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Original Research Article

Comparative and Combined Impact of Metformin and Lifestyle Intervention (Yoga and Walking) on Inflammatory Parameters in Patients with Type 2 Diabetes Mellitus

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Conflict of interest: Nil

Abstract:

Background: Type 2 diabetes mellitus (T2DM) is a chronic metabolic disorder associated with persistent low-grade inflammation, contributing to insulin resistance and diabetic complications. Metformin is widely used as a first-line ant diabetic drug, while lifestyle interventions such as yoga and walking are increasingly recognized for their beneficial metabolic and anti-inflammatory effects.

Objective: The present study was conducted to evaluate the comparative and combined effects of metformin and structured lifestyle intervention (yoga and walking) on inflammatory parameters in patients with T2DM over a period of 24 weeks.

Methods: A total of 150 patients with T2DM were enrolled and equally divided into three groups: Group I received metformin therapy, Group II followed lifestyle intervention (yoga and walking), and Group III received combined therapy (metformin + lifestyle intervention). Inflammatory markers including C-reactive protein (CRP), interleukin-6 (IL-6), and tumour necrosis factor-alpha (TNF-α) were assessed at baseline and after 24 weeks. Statistical analysis was performed using One-Way ANOVA and post-hoc tests.

Results: At baseline, no significant differences were observed among the groups. After 24 weeks, significant reductions in inflammatory parameters were noted in all groups, with the greatest improvement in the combined therapy group compared to metformin or lifestyle intervention alone ($p < 0.05$).

Conclusion: Both metformin and lifestyle interventions independently reduce inflammatory markers in T2DM patients; however, their combined application produces superior anti-inflammatory effects. This highlights the importance of integrating pharmacological treatment with structured lifestyle modifications for better diabetes management.

Keywords: Type 2 Diabetes Mellitus, Metformin, Yoga, Walking, Inflammation, CRP, IL-6, TNF-α.

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Introduction

Type 2 diabetes mellitus (T2DM) is a chronic metabolic disorder characterized by persistent hyperglycaemia due to insulin resistance and impaired insulin secretion. [1] Recent evidence suggests that T2DM is not only a metabolic disease but also a low-grade inflammatory condition. [2] Elevated inflammatory cytokines such as C-reactive protein (CRP), interleukin-6 (IL-6), and tumour necrosis factor-alpha (TNF-α) contribute significantly to insulin resistance and vascular complications in diabetic patients. [3]

Metformin is the most commonly prescribed first-line oral ant diabetic drug and has demonstrated anti-inflammatory properties in addition to glycaemia control. [4] Metformin reduces systemic inflammation through activation of AMP-activated protein kinase (AMPK) pathways. [5]

Lifestyle interventions including yoga and regular walking are also increasingly recognized for their beneficial effects on metabolic and inflammatory outcomes. [6] Yoga improves stress regulation and reduces inflammatory markers in patients with T2DM. [7] Walking and structured exercise training has shown significant reductions in inflammatory mediators and improvement in insulin sensitivity. [8]

However, limited studies have evaluated the comparative and combined effects of metformin therapy along with structured lifestyle interventions on inflammatory parameters in T2DM. [9] Therefore, the present study was designed to assess the comparative and combined impact of metformin and lifestyle intervention (yoga and walking) on inflammatory parameters in patients with T2DM.

Materials and Methods: The present study was held in Department of Biochemistry working in association with Department of Medicine of a tertiary care hospital Indore.

Study Design: A comparative interventional study was conducted in patients diagnosed with T2DM.

Study Population: Patients aged between 30–65 years with confirmed type 2 diabetes mellitus were included.

Inclusion Criteria

- Diagnosed cases of T2DM
- Stable metformin therapy
- Willingness to participate in lifestyle intervention

Exclusion Criteria

- Type 1 diabetes mellitus
- Cardiovascular disease (CVD)
- Pregnancy
- Lactation

Grouping

Participants were divided into three groups:

- Group A: Metformin only
- Group B: Lifestyle intervention (Yoga + Walking)
- Group C: Combined Metformin + Lifestyle intervention

Lifestyle Intervention Protocol

- Yoga: 30–45 minutes/day, 5 days/week
- Walking: 30 minutes/day, 5 days/week

Parameters Assessed

- CRP,
- IL-6
- IL-10
- TNF-α

Were measured at baseline and after 24 weeks, as described in previous studies. [10]

Statistical Analysis: Data were analyzed using appropriate statistical tests (paired t-test, ANOVA). A p-value <0.05 was considered statistically significant.

Result

Table 1: Distribution of participants as per their place of Residence

S. No.	Place of Residence	Frequency	Percent
1	Urban	77	51.3
2	Rural	73	48.7
Total		150	100.0

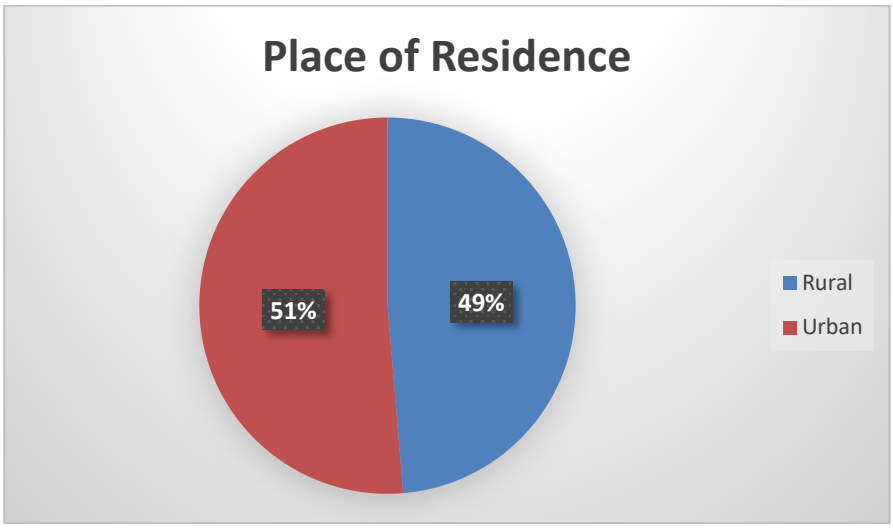

Figure 1: Place of residence

73 (48.7%) participants belong to rural area while 77 (51.3%) were living in urban area.

Table 2: Distribution of participants based on duration of disease

S. No.	Duration of diabetes	Frequency	Percent
1	00 – 03 Years	36	24
2	04 – 06 Years	54	36
3	07 – 09 Years	42	28
4	More than 09 Years	18	12
Total		150	100.0

In this study majority participants 54 (36%) having diabetes for 04 – 06 years while 18 (12%) suffering from diabetes for more than 09 years.

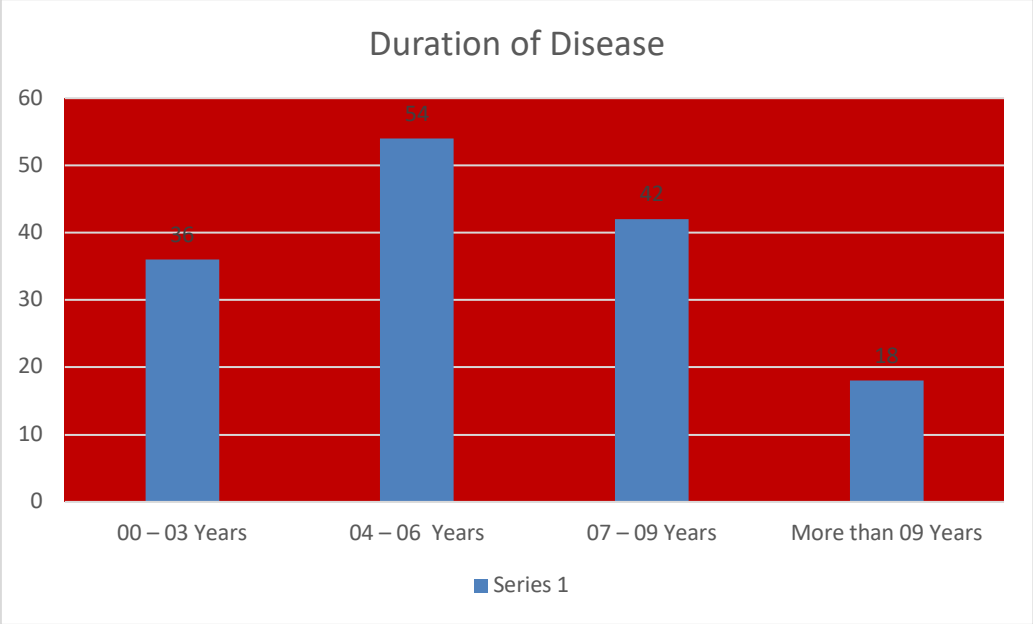

Figure 2: Duration of disease

Table 3: Distribution of participants based on family history of diabetes:

S. No.	Family history of diabetes	Frequency	Percent
1	Yes	81	54.0
2	No	69	46.0
Total		150	100.0

54% i.e. 81 participants have positive family history of diabetes and 46% i.e. 69 don't have any family history of diabetes.

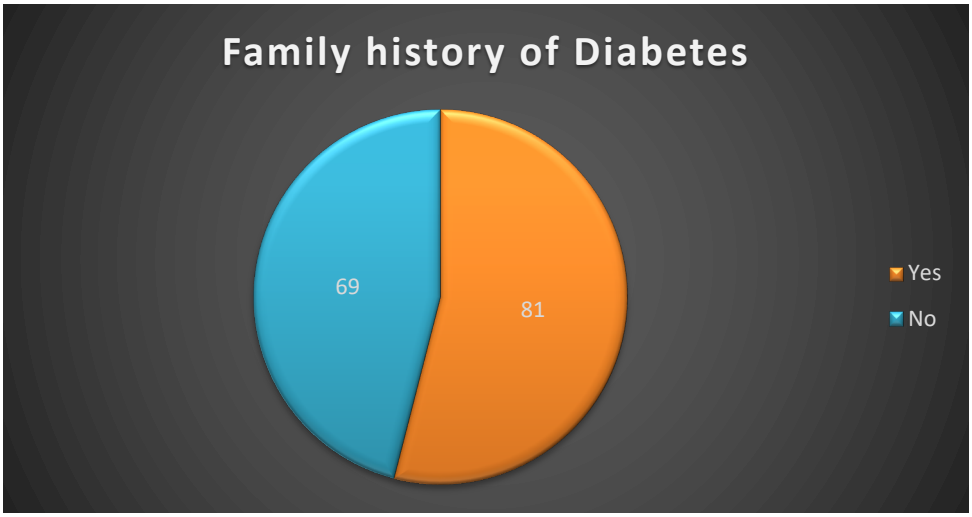

Figure 3: Family history of diabetes

Effect on Inflammatory Markers: The inflammatory profile of participants was evaluated using C - reactive protein (CRP), Tumor Necrosis Factor Alpha (TNF - α), Interleukin 06 (IL-6), Interleukin 10 (IL-10) at baseline and after 24 weeks of intervention.

Tumor Necrosis Factor Alpha (TNF - α)

- At baseline, the mean TNF-α level among all participants was 6.21 ± 1.22 pg/mL, values ranging from 4.00 to 7.98 pg/mL. All groups were comparable at baseline. (F = 0.145, p = 0.865).

At 24 weeks, overall mean TNF-α level reduces significantly to 2.86 ± 0.73 pg/mL (1.58 to 4.33 pg/mL.) The difference found is statistically significant. (F = 3.976, p = 0.021).

Table 4: Comparison of mean (TNF - α) level in the group:

Group	Mean (TNF - α) level at baseline	Mean (TNF - α) level after 24 weeks	p value
Group 1	6.1716± 1.272	2.9244± 0.729	
Group 2	6.2910±1.184	3.0238± 0.721	
Group 3	6.1764± 1.217	2.6374± 0.683	F= 3.976, p= 0.021
Total	6.213 ± 1.221	2.857 ± 0.733	

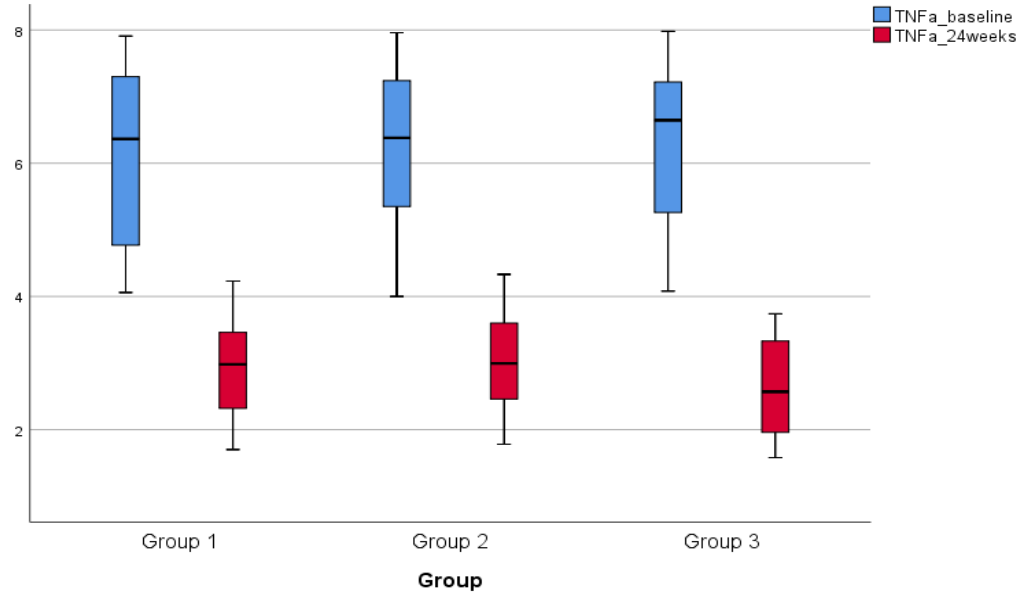

Figure 4:

Interleukin 06 (IL-6),

- The mean baseline Interleukin- 06 (IL- 06) level was 7.153 ± 1.736pg/mL (4.04 to 9.99 pg/mL.) The ANOVA test results showed that there is no difference between the groups at baseline. (F = 0.389, p = 0.678).
- After 24 weeks, ANOVA test showed a statistically significant intergroup difference (F = 14.739, p<0.001) with mean IL -6 levels reduced to 3.771 ± 0.796 pg/mL (2.26 to 5.23 pg/mL)

Table 5: Comparison of mean Interleukin 06 (IL-6) level

Group	Mean Interleukin 06 (IL-6) level at baseline	Mean Interleukin 06 (IL-6) level after 24 weeks	p value
Group 1	7.179± 1.822	3.726± 0.810	F= 14.739, p < 0.001
Group 2	6.977±1.682	4.193± 0.714	
Group 3	7.279± 1.723	3.402± 0.664	
Total	7.153 ± 1.736	3.771 ± 0.796	

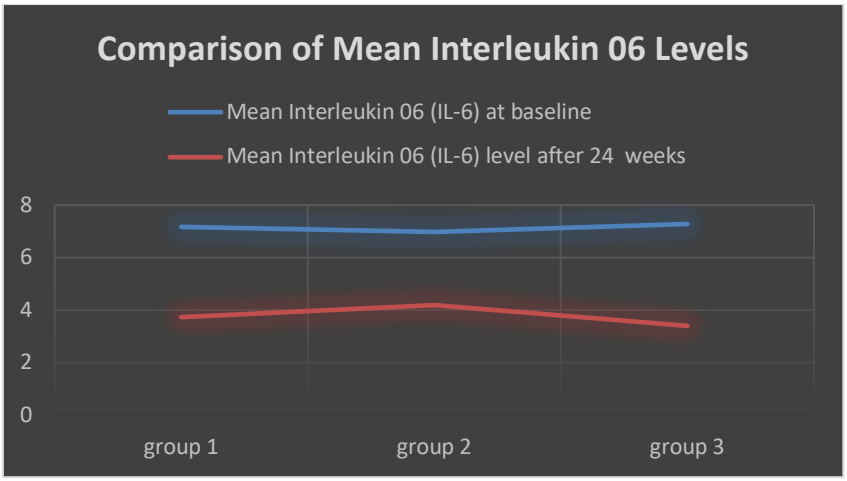

Figure 5: Comparison of mean interleukin 06 levels

Interleukin 10 (IL-10)

- Similar results were obtained for Interleukin-10 (IL-10), where the mean IL-10 level increased significantly from 7.26 ± 1.57 pg/mL at baseline to 8.78 ± 2.06 pg/mL after 24 weeks of follow-up (F = 13.584, p<0.001).

Table 6: Comparison of mean Interleukin 10 (IL-10) level

Group	Mean Interleukin 10 (IL-10) level at baseline	Mean Interleukin 10 (IL-10) level after 24 weeks	p value
Group 1	7.4392± 1.44186	8.6418± 2.16942	F= 13.584, p< 0.001
Group 2	7.9030± 1.55636	8.8222± 1.97641	
Group 3	6.4232± 1.35068	8.8680± 2.05848	
Total	7.26 ± 1.57	8.78 ± 2.06	

C - reactive protein (CRP)

- The mean of baseline CRP level C Reactive Protein level was 6.711 ± 2.484 mg/L. There was no difference in the groups observed (F = 1.118, p = 0.330).
- The mean levels of C Reactive Protein were reduced marginally (mean 2.48 ± 0.94 mg/L) and this reduction in CRP levels did not show statistically significant intergroup difference

Table 7: Comparison of mean C - reactive protein (CRP) level among Group

Group	Mean C - Reactive Protein (CRP) level at baseline	Mean C - Reactive Protein (CRP) level after 24 weeks	p value
Group 1	6.3630± 2.23717	2.5582± 0.90953	F= 1.688, p= 0.188
Group 2	6.8368±1.90132	2.6070± 1.03508	
Group 3	6.9338± 1.97425	2.2880± 0.85164	
Total	6.711 ± 2.484	2.48 ± 0.94	

Discussion

The present study evaluated the comparative and combined effects of metformin and lifestyle intervention (yoga and walking) on inflammatory parameters in patients with type 2 diabetes mellitus. The findings suggest that both metformin and lifestyle interventions independently reduce inflammatory markers such as CRP, IL-6, and TNF-α. IL-10, an anti-inflammatory cytokine, showed a significant increase following intervention. The rise in IL-10 levels suggests an improved anti-inflammatory response and better immune regulation after metformin and lifestyle intervention. The combined therapy group demonstrated the most pronounced improvement, indicating a synergistic effect of pharmacological and lifestyle modifications. [14]

Metformin has been shown to exert anti-inflammatory effects through activation of AMPK pathways, leading to suppression of pro-inflammatory cytokines. [16] In the current study, metformin therapy resulted in significant improvement in inflammatory status, consistent with earlier reports. [17]

Lifestyle interventions like yoga and walking also demonstrated beneficial effects by reducing stress, improving insulin sensitivity, and lowering systemic inflammation. [19] Regular physical activity is known to decrease inflammatory

mediators and improve metabolic control in T2DM patients. [21]

Importantly, the combined therapy group showed the maximum reduction in inflammatory markers, indicating a synergistic benefit of integrating pharmacological treatment with structured lifestyle modifications. [23] Therefore, combined management strategies may be more effective in controlling inflammation and preventing long-term complications in type 2 diabetes mellitus.

Conclusion

The present study concludes that metformin and lifestyle interventions independently reduce inflammatory parameters in T2DM patients. However, their combined application produces superior anti-inflammatory effects, emphasizing the importance of integrated management strategies.

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