poses that are beneficial include:

- **Bow Pose (*Dhanurasana*):** Lying on your stomach, hold your ankles and lift your chest up to stretch the belly area and stimulate the pancreas.
- **Half Spinal Twist (*Ardha Matsyendrasana*):** Sit and twist your torso to gently squeeze the abdominal organs.
- **Seated Forward Bend (*Paschimottanasana*):** Sit with legs straight, reach for your toes to calm the mind and stretch the back.
- **Legs-Up-the-Wall (*Viparita Karani*):** Lie on your back with legs resting up against a wall to relax and improve blood flow.



Fig 26. ASANAS – For Management of Diabetes

Key Benefits of Yoga

- **Lower Stress:** Reduces cortisol, which stops blood sugar from spiking.
- **Better Insulin Use:** Helps muscles absorb glucose and massages abdominal organs to support the pancreas.
- **Good Circulation:** Keeps blood moving well to protect your heart and nerves.

Calf Exercises:

Soleus push-ups or Seated calf raises, improve metabolic health by activating a specific lower leg muscle that pulls glucose directly from the

bloodstream, helping to lower the blood sugar levels.



Fig. 27. Calf Exercises for lowering sugar spikes

Basic scientific-based advantages of Calf exercises in controlling the diabetes are :

1. Soleus muscle in calves can raise oxidative metabolism for hours and improve glucose regulation.
2. 3 minutes of calf raises every 30 minutes for 8 hours lowers postprandial glucose spike.
3. It makes cells more insulin-sensitive and improves glucose uptake and circulation.
4. Calf raises are a simple method to control post-meal blood sugar.

The unique blend of physical postures, controlled breathing methods, and meditation is the foundation of the well-discussed holistic approach to managing diabetes [23]. Raveendran AV and his team also examined clinical evidence [24] in which regular yoga practice helps diabetics achieve glycemic control and lower their risk of problems.

Other Therapies :

Due to its anti-neuro-inflammatory actions linked to diabetes mellitus, oral and subcutaneous semaglutide therapies [25] are very effective in improving glycemic control, weight loss, and lowering cardiovascular risks and Alzheimer's disease.

Use of Advanced Technology:

Grunberger et al [26] says, Use Continuous CGMs for real-time sugar control, smart pens and insulin pumps for precise dosing, and their combination for automated, personalized diabetes management. Proper education from healthcare team is needed to use these technologies effectively for every person.

Red Light Therapy emerges as a valuable addition to diabetes care. RED LIGHT THERAPY-covers near infra red (600-850nm). Exposure for 15 min at 670 nm lowers post-meal sugar spikes by 27.7% in healthy. It may help diabetic nerve pain and slow-healing ulcers by boosting mitochondrial ATP. May improve circulation, lower inflammation, support tissue repair. But it is still

experimental add-on, can not replace insulin, oral medications, exercise and needs eye protection, as direct exposure can cause eye strain. Powner MB and Jeffery G [27] explained the experimental outputs

Role of Artificial Intelligence :

As per Tahir and Farhan [28] AI helps machine learning as well as it helps from diagnosis to personalized treatment / monitoring by classifying pre diabetes/ diabetes/ advanced diabetes based on HbA1c and predicting T2DM risk to prevent onset, progression and complications. Its only a complementary tool, not a doctors replacement, and needs ethics, privacy and bias-free use. Tie et al [29] and Zhang et al [30] also stress doctor-AI collaboration for future AI-driven personalized care.

Regulatory Strategy:

In India, CDSCO prioritizes centralized clearance for novel medications and combination treatments [31]. In order to improve FDC oversight in India, Samjdar SS et al. [32] evaluated the evidence gaps in prohibited fixed-dose combination (FDCs) and outlined actionable recommendations. Pawar M et al. [33] provided supporting and complementary techniques that prioritize holistic treatment, long-term repair, and minimum side effects through a comparative analysis of several systems.

CONCLUSION

Diabetes management is most effective when multiple systems work together.

Allopathy provides rapid, evidence-based glycemic control and manages complications. **Ayurveda** focuses on root-cause correction through diet, herbs, and lifestyle to improve insulin sensitivity. **Naturopathy** supports detoxification, weight management, and metabolic



balance with natural therapies. **Yoga** reduces stress, enhances insulin function, and improves overall compliance and quality of life. Together, this integrative model leverages the speed of allopathy with the preventive and holistic benefits of Ayurveda, Naturopathy and Yoga- offering safer, more sustainable and patient-centered diabetes care. Incorporation of AI is desirable, for providing efficient data to enhance care. It can be used as a complementary tool not replacement for doctors. Combining the strengths of each system may offer a multidimensional therapeutic approach to diabetes, targeting both symptoms and root causes to enhance overall patient care. Maintaining a healthy lifestyle can be facilitated by eating a balanced diet and getting frequent checkups.

Further large-scale clinical trials are required to establish efficacy, standardize integrative protocols, evaluate herb-drug interactions and long-term safety. Mainstream integration into standard diabetic care will require policy support and individualized, evidence-based frameworks.

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