



A Comparative Analysis of Aerobic Exercise and Strength Training Combined with Dietary Intervention on Glycaemic Regulation in Middle-Aged Adults with Type 2 Diabetes

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ABSTRACT

Type 2 diabetes mellitus (T2DM) is a growing global health concern associated with substantial morbidity, mortality, and reduced quality of life. Lifestyle interventions—particularly physical activity and dietary modification—are central to glycaemic management. This comparative study evaluated the effects of aerobic exercise and strength training combined with dietary intervention on glycaemic regulation in middle-aged adults with T2DM.

A total of 44 participants initially screened, 30 sedentary adults aged 45–65 years with HbA1c $\geq 6.5\%$ completed an 8-week trial. Participants were randomly assigned to Group A (diet with irregular exercise, $n=15$) or Group B (diet with structured aerobic and resistance training three times weekly, $n=15$). Fasting glucose, postprandial glucose, random glucose, HbA1c, lipid profile, and blood pressure were assessed at baseline and post-intervention; the Diabetes Self-Management Questionnaire (DSMQ) assessed self-care behaviours.

Group B showed significantly greater reductions in postprandial and random glucose and in systolic blood pressure than Group A ($p<0.05$), along with improved lipid profiles and self-management adherence. Both groups improved significantly from baseline on paired analysis ($p<0.001$), but between-group differences favoured structured combined training.

A structured program combining aerobic and resistance training with dietary intervention is more effective for glycaemic regulation than diet with irregular activity alone, reinforcing the value of consistent, supervised exercise in T2DM management.

Keywords: Type 2 diabetes mellitus, aerobic exercise, resistance training, diet, glycaemic control, HbA1c, lifestyle intervention

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I. INTRODUCTION

Type 2 diabetes mellitus (T2DM) is a chronic metabolic disorder characterized by insulin resistance and progressive β -cell dysfunction, and its prevalence continues to rise worldwide [1,2]. It is a leading cause of premature mortality and morbidity related to cardiovascular disease, blindness, kidney and nerve disease, and amputation, and although regular physical activity can prevent or delay its onset and complications, most affected individuals remain inactive [1,2]. Diabetes accounted for an estimated 6.8% of global mortality in the 20–79 age group [4], and its incidence varies substantially across regions, with the sharpest projected increases in the Middle East, Sub-Saharan Africa, South and East Asia, and Latin America [7,8].

Well-established risk factors for T2DM include genetic predisposition, sedentary behavior, obesity, hypertension and dyslipidemia, smoking, gestational diabetes, and polycystic ovary syndrome [4]. Diagnosis follows American Diabetes Association criteria: HbA1c $\geq 6.5\%$, fasting plasma glucose ≥ 126 mg/dL, 2-hour plasma glucose ≥ 200 mg/dL on oral glucose tolerance testing, or classic hyperglycaemic symptoms with random glucose ≥ 200 mg/dL [1].

Exercise improves insulin sensitivity, lowers HbA1c, and favourably affects lipid profile, blood pressure, and body composition [5]. Aerobic training improves insulin sensitivity by up to 30% and mobilizes visceral adipose tissue, while resistance training increases lean mass and reduces visceral fat [9–12]. Evidence increasingly

suggests that combined aerobic and resistance training outperforms either modality alone for glycaemic control [10,11,18], though direct comparative data in middle-aged South Asian populations remain limited. This study compared glycaemic and cardiometabolic outcomes between diet with irregular exercise and diet with structured combined aerobic-resistance training in adults with T2DM.

II. METHODOLOGY

Study Design and Participants

This was a comparative interventional study conducted at diabetes clinics and hospitals in Guwahati. Of 83 individuals screened, 44 entered a 2-week run-in phase, and 30 sedentary adults aged 45–65 years with HbA1c $\geq 6.5\%$ completed the 8-week study. Inclusion criteria required documented HbA1c testing within the prior 6 months, oral antidiabetic medication use, a diabetes duration of approximately 10–15 years, no kidney impairment, and a sedentary baseline (no more than 20 minutes of exercise on 3 or more days/week). Exclusion criteria included BMI ≥ 48 kg/m², blood pressure $\geq 160/100$ mmHg, fasting triglycerides ≥ 500 mg/dL, insulin pump use, proteinuria, serum creatinine >1.5 mg/dL, stroke history, advanced neuropathy or retinopathy, or any condition precluding safe participation.

After screening, participants were randomly assigned to Group A (diet with irregular exercise, n=15) or Group B (diet with structured aerobic and resistance training, n=15), with individualized diet and exercise regimens. Medication type and dosage were confirmed by questionnaire and visual inspection of prescriptions.

Intervention

Group B completed three supervised sessions per week combining aerobic and resistance exercise (Table 1), with follow-up assessments at weeks 4 and 8. Dietary guidance for both groups emphasized whole grains, lean protein, legumes, and vegetables, with reduced refined carbohydrate and fat intake (Table 2).

Table 1. Minimum exercise prescription for Group B

Type	Intensity	Frequency
Aerobic (walking, cycling, swimming)	Moderate (40–59% VO ₂ R/HRR) or vigorous (60–84% VO ₂ R/HRR); ~90–125 min/week	≥ 3 days/week; no more than 2 consecutive rest days
Resistance (multi-joint, large muscle groups)	2–4 sets $\times$ 8–10 reps at 70–84% 1RM; 1–2 min rest	≥ 2 sessions/week

VO₂R = VO₂ reserve, HRR = heart rate reserve.

Resistance training repetitions should be performed at a weight that cannot be lifted more than 8–10 times (70–84% of 1 RM).

Table 2. Diet chart for type 2 diabetes

Timing	Food items
Early morning	Green tea/black coffee with sugar free biscuit/ soaked nuts and seeds
Morning Breakfast	1 small bowl vegetable dalia/oatmeal/low-fat milk 1 whole egg or 2 boiled eggs white portion
Mid-Morning	1 small fruit (apple, pear, guava, cucumber, or grape, jamun)/butter milk/ lemon water
Lunch	2 small whole wheat chapati / 1 small bowl brown rice 1 small bowl lentils/dal 1 small bowl vegetable curry (leafygreens/beans/mixed) 1 bowl of chicken/fish/paneer curry 1 small bowl salad
Evening Snack	- Green tea/black coffee 1 small bowl roasted chana/makhana or boiled corn or low-fat milk/puffed rice
Dinner	1–2 small whole wheat chapati with vegetables / lentil or - A bowl of vegetable / chicken soup/ grilled fish with vegetables

Outcome Measures

Fasting, postprandial, and random blood glucose, blood pressure, HbA1c, and lipid profile were measured at baseline and post-intervention. Self-management behaviour was assessed with the validated 16-item Diabetes Self-Management Questionnaire (DSMQ) [6].

III. RESULTS

At baseline, fasting glucose and blood pressure did not differ significantly between groups ($p>0.05$), but postprandial and random glucose were significantly higher in Group A ($p<0.05$). Table 3 summarizes pre- and post-intervention values for both groups.

Table 3. Glycemic and blood pressure outcomes before and after intervention

Parameter	Group A Pre (Mean±SD)	Group A Post (Mean±SD)	Group B Pre (Mean±SD)	Group B Post (Mean±SD)	Between-group p (post)
Fasting glucose (mg/dL)	169.00 ± 15.63	145.27 ± 18.07	167.40 ± 15.95	135.13 ± 8.38	NS
Postprandial glucose (mg/dL)	287.13 ± 51.79	223.40 ± 39.68	228.87 ± 70.63	160.80 ± 11.45	<0.05
Random glucose (mg/dL)	341.07 ± 53.27	272.20 ± 45.11	235.67 ± 63.62	170.33 ± 22.15	<0.05
Systolic BP (mmHg)	161.73 ± 9.96	145.60 ± 10.66	154.53 ± 10.39	137.87 ± 7.41	<0.05
Diastolic BP (mmHg)	133.20 ± 12.63	120.33 ± 14.76	135.00 ± 10.34	116.47 ± 7.83	NS

Both groups improved significantly from baseline on paired analysis ($p<0.001$ for all variables). However, post-intervention postprandial glucose, random glucose, and systolic blood pressure were significantly lower in Group B than Group A ($p<0.05$); fasting glucose and diastolic blood pressure did not differ significantly between groups post-intervention. Group B also showed a significantly greater improvement in lipid profile and better adherence on the DSMQ than Group A, whereas Group A showed only modest improvement in HbA1c and lipid parameters.

IV. DISCUSSION

These findings are consistent with evidence that combined aerobic and resistance training is more effective for glycaemic control than either modality alone [10,11,18]. Resistance training increases muscle mass and glucose disposal capacity, while aerobic exercise enhances glucose uptake through improved insulin action; together, these mechanisms—along with greater total energy expenditure—likely explain the superior outcomes observed in Group B [10–12]. The Diabetes Aerobic and Resistance Exercise (DARE) trial similarly found that combined training produced greater HbA1c reduction than either aerobic or resistance training alone in previously inactive adults with T2DM [11].

Recent evidence reinforces these conclusions. A 2025 network meta-analysis found that combined aerobic-resistance training and high-intensity interval training produced the greatest HbA1c improvements among people with T2DM [20]. A separate randomized trial found combined training produced the most favorable changes in insulin secretion and glucose effectiveness [21], and a Bayesian network meta-analysis found that 14–48 weeks of combined aerobic-resistance training produced the greatest improvements in fasting glucose, postprandial glucose, and HbA1c [22]. Together with the present findings, this evidence supports combined aerobic-resistance training as a first-line lifestyle intervention for glycaemic control in T2DM.

LIMITATION AND FUTURE RESEARCH

This study was limited by a small sample size, a short 8-week duration, and a limited set of outcome measures. Future studies should use larger, more diverse samples, longer follow-up, and additional stratification by sex and comorbidity (e.g., thyroid disease), and should examine the long-term effects of specific exercise modalities (e.g., yoga, Pilates, resistance-focused training) and their interaction with pharmacologic therapy such as metformin.

V. CONCLUSION

Diabetes cannot currently be cured, but it can be effectively managed through pharmacologic therapy, healthy eating, and physical exercise. This study demonstrates that a structured program combining aerobic and resistance training with dietary intervention produces greater improvements in glycemic control and blood pressure than diet with irregular exercise alone, supporting supervised combined exercise as a key component of T2DM management.

ABBREVIATIONS

DM: Diabetes mellitus; T1DM: Type 1 diabetes mellitus; T2DM: Type 2 diabetes mellitus; PA: Physical activity; ADA: American Diabetes Association; BG: Blood glucose; DSMQ: Diabetes Self-Management Questionnaire; BP: Blood pressure.

DECLARATIONS

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