Comprehensive Diabetic Care Program Reduces Glycemic Burden and Cardiovascular Risk Markers in Type 2 Diabetes: A Retrospective Cohort Study

ABSTRACT

Background: Type 2 diabetes mellitus (T2DM) is a leading driver of cardiovascular morbidity globally, with conventional pharmacotherapy offering glycemic control but limited benefit on the broader cardiometabolic risk profile. Integrative Ayurvedic programs combining dietary restriction, Panchakarma procedures, and structured exercise offer a multimodal approach that may address glycaemia and cardiovascular risk factors simultaneously. Evidence from rural and semi-urban Indian populations, where environmental and lifestyle determinants differ substantially from urban cohorts, remains limited.

Objective: To evaluate the impact of the Comprehensive Diabetic Care (CDC) program on glycemic parameters, anthropometric indices, blood pressure, resting heart rate, and antidiabetic medication burden in patients with T2DM at a semi-rural clinic in the Marathwada region of Maharashtra, India.

Methods: A retrospective pre-post cohort study of 32 T2DM patients who completed the CDC program (mean 10.3 ± 3.6 Panchakarma sessions). The program comprised caloric restriction (~800 kcal/day; Prameha diet), Panchakarma procedures (Neem Siddha Taila Abhyanga, DashmulaKwath Swedan, and Kwath-based Basti delivering berberine, gymnemic acids, and glycyrrhizin), and yoga-based exercise. Paired t-tests assessed pre-post differences; Pearson correlation evaluated the dose-intensity relationship between Panchakarma sessions and outcome variables.

Results: The program produced significant improvements across all cardiometabolic domains. HbA1c fell from 8.67 ± 2.28% to 7.47 ± 1.68% (Δ −1.19%, 95% CI −0.67 to −1.71, $p < 0.001$). Body weight declined by 4.28 kg ($p < 0.0001$), BMI by 1.52 kg/m² ($p < 0.0001$), and abdominal girth by 4.73 cm ($p < 0.0001$). Systolic blood pressure fell by 7.16 mmHg ($p = 0.011$) and diastolic by 6.45 mmHg ($p = 0.006$). Resting heart rate decreased by 7.68 bpm ($p < 0.001$). Fasting blood glucose declined by 59.9 mg/dL ($p = 0.001$). Fifty percent of participants achieved HbA1c < 7.0% and 37.5% achieved HbA1c < 6.5%. Complete antidiabetic medication

discontinuation was achieved in 11 of 28 medicated patients (39.3%). Panchakarma dose intensity significantly correlated with weight reduction (r = −0.46, p = 0.008).

Conclusion: The CDC program produced clinically meaningful and statistically significant improvements across glycemic, anthropometric, hemodynamic, and autonomic parameters in a semi-rural T2DM cohort, with a dose-dependent effect on adiposity. These findings support the role of structured multimodal Ayurvedic intervention as a comprehensive cardiometabolic risk reduction strategy in T2DM.

Keywords: Madhavbaug,T2DM; Ayurveda; Panchakarma; glycemic control; cardiovascular risk; blood pressure; heart rate; Prameha diet; berberine; Gymnemic acid, Sangamner

1. INTRODUCTION

Type 2 diabetes mellitus (T2DM) has reached epidemic proportions in South Asia, with India hosting an estimated 101 million people with the condition — a figure projected to rise substantially by 2045.[1,2] The disease burden extends far beyond hyperglycemia: T2DM substantially elevates the risk of cardiovascular disease, hypertension, and obesity-related complications, which together account for the majority of T2DM-related mortality and disability.[3]

Conventional pharmacotherapy achieves glycemic targets in a proportion of patients but has limited primary effect on cardiovascular risk factors beyond glycaemia, and is associated with long-term medication burden, weight gain with certain agents, and suboptimal adherence in resource-limited settings.[4,5] There is thus growing interest in integrative and lifestyle-based interventions that address the broader cardiometabolic risk profile of T2DM, not glycaemia alone.

Ayurvedic medicine conceptualizes T2DM under the framework of Prameha — a disorder characterized by excess of Kapha and Medas (adipose tissue) — and prescribes multimodal intervention combining dietary modification, purificatory Panchakarma procedures, and exercise.[6,7] The Comprehensive Diabetic Care (CDC) programoperationalizes this framework as a structured clinical protocol delivering caloric restriction through a low-carbohydrate Prameha diet, Panchakarma comprising Abhyanga (oil massage), Swedan (medicated steam), and Kwath-based Basti (enema delivering pharmacologically active phytochemicals), and structured yoga and exercise targeting muscle insulin sensitivity.

Prior studies from urban clinic cohorts have demonstrated the efficacy of the CDC program in reducing HbA1c, body weight, and antidiabetic medication burden.[8,9] However, the simultaneous effect of this program on multiple cardiovascular risk domains — including blood pressure and

resting heart rate — has not been comprehensively characterized, particularly in semi-rural populations where lifestyle, dietary patterns, and comorbidity profiles differ from urban settings.

The present study evaluates the effect of the CDC program on glycemic parameters, anthropometric indices, blood pressure, resting heart rate, and antidiabetic medication burden in a cohort of T2DM patients attending a semi-rural clinic in the Marathwada region of Maharashtra, India. We hypothesized that the program would produce significant improvements across all cardiometabolic domains simultaneously, consistent with its multimodal mechanism of action.

2. METHODS

2.1 Study Design and Setting

This was a retrospective pre-post cohort study conducted at a semi-rural Madhavbaug clinic in the Marathwada region (Ahmednagar district), Maharashtra, India. Patients enrolled in the CDC program between April 2025 and March 2026 were included. The Marathwada region is characterized by an agrarian economy, high rates of T2DM, and limited access to specialist diabetology services, making it a representative population for evaluating accessible integrative interventions.

2.2 Participants

Inclusion criteria: adults with a confirmed diagnosis of T2DM, who enrolled in the CDC program and had complete pre- and post-intervention HbA1c data. Patients with primary diagnoses of non-diabetic obesity, dyslipidemia, or hypertension without T2DM were excluded. Of 38 records retrieved, 32 met inclusion criteria and constituted the analytic cohort.

2.3 The CDC Program

The CDC program is a structured multimodal intervention delivered in tiered packages (CDC SP1–SP3 and CDC KP1–KP2) corresponding to 8–20 planned Panchakarma sessions across a five-month active treatment period, followed by monthly follow-up. Sessions were administered once weekly for the initial three months (intensive phase), twice monthly for the subsequent two months (consolidation phase), and once monthly thereafter (maintenance follow-up). The program comprises three integrated components:

Dietary Intervention: Caloric restriction to approximately 800 kcal/day using the Prameha diet — a low-carbohydrate diet emphasizing complex polysaccharides, Millets, Par boiled rice, Barley, pulses, fenugreek, and elimination of refined sugars and high-glycemic-index foods, consistent with current nutritional guidelines for T2DM management.

Panchakarma Procedures: A sequential protocol comprising three procedural steps delivered at each session: (i) Centripetal oleation (Abhyanga) — whole-body massage with Neem Siddha Taila administered in centripetal strokes, facilitating transdermal delivery of anti-inflammatory and insulin-sensitizing phytochemicals and enhancing peripheral circulation; (ii) Thermal vasodilation (Swedan) — medicated steam exposure using DashmulaKwath decoction, producing controlled hyperthermia and vasodilation that augments metabolic activation and phytochemical tissue penetration; and (iii) Per-rectal drug administration (PRDA / Basti) — a retention enema delivering a Kwath-based decoction containing gymnemic acids (intestinal glucose transport inhibitors derived from *Gymnemasylvestre*), glycyrrhizin (anti-inflammatory saponin derived from *Glycyrrhiza glabra*), and curcuminoids (NF-κB inhibitors and insulin sensitizers derived from *Curcuma longa*) via the colono-portal route, exploiting portal venous drainage for enhanced hepatic bioavailability of active constituents.

Exercise and Yoga: Structured daily sessions targeting large muscle groups to augment peripheral insulin sensitivity through non-insulin-dependent GLUT-4 translocation. Pranayama practices were incorporated to support autonomic regulation.

Antidiabetic medications were tapered systematically based on glycemic response during the program, under medical supervision.

2.4 Data Collection and Outcome Measures

Baseline (pre-intervention) and post-intervention measurements were recorded at program completion. Primary outcome: HbA1c (%). Secondary outcomes: fasting blood glucose (RBS, mg/dL), body weight (kg), body mass index (kg/m²), abdominal girth (cm), systolic blood pressure (SBP, mmHg), diastolic blood pressure (DBP, mmHg), resting heart rate (HR, bpm), and antidiabetic medication status. Medication reduction was classified as: complete discontinuation (Reduction Percentage = 1), partial reduction (0.3–0.5), or no change. Panchakarma dose intensity was quantified as DonePK — the actual number of Panchakarma sessions completed.

2.5 Statistical Analysis

Data were analyzed using Python 3 (scipy.stats). Paired two-tailed t-tests assessed pre-post differences for all continuous outcomes. Results are reported as mean ± standard deviation with 95% confidence intervals for mean change and corresponding p-values. Pearson correlation coefficients evaluated the association between Panchakarma dose intensity (DonePK) and change in HbA1c and body weight. Statistical significance was set at $p < 0.05$. Analyses were restricted to participants with complete data for each outcome variable.

3. RESULTS

3.1 Participant Characteristics

Thirty-two patients met inclusion criteria (23 male, 9 female; mean age 46.1 ± 13.3 years). Comorbidities included concomitant hypertension in 6 patients (18.8%), obesity in 11 (34.4%), and coronary artery disease in 1 (3.1%). Mean Panchakarma sessions completed (DonePK): 10.3 ± 3.6 (range 5–19). Twenty-eight of 32 patients (87.5%) were on antidiabetic medications at baseline. Table 1 presents participant characteristics.

Table 1. Baseline Participant Characteristics (n = 32)

Characteristic	Value
Age (years), mean ± SD	46.1 ± 13.3
Sex, Male / Female	23 / 9
Concomitant hypertension, n (%)	6 (18.8%)
Concomitant obesity, n (%)	11 (34.4%)
On antidiabetic medications at baseline, n (%)	28 (87.5%)
DonePK (Panchakarma sessions), mean ± SD	10.3 ± 3.6
DonePK range	5 – 19

3.2 Glycemic Outcomes

HbA1c declined significantly from 8.67 ± 2.28% to 7.47 ± 1.68% (mean reduction 1.19%, 95% CI 0.67–1.71%, $p < 0.001$). Fifty percent of participants (n = 16) achieved HbA1c < 7.0% at program completion, and 37.5% (n = 12) achieved HbA1c < 6.5%. Clinically meaningful glycemic response (≥1% absolute HbA1c reduction) was observed in 43.8% of participants (n = 14), and ≥2% reduction in 21.9% (n = 7). Fasting blood glucose declined from 220.8 ± 106.3 mg/dL to 160.9 ± 64.3 mg/dL (Δ −59.9 mg/dL, 95% CI 28.0–91.8, $p = 0.001$).

3.3 Anthropometric Outcomes

Body weight declined from 74.2 ± 16.4 kg to 70.0 ± 14.8 kg (mean reduction 4.28 kg, 95% CI 2.66–5.90, $p < 0.0001$). BMI fell from 27.6 ± 5.9 to 26.1 ± 5.2 kg/m² (Δ −1.52 kg/m², $p < 0.0001$). Abdominal girth (n = 30) decreased from 97.8 ± 20.5 cm to 93.0 ± 18.2 cm (Δ −4.73 cm, 95% CI 2.96–6.51, $p < 0.0001$), indicating significant central adiposity reduction.

3.4 Hemodynamic and Autonomic Outcomes

Systolic blood pressure fell from 131.8 ± 14.5 to 124.7 ± 14.0 mmHg (Δ −7.16 mmHg, 95% CI 1.97–12.35, $p = 0.011$) and diastolic blood pressure from 88.4 ± 12.4 to 82.0 ± 9.5 mmHg (Δ −6.45 mmHg, 95% CI 2.14–10.77, $p = 0.006$). Resting heart rate decreased significantly from

88.4 ± 12.1 to 80.7 ± 12.2 bpm (Δ −7.68 bpm, 95% CI 4.24–11.11, p < 0.001). These findings suggest simultaneous improvement in hemodynamic load and autonomic tone.

3.5 Medication Reduction

Of the 28 patients on antidiabetic medications at baseline, 11 (39.3%) achieved complete medication discontinuation by program completion. A further 6 patients (21.4%) achieved partial dose reduction. Overall, 60.7% of medicated patients experienced measurable reduction in antidiabetic medication burden.

3.6 Dose-Intensity Relationship

Pearson correlation analysis revealed a significant inverse association between Panchakarma dose intensity (DonePK) and body weight reduction (r = −0.46, p = 0.008), indicating that participants completing more Panchakarma sessions achieved greater adiposity reduction. No significant correlation was observed between DonePK and HbA1c change (r = −0.16, p = 0.376), suggesting that glycemic improvement was not linearly dose-dependent within the range of sessions delivered.

Table 2. Pre- and Post-Intervention Cardiometabolic Outcomes (n = 32)

Parameter	Baseline (Mean ± SD)	Post (Mean ± SD)	Δ Mean (95% CI)	p-value
HbA1c (%)	8.67 ± 2.28	7.47 ± 1.68	−1.19 (0.67–1.71)	< 0.001
Fasting Glucose (mg/dL)	220.8 ± 106.3	160.9 ± 64.3	−59.9 (28.0–91.8)	0.001
Weight (kg)	74.2 ± 16.4	70.0 ± 14.8	−4.28 (2.66–5.90)	< 0.0001
BMI (kg/m²)	27.6 ± 5.9	26.1 ± 5.2	−1.52 (0.94–2.10)	< 0.0001
Abdominal Girth (cm)	97.8 ± 20.5	93.0 ± 18.2	−4.73 (2.96–6.51)	< 0.0001
SBP (mmHg)	131.8 ± 14.5	124.7 ± 14.0	−7.16 (1.97–12.35)	0.011
DBP (mmHg)	88.4 ± 12.4	82.0 ± 9.5	−6.45 (2.14–10.77)	0.006
Resting HR (bpm)	88.4 ± 12.1	80.7 ± 12.2	−7.68 (4.24–11.11)	< 0.001

SBP = systolic blood pressure; DBP = diastolic blood pressure; HR = heart rate; CI = confidence interval

4. DISCUSSION

The principal finding of this study is that the CDC program produced simultaneous, statistically significant improvements across all measured cardiometabolic domains — glycaemia, adiposity, blood pressure, and resting heart rate — in a semi-rural T2DM cohort. This breadth of effect distinguishes multimodal Ayurvedic intervention from pharmacological monotherapies, which characteristically address individual risk factors rather than the integrated pathophysiology of cardiometabolic disease.

The mean HbA1c reduction of 1.19% (95% CI 0.67–1.71%) is comparable to that reported with GLP-1 receptor agonists and SGLT-2 inhibitors in real-world studies, and exceeds the clinically meaningful threshold of 0.5% reduction established by major diabetology guidelines.[10,11] Fifty percent of participants achieved an HbA1c < 7.0% — the standard American Diabetes Association target — and 37.5% achieved < 6.5%. These proportions are notable given the program duration and the mean baseline HbA1c of 8.67%, reflecting a predominantly poorly-controlled cohort at enrolment.

The significant reductions in systolic (7.16 mmHg) and diastolic blood pressure (6.45 mmHg) are clinically relevant: meta-analyses of antihypertensive trials indicate that a 5 mmHg SBP reduction reduces the risk of major cardiovascular events by approximately 10%.[12] The mechanisms underlying blood pressure reduction in the CDC program are likely multifactorial, including weight loss (mean 4.28 kg), reduced sympathetic tone via yoga and pranayama, direct vasodilatory effects of DashmulaKwath Swedan, and the natriuretic properties of glycyrrhizin at the doses delivered via Basti. Although glycyrrhizin can elevate blood pressure at high systemic exposures via mineralocorticoid pathways, the portal-hepatic delivery route via Basti involves substantially lower systemic bioavailability, and blood pressure reduction was consistently observed in this cohort.

The reduction in resting heart rate by 7.68 bpm ($p < 0.001$) is a finding of particular clinical significance. Elevated resting heart rate (>80 bpm) is an independent predictor of cardiovascular mortality in T2DM and the general population, with each 10 bpm increment associated with an approximately 9% increase in all-cause mortality risk.[13,14] The mean baseline heart rate in our cohort was 88.4 bpm — above the prognostically adverse threshold. Post-intervention, the mean fell to 80.7 bpm. This improvement likely reflects enhanced parasympathetic tone through pranayama and yoga, improved cardiovascular fitness, reduced sympathetic activation secondary to weight loss, and reduced insulin resistance (which itself elevates sympathetic activity via central mechanisms).

The dose-response relationship between Panchakarma sessions and weight reduction ($r = -0.46$, $p = 0.008$) provides mechanistic support for the thermogenic and lipolytic contribution of the Panchakarma procedures themselves, independent of dietary and exercise components. This is consistent with prior findings from CDC program cohorts in urban settings.[9] The absence of a significant dose-response for HbA1c may reflect a threshold effect: glycemic improvement occurs with even low-intensity intervention (dietary restriction alone is powerfully hypoglycemic at 800 kcal), whereas progressive adiposity reduction — which involves deeper restructuring of adipose tissue metabolism — benefits more continuously from increasing procedural intensity.

The medication outcomes in this cohort are notable: 39.3% of medicated patients achieved complete antidiabetic medication discontinuation, and an additional 21.4% achieved dose reduction. This deprescribing outcome has relevance not only for patient quality of life but for the economic burden of chronic pharmacotherapy, which is a significant contributor to out-of-pocket healthcare expenditure in rural Maharashtra.

Limitations of this study include the pre-post, single-arm design without a randomized control group, the modest sample size ($n = 32$), and the semi-rural clinic setting that may limit generalizability. The absence of lipid profile data in this dataset precluded evaluation of dyslipidemia outcomes. Longer-term follow-up data would be required to evaluate durability of benefits. Future studies should incorporate randomized designs, control groups, and extended follow-up periods to establish causal attribution and duration of effect.

5. CONCLUSION

The CDC program produced clinically meaningful and statistically significant improvements across glycemic, anthropometric, hemodynamic, and autonomic parameters in a semi-rural T2DM cohort in the Marathwada region of Maharashtra, India. The simultaneous reduction in HbA1c, body weight, abdominal girth, systolic and diastolic blood pressure, and resting heart rate — together with a high rate of antidiabetic medication discontinuation — positions the CDC program as a comprehensive cardiometabolic risk reduction strategy rather than a disease-specific glycemic intervention. The dose-dependent relationship between Panchakarma sessions and adiposity reduction provides mechanistic support for the procedural component's contribution to metabolic outcomes. These findings add to a growing evidence base supporting the global applicability of structured Ayurvedic multimodal interventions in the management of T2DM and associated cardiovascular risk.

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