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INVESTIGATION OF THE EFFECTS OF MEDICINAL PLANTS ON IMMUNE SYSTEM PARAMETERS AND INFLAMMATORY BIOMARKERS IN PATIENTS WITH CONCOMITANT TUBERCULOSIS AND DIABETES MELLITUS

Abstract. This study investigates the effects of medicinal plants on immune system parameters and inflammatory biomarkers in patients with concomitant tuberculosis (TB) and diabetes mellitus (DM). A comparative analysis was conducted between patients receiving standard therapy and those receiving additional phytotherapy. Immunological indicators ($CD4^+$, $CD8^+$ T lymphocytes, NK cells) and inflammatory biomarkers (IL-6, TNF-α, CRP) were assessed before and after treatment. The results demonstrated that medicinal plant–based therapy significantly enhanced immune responses, reduced systemic inflammation, and improved clinical outcomes without serious adverse effects. These findings support the integration of phytotherapy as an adjunctive approach in the comprehensive management of TB–DM comorbidity.

Keywords: tuberculosis, diabetes mellitus, medicinal plants, immune response, inflammatory biomarkers, phytotherapy.

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ИССЛЕДОВАНИЕ ВЛИЯНИЯ ЛЕКАРСТВЕННЫХ РАСТЕНИЙ НА ПАРАМЕТРЫ ИММУННОЙ СИСТЕМЫ И ВОСПАЛИТЕЛЬНЫЕ БИОМАРКЕРЫ У ПАЦИЕНТОВ С СОЧЕТАННЫМ ТУБЕРКУЛЁЗОМ И САХАРНЫМ ДИАБЕТОМ

Аннотация. В данном исследовании изучено влияние лекарственных растений на параметры иммунной системы и воспалительные биомаркеры у пациентов с сочетанным течением туберкулёза (ТБ) и сахарного диабета (СД). Проведён сравнительный анализ между пациентами, получавшими стандартную терапию, и пациентами, у которых стандартное лечение было дополнено фитотерапией. Иммунологические показатели ($CD4^+$, $CD8^+$ Т-лимфоциты, NK-клетки) и воспалительные биомаркеры (IL-6, TNF-α, CRP) оценивались до и после лечения. Результаты показали, что терапия на основе лекарственных растений достоверно усиливает иммунный ответ, снижает уровень системного воспаления и улучшает клинические исходы без развития серьёзных побочных эффектов. Полученные данные подтверждают целесообразность включения фитотерапии в качестве вспомогательного метода в комплексное лечение пациентов с сочетанием туберкулёза и сахарного диабета.

Ключевые слова: туберкулёз, сахарный диабет, лекарственные растения, иммунный ответ, воспалительные биомаркеры, фитотерапия.

Relevance of the Study. The coexistence of tuberculosis and diabetes mellitus represents one of the most pressing challenges in modern clinical medicine and global public health. Diabetes mellitus is recognized as a major risk factor for the development, progression, and poor prognosis of tuberculosis. Patients with diabetes have a threefold higher risk of developing active TB compared to non-diabetic individuals, primarily due to chronic hyperglycemia-induced immune dysfunction.

From an immunological perspective, diabetes mellitus is associated with impaired cellular immunity, including reduced macrophage activity, decreased $CD4^+$ T-cell proliferation, altered cytokine production, and diminished natural killer (NK) cell function. These alterations compromise the host's ability to control *Mycobacterium tuberculosis*, leading to more severe disease forms, delayed sputum conversion, higher relapse rates, and increased mortality.

In addition, TB–DM comorbidity is characterized by persistent low-grade systemic inflammation. Elevated levels of pro-inflammatory cytokines such as interleukin-6 (IL-6), tumor necrosis factor-alpha (TNF-α), and C-reactive protein (CRP) contribute to tissue damage, insulin resistance, and poor treatment outcomes. Conventional antituberculosis therapy, while effective against the pathogen, does not adequately address immune dysregulation and chronic inflammation, and prolonged drug use may lead to hepatotoxicity, nephrotoxicity, and metabolic complications.

Medicinal plants have been widely used in traditional medicine for centuries due to their immunomodulatory, anti-inflammatory, antioxidant, and metabolic regulatory properties. Recent experimental and clinical studies suggest that bioactive compounds derived from medicinal plants can enhance cellular immunity, suppress excessive inflammatory responses, and improve metabolic balance with minimal adverse effects.

Aim of the Study. To evaluate the effects of medicinal plants on immune system parameters and inflammatory biomarkers in patients with concomitant tuberculosis and diabetes mellitus.

Materials and methods. A total of 60 patients diagnosed with active pulmonary tuberculosis and type 2 diabetes mellitus were enrolled in the study. Participants were divided into two groups:

- Control group (n = 30): received standard antituberculosis therapy combined with antidiabetic treatment.

- Intervention group (n = 30): received standard therapy plus medicinal plant-based phytotherapy.

Immunological parameters ($CD4^+$, $CD8^+$ T lymphocytes, NK cells) were measured using flow cytometry. Inflammatory biomarkers (IL-6, TNF-α, CRP) were assessed by enzyme-linked immunosorbent assay (ELISA). Clinical and laboratory evaluations were performed at baseline and after 3 months of treatment.

Results. After 3 months of treatment, significant improvements in immune system parameters were observed in the intervention group compared to the control group. The mean $CD4^+$ T-cell count increased from **412.3 ± 48.6 cells/μL** to **545.7 ± 52.1 cells/μL** in the phytotherapy group, representing a **32.3% increase** ($p < 0.001$; 95% CI: 118.6–148.2). In contrast, the control group showed a modest increase from **418.9 ± 50.2 cells/μL** to **465.4 ± 49.7 cells/μL** (**11.1% increase**, $p = 0.041$; 95% CI: 12.4–80.6).

Inflammatory Biomarkers. A significant reduction in inflammatory biomarkers was observed in both groups; however, the magnitude of reduction was substantially greater in the intervention group.

Serum IL-6 levels decreased from 14.8 ± 3.2 pg/mL to 8.1 ± 2.4 pg/mL in the phytotherapy group (45.3% reduction, $p < 0.001$; 95% CI: −8.4 to −5.2), while the control group showed a reduction of only 18.6% ($p = 0.034$).

TNF-α levels declined by 37.9% in the intervention group (from 22.6 ± 4.1 pg/mL to 14.0 ± 3.5 pg/mL, $p < 0.001$; 95% CI: −11.1 to −6.3), compared to a 16.4% reduction in the control group ($p = 0.048$).

CRP concentrations showed the most prominent change, decreasing from 12.4 ± 3.6 mg/L to 6.5 ± 2.1 mg/L (47.6% reduction, $p < 0.001$; 95% CI: −7.4 to −4.2). In contrast, the control group experienced a 19.8% reduction ($p = 0.039$).

Clinical and Metabolic Outcomes

Patients in the intervention group showed improved glycemic stability, with a mean reduction in fasting blood glucose of 1.8 ± 0.6 mmol/L ($p < 0.01$) and

a downward trend in HbA1c levels (mean decrease: 0.9 ± 0.3%, $p < 0.01$). The control group exhibited smaller, statistically borderline changes ($p = 0.062$).

Clinically, symptom resolution—including fatigue, cough severity, and appetite loss—occurred earlier in the phytotherapy group. Additionally, the frequency of mild adverse drug reactions was lower among these patients, and no serious adverse events related to medicinal plant use were reported.

Inflammatory Biomarkers

A pronounced reduction in systemic inflammation was observed among patients receiving medicinal plants. IL-6 levels decreased by 40–45%, TNF-α by 35–38%, and CRP by 45–50% compared to baseline values. These reductions were significantly greater than those observed in the control group, where biomarker levels declined by only 15–20%.

The marked decrease in pro-inflammatory cytokines suggests that phytotherapy effectively suppresses excessive inflammatory responses without compromising protective immunity. This balance is particularly important in TB–DM patients, where chronic inflammation exacerbates insulin resistance and tissue damage.

Conclusion. Medicinal plant–based phytotherapy significantly improves immune system parameters, reduces inflammatory biomarkers, and enhances clinical outcomes in patients with concomitant tuberculosis and diabetes mellitus. The findings support the inclusion of medicinal plants as a safe and effective adjunct to standard therapy, contributing to immune restoration, inflammation control, and improved treatment tolerance.

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