

Effects of Bee-Derived Products, Yoga, and Dietary Intervention on Metabolic Parameters in Patients with Type 2 Diabetes Mellitus

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ABSTRACT

Background

Type 2 Diabetes Mellitus (T2DM) is a rapidly increasing global health concern, closely associated with lifestyle-related factors such as obesity, dietary habits, and physical inactivity. Integrative approaches combining nutritional and lifestyle interventions may offer complementary strategies for improving metabolic outcomes under real-world clinical conditions.

Objective

This study aimed to evaluate the effects of a combined intervention including bee-derived products (propolis and bee bread), dietary modification, and structured physical activity on glycaemic control and metabolic parameters in patients with T2DM.

Methods

This pilot, practice-based observational study applied a within-subject design, in which each participant served as their own control. A total of 130 patients initiated the intervention, and 10 participants who completed the full protocol were included in the final analysis. The intervention consisted of daily supplementation with propolis (15 drops) and bee bread (10 g), a structured yoga programme (three sessions per week), and a progressive dietary intervention including time-restricted feeding over a three-month period. Primary outcome measures included fasting blood glucose (FBG), glycated haemoglobin (HbA1c), and liver function parameters (SGPT and SGOT).

Results

Significant improvements were observed in glycaemic and metabolic parameters. Mean fasting blood glucose decreased from 234.1 ± 71.5 mg/dL to 110.0 ± 23.7 mg/dL ($p = .001$), while HbA1c levels decreased from $9.5 \pm 2.1\%$ to $5.8 \pm 0.6\%$ ($p = .001$). Liver function parameters also improved, with reductions in SGPT and SGOT levels. Postprandial physical activity was associated with additional reductions in blood glucose levels. HPLC-DAD analysis of propolis identified bioactive compounds including caffeic acid phenethyl ester (CAPE) and chlorogenic acid.

Conclusion

The findings suggest that a combined intervention including bee-derived products, dietary modification, and structured physical activity may be associated with substantial improvements in metabolic parameters in patients with T2DM. These results support the potential relevance of integrative, multimodal approaches in real-world clinical settings. Further studies with larger sample sizes and optimised intervention protocols are required to confirm these findings.

Keywords: Type 2 diabetes mellitus; propolis; bee bread; dietary intervention; yoga; glycaemic control

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INTRODUCTION

The global prevalence of Type 2 Diabetes Mellitus (T2DM) has increased markedly over recent decades and is expected to continue rising. According to the International Diabetes Federation, the number of adults aged 20–79 years living with diabetes is projected to increase from 537 million in 2021 to approximately 783 million by 2045, corresponding to an increase from around 10% to over 12% of the global adult population (Sun et al., 2022).

Regional trends further highlight the growing burden of the disease. In Europe, the number of individuals affected by diabetes is expected to rise from 61.4 million in 2021 to 69.0 million by 2045, while in North America and the Caribbean, cases are projected to increase from 51.7 million to 63.0 million. Substantial increases are also anticipated in Central and South America (32.5 million to 48.9 million), the Middle East and North Africa (73.0 million to 135.7 million), South-East Asia (90.2 million to 152.8 million), and the Western Pacific region (206.0 million to 260.2 million). Africa is expected to experience one of the most pronounced relative increases, rising from 24.0 million to 55.0 million (Sun et al., 2022).

These trends demonstrate that diabetes represents a rapidly escalating global public health challenge. The increase is closely linked to lifestyle-related factors, particularly the rising prevalence of overweight and obesity. According to the World Health Organization (WHO, 2021), approximately 39% of adults worldwide are overweight, while a further 13% are classified as obese. Epidemiological evidence indicates that approximately 70–90% of individuals with Type 2 Diabetes Mellitus are overweight or obese, underscoring the central role of excess body weight in the development and progression of the disease (Colberg et al., 2010; Meigs, 2010; Ginter & Simko, 2012; Jaacks et al., 2016; Kahn et al., 2014).

From a clinical and epidemiological perspective, T2DM is increasingly recognised not merely as a disorder of glycaemic control, but as a complex metabolic condition involving multiple organ systems. It is characterised by insulin resistance, progressive β -cell dysfunction, and a close relationship with hepatic metabolism (Petersmann et al., 2019). This evolving understanding supports the need for comprehensive therapeutic strategies that extend beyond glycaemic control and target the broader metabolic context of the disease.

Although diabetes is widely studied at the population level, data on specific professional subgroups remain limited. In a cross-sectional study of 138 healthcare workers, diabetes mellitus was reported in 6% of physicians and 8% of nurses, while substantially higher rates of obesity were observed in both groups (47% and 48%, respectively), suggesting the presence of metabolic risk factors even within healthcare populations (Shah, 2023).

The intervention protocol was designed as a multimodal therapeutic approach integrating several lifestyle and nutritional components previously associated with beneficial metabolic effects in patients with Type 2 Diabetes Mellitus.

The aim of the present study was to evaluate the effects of a combined intervention consisting of bee-derived products (propolis and bee bread), dietary modification, and structured physical activity on glycaemic control and metabolic parameters in patients with Type 2 Diabetes Mellitus under real-world clinical conditions.

MATERIALS AND METHODS

This was a pilot, practice-based observational study with longitudinal evaluation of metabolic parameters under real-world clinical conditions. The study investigated the effects of bee-derived products in combination with lifestyle interventions on metabolic parameters in patients with Type 2 Diabetes Mellitus (T2DM). A high attrition rate was observed during the study.

Study Design and Participants

A total of 130 patients with Type 2 Diabetes Mellitus (T2DM) initiated the intervention. Participation and adherence to the prescribed dietary and lifestyle protocol were monitored throughout the three-month study period. Only participants who completed the full intervention and adhered to the protocol were included in the final analysis ($n = 10$). Participants who did not complete the intervention or did not meet adherence criteria were not included in the final analysis. A high attrition rate was observed during the study.

Participants were monitored over a period of three months, during which metabolic parameters were recorded and evaluated. Blood glucose levels were measured daily using a finger-prick method, both before and after meals, to assess short-term glycaemic responses.

Inclusion Criteria

Patients diagnosed with T2DM, aged 40–60 years, without major comorbidities, and willing to follow the prescribed dietary and lifestyle intervention.

Adherence

Adherence was defined as compliance with the prescribed dietary and postprandial physical activity protocol.

Standard Medical Treatment

Participants continued their standard medical treatment as prescribed by their physicians, and no modifications were introduced as part of the study protocol during the intervention period.

Ethical Considerations

This study represents a retrospective analysis of data collected during routine clinical practice. All participants provided informed consent for the use of their anonymised data. The study was conducted in accordance with the principles of the Declaration of Helsinki.

Materials

Propolis, a resinous substance collected by honeybees, is rich in phenolic compounds and has been associated with anti-inflammatory and metabolic regulatory properties. Bee bread, a fermented pollen product, contains a wide range of nutrients, including proteins, vitamins, and bioactive compounds that may support metabolic health. In addition to nutritional supplementation, a structured yoga programme and a controlled dietary regimen were implemented as part of the intervention.

Bee bread, a fermented pollen product, contains proteins, amino acids, vitamins, minerals, fatty acids, and phenolic compounds, and has been described as a functional food with potential nutritional and metabolic benefits (Mattila et al., 2012).

The propolis and bee bread samples were provided from the apiary of Honey Bee Science Center, Gagalphedi (N: 27° 46' 5" ; E: 85° 26' 56"), Nepal. The propolis samples collected from Gagalphedi at elevation of 1,950 m, Kathmandu, Nepal were surrounded by *Alnus nepalensis* (Utis) and *Pinus roxburghii* (Pine) trees.

The comparison of the botanical occurrence profile of CAPE with the local vegetation surrounding the apiary provides strong evidence that the investigated propolis can be classified as poplar-type propolis (Bankova et al., 2018).

The ethanolic extract of propolis was obtained by maceration using a 1:3 propolis-to-ethanol ratio (with 70 % of ethanol), with intermittent shaking during the 7 days extraction period, followed by filtration of the extract (López-Patiño et al., 2021).

Biochemical Analysis

Chemical analysis of raw propolis samples collected from Kathmandu was performed to determine their composition using high-performance liquid chromatography with diode-array detection (HPLC-DAD). The raw propolis was crushed into small pieces, accurately weighed, and extracted in 70% ethanol (60:100, w/v). The mixture was continuously shaken at room temperature for 72 hours and subsequently filtered using Whatman No. 4 filter paper.

The identification and quantification of chemical compounds in the propolis extracts were carried out using HPLC-DAD, following previously described methods (Pellati et al., 2011; 2013) with slight modifications. Chromatographic separation was performed on a C18 column (250 × 4.6 mm i.d.). The mobile phase consisted of (A) 0.1% formic acid in water and (B) acetonitrile.

Gradient elution was applied as follows: 0 min (10% B); 0–3 min (20% B); 3–10 min (30% B); 10–40 min (40% B); 40–50 min (60% B); 50–60 min (80% B); and 60–65 min (90% B). The flow rate was set at 1 mL/min, with a post-run time of 10 minutes. The column temperature was maintained at 30 °C, and the injection volume was 5 µL.

Detection was performed over a wavelength range of 190–450 nm. Gallic acid, caffeic acid, and quercetin were used as external standards, while salicylic acid served as the internal standard.



Figure 1. The Yoga sessions are based on five asanas. (Photo by Sarmila Moktan)

INTERVENTION PROTOCOL

Nutritional Supplementation

Participants received a daily oral dose of:

- 15 drops of propolis
- 10 g of bee bread

Supplementation was administered continuously for 12 weeks.

Physical Activity (Yoga Intervention)

Participants were instructed to engage in a structured yoga programme consisting of three sessions per week, with a duration of 30 minutes per session. The intervention was implemented throughout the study period and was designed to support metabolic regulation through moderate, regular physical activity (see figure 1.).

Dietary Intervention

Participants followed a structured dietary plan developed by Api and Natural Therapy. The intervention was progressive and included both a defined macronutrient composition and time-restricted feeding patterns.

The recommended diet consisted of approximately (see figure 2.):

- 50% vegetables
- 25% protein-rich foods (including meat, fish, and eggs)
- 25% complex carbohydrates (primarily rice)

Meal frequency was gradually reduced over the study period:

- Month 1: four meals per day (breakfast, lunch, snack, and dinner), all completed before 19:00
- Month 2: two meals per day (lunch and dinner), completed before 19:00
- Month 3: one meal per day (lunch)

This combined approach to dietary composition and meal timing was intended to support metabolic adaptation and glycaemic control.

Safety and Tolerability

The dietary intervention, including the reduction to one meal per day, was implemented under routine clinical supervision. Participants were monitored throughout the study period for tolerability.

Some participants reported transient symptoms of weakness during the initial adaptation phase (approximately 1–2 weeks), which resolved without further intervention. No severe adverse events were reported.

According to Ayurvedic dietary principles, reduced meal frequency is traditionally considered beneficial for metabolic balance. In addition, bee bread contains a range of vitamins, minerals, and bioactive compounds and may have contributed to maintaining nutritional status during the intervention.

Blood Glucose Measurement Protocol

Blood glucose levels were measured using a finger-prick method. During the first month, measurements were performed before meals and two hours after meals. During the second and third months, measurements were performed twice daily: before the first meal of the day and before going to bed.

Outcome Measures

The primary outcome measures included fasting blood glucose (FBS), glycated haemoglobin (HbA1c), and liver function parameters (SGPT and SGOT).

Additional Observations

Participants were also evaluated for the effects of postprandial physical activity: walking or squatting exercises after meals.

Control considerations

The study applied a within-subject design, in which each participant served as their own control. This approach is consistent with practice-based, real-world clinical research methodologies, particularly in the evaluation of complex, multimodal interventions where individual-level longitudinal changes are of primary interest (Körmendy-Rácz, 2025).

In this study, all interventions were implemented within routine clinical practice, and outcomes were assessed longitudinally within the same individuals. Given the chronic nature of Type 2 Diabetes Mellitus and the need for ongoing therapeutic management, the use of a traditional control group without access to potentially beneficial lifestyle components may present practical and ethical challenges in this context.

Therefore, a within-subject design was considered appropriate for the early-phase evaluation of this integrated, low-risk intervention, allowing for the assessment of real-world effectiveness while maintaining continuity of care.

Statistical Analysis

All results are expressed as mean \pm standard deviation (SD). Statistical analyses were performed using GraphPad Prism 5 (GraphPad Software, USA). A paired Student's t-test was used to compare fasting blood glucose, HbA1c, and liver function parameters before and after the three-month intervention. A p-value of < 0.05 was considered statistically significant.

RESULTS

The combined intervention including propolis, bee bread, yoga, and dietary modification was associated with significant improvements in multiple metabolic parameters in patients with Type 2 Diabetes Mellitus.

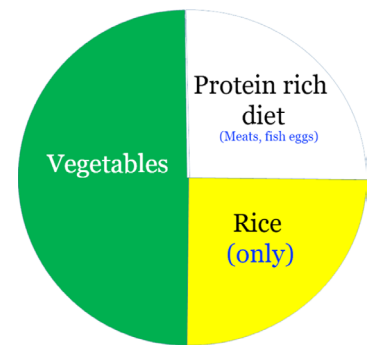


Figure 2. Api and Natural Therapy Diet Plan

Chemical Composition of Propolis

HPLC-DAD analysis of Kathmandu propolis identified several bioactive compounds, including *caffeic acid phenethyl ester (CAPE)* and *chlorogenic acid*.

Baseline Blood Glucose Distribution

Baseline blood glucose values showed considerable variability among participants, ranging from 150 mg/dL to 380 mg/dL, indicating heterogeneous glycaemic status at study entry.

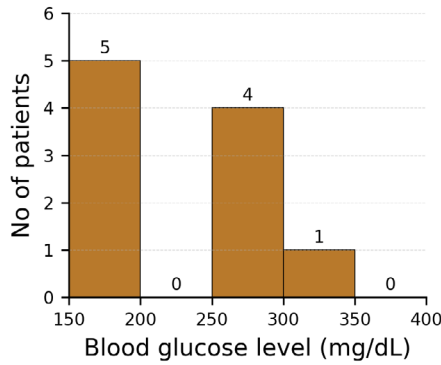


Figure 3. Distribution of baseline blood glucose values among patients with Type 2 Diabetes Mellitus.

Glycaemic Outcomes

Fasting blood glucose (FBG) levels decreased from 234.1 ± 71.5 mg/dL at baseline to 110.0 ± 23.7 mg/dL after the intervention. This reduction was statistically significant ($t(9) = 5.113, p = .001$). (see figure 4.)

Glycated haemoglobin (HbA1c) decreased from $9.5 \pm 2.1\%$ to $5.8 \pm 0.6\%$, representing a statistically significant improvement ($t(9) = 5.019, p = .001$). (see figure 5.)

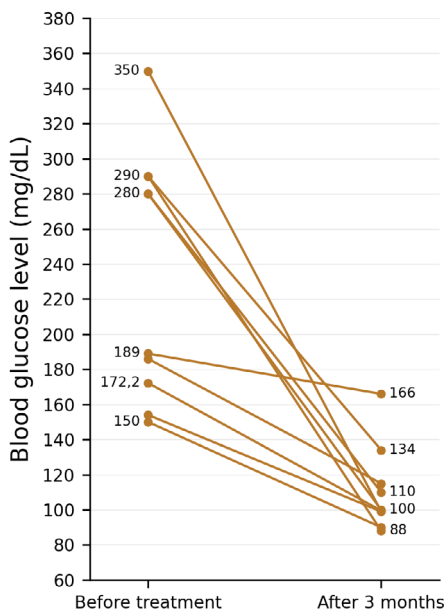


Figure 4. Fasting Blood Sugar before and after treatment

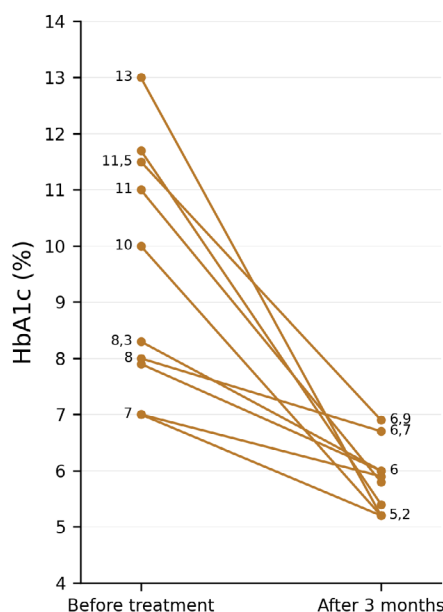


Figure 5. Glycated haemoglobin (HbA1c) before and after treatment

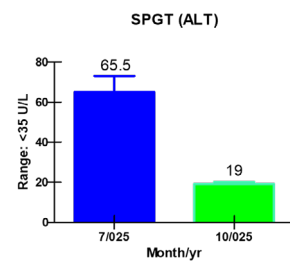


Figure 6. SGPT level before and after treatment

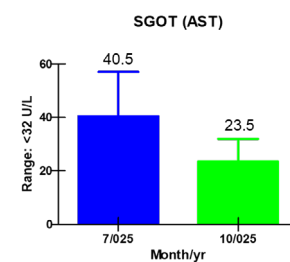


Figure 7. SGOT level before and after treatment

Liver Function Parameters

SGPT levels decreased from 65.5 ± 50 U/L to 19.0 ± 15 U/L ($p = .002$), (see figure 6.), while SGOT levels decreased from 40.5 ± 26 U/L to 23.5 ± 51 U/L ($p = .002$). (see figure 7.)

DISCUSSION

Overview of Findings

This pilot, practice-based observational study evaluated the effects of a combined intervention including bee-derived products, dietary modification, and physical activity in patients with long-standing Type 2 Diabetes Mellitus

(T2DM). The findings suggest that this integrated approach may be associated with improvements in glycaemic control and metabolic parameters under real-world clinical conditions.

Interpretation of Glycaemic Outcomes

The most prominent finding of the study was the significant reduction in fasting blood glucose (FBS) and HbA1c levels. The decrease in FBS from 234.1 mg/dL to 110.0 mg/dL, together with the reduction in HbA1c from 9.5% to 5.8%, indicates substantial improvement in both short-term and long-term glycaemic control.

Given the baseline variability in blood glucose values (150–380 mg/dL), the observed improvements suggest that the intervention may be effective across a heterogeneous patient population with differing levels of metabolic dysregulation.

Role of Propolis and Bee Bread

The identification of bioactive compounds in the propolis sample, including caffeic acid phenethyl ester (CAPE) and chlorogenic acid, provides a possible mechanistic explanation for the observed metabolic effects. Chlorogenic acid has been associated with regulation of glucose metabolism, reduction of hepatic glucose production, and modulation of gut microbiota.

These compounds have been associated with antioxidant activity (Sulaiman et al., 2011; Kuropatnicki et al., 2013; Diniz et al., 2020) and anti-inflammatory effects (Silva et al., 2012; Franchin et al., 2018), which may contribute to improved metabolic outcomes. Previous studies have also reported that propolis exhibits hypoglycaemic activity and may positively influence diabetic complications. It has been shown to modulate lipid metabolism, reduce lipid peroxidation, and scavenge free radicals (Matsui et al., 2004; Fuliang et al., 2005; Li et al., 2012).

Furthermore, propolis may influence glucose homeostasis through stimulation of insulin secretion or sensitivity and inhibition of intestinal α -glucosidase activity, thereby slowing carbohydrate digestion (Mujica et al., 2017; Wei et al., 2018), although these mechanisms were not directly assessed in the present study.

Bee bread, a functional food, may have contributed to the observed outcomes through its nutritional composition and enhanced bioavailability of nutrients resulting from fermentation. Its content of proteins, vitamins, and bioactive compounds may support overall metabolic function (Didaras et al., 2020). It is known that variations in flavonoid composition may be influenced by geographic origin, as reported in bee bread from Georgia (Tavdidishvili et al., 2014), Portugal (Sobral et al., 2017), and Romania (Dranca et al., 2020).

Contribution of Dietary and Lifestyle Interventions

The structured dietary intervention, including defined macronutrient composition and progressive changes in meal frequency, may have played a central role in the observed improvements. In particular, the reduction in meal frequency and the emphasis on vegetables and protein-rich foods may have contributed to improved insulin sensitivity and reduced glycaemic load.

Similarly, the incorporation of regular physical activity, including yoga and postprandial movement, is likely to have supported glucose utilisation and metabolic regulation (Yuniartika et al., 2021). A daily habit of yogic practice has been reported to reduce mental and oxidative stress and may be beneficial for glycaemic control (Hedge et al., 2011; Raveendran et al., 2018). Lifestyle interventions, including dietary modification and exercise, are widely recognised as first-line therapeutic strategies in T2DM management (Braga et al., 2019).

Hegde et al. (2011) reported that a 3-month Yoga intervention in addition to standard diabetes care resulted in significant reductions in HbA1c and fasting blood glucose levels. Furthermore, the review by Raveendran et al. (2018) summarised that Yoga-based interventions were associated with an average reduction in fasting blood glucose of approximately 23.7–25.7 mg/dL and HbA1c reductions of approximately 0.47%. In the present study, fasting blood glucose decreased from 234.1 ± 71.5 mg/dL to 110.0 ± 23.7 mg/dL, corresponding to a reduction of 124.1 mg/dL, while HbA1c levels decreased from $9.5 \pm 2.1\%$ to $5.8 \pm 0.6\%$, corresponding to a reduction of 3.7%. These findings may suggest that the addition of progressive meal-frequency reduction, bee-derived products, and postprandial physical activity could further enhance the metabolic effects previously described for Yoga-based interventions alone.

The dietary composition applied in the present study is consistent with nutritional approaches previously associated with improved metabolic outcomes in patients with Type 2 Diabetes Mellitus, particularly diets characterised by high vegetable intake, moderate protein content, and controlled carbohydrate consumption (Evert et al., 2019; Esposito et al., 2009).

Previous dietary intervention studies in patients with Type 2 Diabetes Mellitus have demonstrated that nutritional approaches characterised by high vegetable intake and controlled carbohydrate consumption are associated with HbA1c reductions of approximately 0.5–1.2% and improvements in fasting blood glucose levels (Esposito et al., 2009). Similarly, studies investigating reduced meal frequency and time-restricted eating have reported HbA1c reductions of approximately 1–2% together with significant improvements in fasting blood glucose and insulin sensitivity (Carter et al., 2018). In the present study, fasting blood glucose decreased from 234.1 ± 71.5 mg/dL to 110.0 ± 23.7 mg/dL, while HbA1c levels decreased from $9.5 \pm 2.1\%$ to $5.8 \pm 0.6\%$, corresponding to a reduction of 3.7%. These findings may suggest additive or synergistic metabolic effects resulting from the combined application of dietary modification, progressive meal-frequency reduction, Yoga, bee-derived products, and postprandial physical activity.

Postprandial Physical Activity

The observed reductions in blood glucose levels following walking (approximately 17%) and squatting (approximately 21%, data not shown) suggest that postprandial physical activity may have an immediate beneficial effect on glycaemic control. Although these findings are exploratory, they are consistent with previous observations that even moderate physical activity after meals can improve glucose metabolism (Colberg, 2012; Najafipour et al., 2017).

Liver Function and Metabolic Implications

The improvements observed in liver function parameters (SGPT and SGOT) suggest that the intervention may have broader metabolic effects beyond glycaemic control. The observed improvements in liver function parameters are consistent with the known role of hepatic metabolism in T2DM.

The hepatoprotective effects of propolis have been demonstrated in various experimental studies (Paulino et al., 2014; Wali, 2015; Omar et al., 2016). In addition, a clinical study reported that supplementation with Brazilian green propolis (830 mg/day) in elderly individuals living at high altitude was associated with reductions in liver enzyme levels over a two-year period (Zhu et al., 2018).

The magnitude of HbA_{1c} reduction observed in the present study may reflect the combined metabolic effects of several intervention components that have individually been associated with improved glycaemic control in previous studies, including Yoga-based interventions, Mediterranean-style dietary modification, and reduced meal-frequency or intermittent fasting protocols. Since these interventions likely act through partially overlapping metabolic pathways, their effects cannot be assumed to be directly additive. Nevertheless, the observed 3.7% reduction in HbA_{1c} is consistent with the possibility of additive or synergistic effects resulting from the multimodal intervention strategy.

Study Design Considerations

This study was conducted using a within-subject design, where each participant served as their own control under real-world clinical conditions. Such an approach is particularly relevant in the evaluation of complex, multimodal interventions, where isolating individual components may not fully reflect routine clinical practice.

Limitations

The intervention included multiple components, including Yoga, dietary modification, reduced meal frequency, bee-derived products, and postprandial physical activity. Several of these intervention elements have previously been associated with improvements in glycaemic control in patients with Type 2 Diabetes Mellitus. However, due to the multimodal nature of the present intervention, the relative contribution and interaction of the individual components (including postprandial physical activity) could not be determined within the current study design.

Future Directions

Further studies with larger sample sizes, extended follow-up periods, and optimised intervention protocols are required to confirm these findings. In particular, future research should aim to develop more feasible and sustainable intervention strategies in order to improve adherence and reduce attrition.

Future investigations may also focus on refining the implementation of combined lifestyle and nutritional interventions in real-world clinical settings.

CONCLUSION

The findings of this pilot, practice-based study suggest that a combined intervention including bee-derived products (propolis and bee bread), dietary modification, and structured physical activity may be associated with substantial improvements in metabolic parameters in patients with Type 2 Diabetes Mellitus. Significant reductions were observed in fasting blood glucose, HbA_{1c}, and liver function markers over the course of the intervention.

These results highlight the potential relevance of integrated, multimodal approaches in the management of T2DM under real-world clinical conditions. The observed improvements within individuals support the applicability of within-subject evaluation frameworks in early-phase studies of complex, low-risk interventions.

The high level of attrition observed in this study underscores the importance of developing more feasible and sustainable intervention protocols in future research. Further studies with larger sample sizes and extended follow-up are required to confirm these findings and to optimise the implementation of such combined therapeutic strategies.

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