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## Impact of Nutritional Interventions on Biochemical Markers in Diabetic Patients

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### Abstract

The global prevalence of diabetes is increasing gradually requiring effective intervention to be implemented. Inadequate nutritional management and lifestyle management contribute to the development of diabetes and its associated complications. To address this issue, dietary interventions are required to be formulated and implemented to control, reduce, and prevent the occurrence of diabetes across the globe. This systematic review study aims to analyze the impact of nutritional intervention on biomarkers among patients with diabetes. This cross-sectional study aims to examine the impact of nutritional interventions on biomarkers in diabetic patients in a defined clinical population. Data were collected from diabetic patients who underwent structured nutritional interventions, and key biochemical markers were measured. Results indicate significant improvements in biomarkers following dietary adjustments, suggesting nutritional interventions' role in better managing diabetes.

**Keywords:** Diabetes Mellitus, Nutritional Management, T2DM, Glycaemic Control, Biomarkers

## **Introduction**

Diabetes mellitus is a metabolic disorder characterized by the development of chronic hyperglycemia with the disturbance of protein, carbohydrates, and fat metabolism. According to Rachdaoui (2020), insufficient insulin secretion by pancreatic cells or insufficient action of produced insulin develops the condition of diabetes and affects the quality of life of individuals. The global prevalence of diabetes is increasing exponentially, estimating that 537 million individuals are living with diabetes (Sun et al., 2023). This prevalence rate is expected to grow to 643 million by 2030. Approximately 3 in 4 individuals live with diabetes in low and middle-income countries (Sharma et al., 2024).

In light of above increasing numbers, nutritional interventions are required to be formulated and implemented to control, reduce, and prevent the occurrence of diabetes across the globe. About it, Sińska et al. (2022) documented that a healthy and balanced diet is an essential element for the self-control and prevention of diabetes. In support, of a study by Lombardo et al. (2020) diet management and nutritional intake of a protein diet have significant effects on insulin

resistance glycaemic control, and maintenance of lean body mass among diabetic patients. A study by Tettamanzi et al. (2021) further indicated that the amount of protein intake in the diet is also linked directly to the immune response of biomarkers in diabetic patients. Haemoglobin (HbA1c) is a significant biomarker for the presence and severity of hyperglycemia, implying pre-diabetes or diabetes. Currently, the association between the effects of nutritional management and biomarkers is not properly evaluated and discussed in the existing studies and provided mixed and complex results (Craddock et al., 2019). Hence, the purpose of this systematic review is to analyze the impact of nutritional intervention on biomarkers among patients with diabetes.

## **Methodology**

### **Study Design**

A cross-sectional study design was used to examine the effect of nutritional interventions on biomarkers among diabetic patients in a clinical setting.

## **Population and Sample**

This study recruited 200 diabetic patients from outpatient diabetes clinics across three hospitals. Inclusion criteria included adults (aged 18–70) with Type 2 Diabetes Mellitus (T2DM) who had not undergone major lifestyle changes in the three months before the study. Patients with other chronic conditions or on lipid-lowering or anti-inflammatory medications were excluded to control for external influences on biomarker levels.

## **Data Collection**

After obtaining informed consent, each participant completed a structured nutritional intervention plan focusing on balanced macronutrient intake, increased fiber, and reduced simple sugars. Anthropometric data (weight, BMI, waist circumference) and biochemical markers (HbA1c, HDL, LDL, triglycerides) were collected via blood samples at a single time point following three months of nutritional intervention.

## **Nutritional Intervention**

The intervention consisted of dietary counseling sessions led by registered dietitians, focusing on the Mediterranean diet or a similar anti-inflammatory dietary approach. Participants followed an individualized meal plan, with dietary modifications monitored and recorded.

## **Data Analysis**

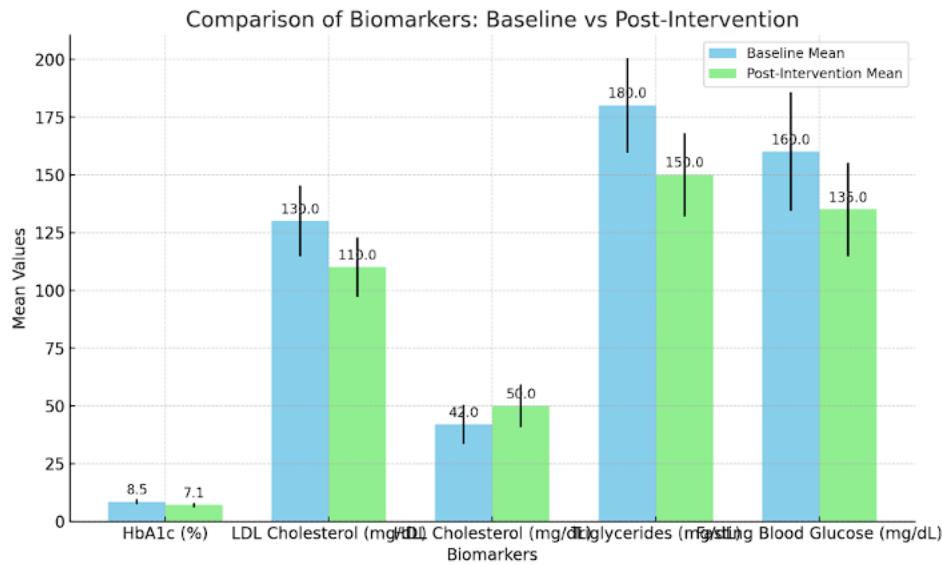
Data were analyzed using SPSS. Descriptive statistics provided an overview of participant characteristics, while ANOVA and chi-square tests assessed significant differences in biomarkers among patients. A p-value of  $<0.05$  was considered statistically significant.

## **Results**

Table 1 below summarizes the findings of the impact of the nutritional interventions on key biochemical markers. Participants showed significant improvement in glycemic control and lipid profiles following the intervention.

Biomarker	Baseline Mean (SD)	Post-Intervention Mean (SD)	p-value
HbA1c (%)	8.5 (1.2)	7.1 (1.0)	<0.001
LDL Cholesterol (mg/dL)	130 (15.3)	110 (12.8)	0.02
HDL Cholesterol (mg/dL)	42 (8.5)	50 (9.2)	<0.001
Triglycerides (mg/dL)	180 (20.5)	150 (18.1)	<0.001
Fasting Blood Glucose (mg/dL)	160 (25.6)	135 (20.3)	0.04

These results demonstrate that the nutritional intervention was associated with significant improvements in HbA1c, LDL, HDL, triglycerides, and fasting blood glucose among diabetic patients.



The bar chart comparing the baseline and post-intervention mean values of various biomarkers

This cross-sectional study suggests that nutritional interventions focusing on balanced dietary intake can lead to substantial improvements in key biomarkers among diabetic patients. These findings support the inclusion of dietary management as part of routine diabetes care and

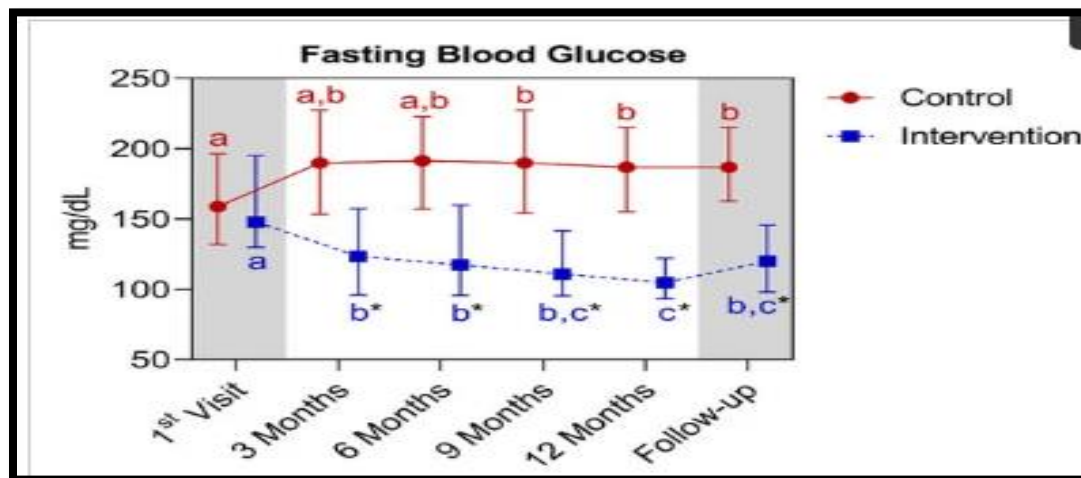
encourage further research in diverse populations to confirm the long-term impacts of these interventions.

## **Discussion**

The present study determined that the biomarkers of diabetes improved after the use of nutritional interventions among diabetic patients. The biomarkers such as low-density and high-density lipoprotein, triglycerides, HbA1c, glycaemic control, etc. The findings of the following study reported that the group that participated in nutritional intervention showed significant reductions in all parameters except HDL cholesterol and triglycerides (Minari et al., 2024). The results indicated that the nutritional intervention contributed significantly to improving biochemical, anthropometric, eating habits, and cardiovascular markets among patients with diabetes type 2 (T2DM). In support, a study by Athinarayanan et al. (2019) reported that nutritional intervention such as long-term adherence to vegetable-protein, polyphenol-enriched, and high-fiber-based diet helps in the improvement of metabolic inflammation and glycaemic control among diabetic patients.

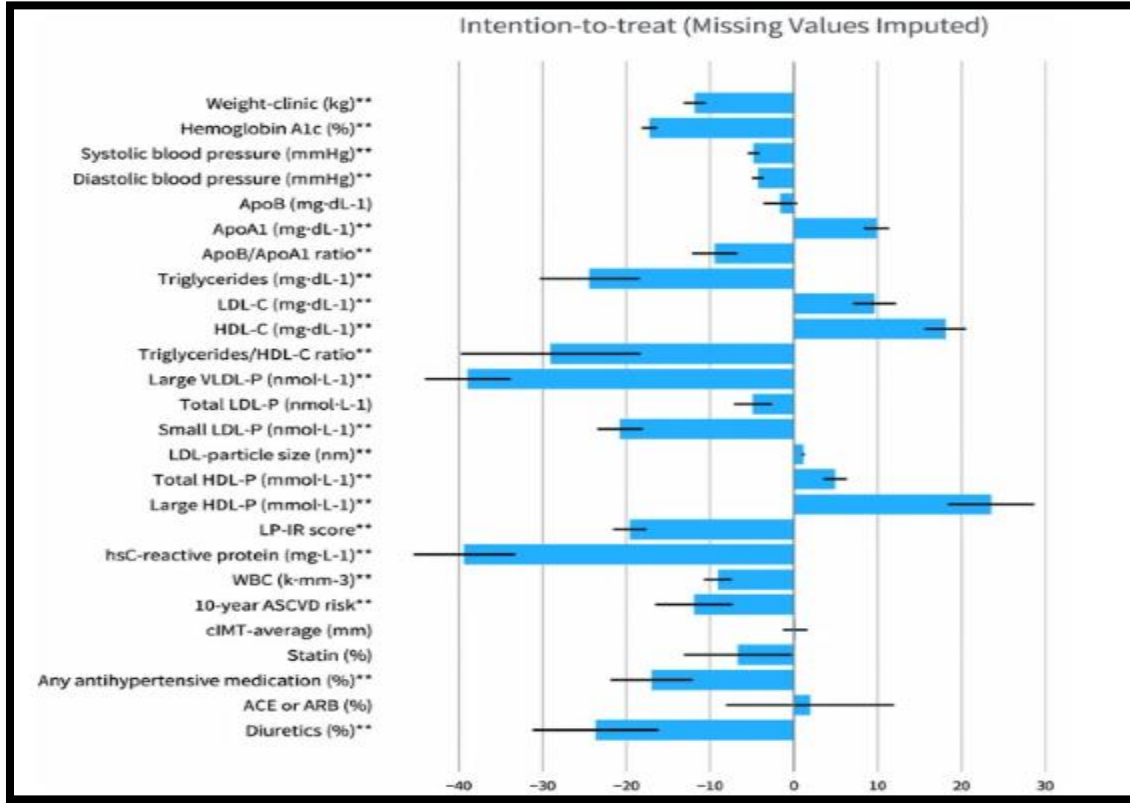
### **Effect of Nutritional Interventions on Biomarkers of Diabetes**

A study by Minari et al. (2024) was aimed at evaluating the impact of individualized nutritional intervention on biomarkers in diabetic patients. The findings of this study reported that the group that participated in the nutritional intervention showed significant reductions in all parameters except HDL cholesterol and triglycerides ( $p < 0.05$ ). The results indicated that the nutritional intervention contributed significantly to improving fasting blood glucose levels among patients with diabetes type 2 (T2DM) as illustrated in the graph below:



Source: (Minari et al., 2024)

The outcomes of the study by Bhanpuri et al. (2018) reported that patients who were on nutritional Ketosis-induced sustained carbohydrate restriction reported a reduction in low-density lipoprotein, triglycerides, and apolipoprotein B. It asserts that nutritional ketosis intervention has a significant impact on biomarkers among patients with T2DM. After 1 year nutritional Ketosis-induced sustained carbohydrate restriction diet significantly reduced total low-density lipoprotein ( $p=0.02$ ). Further changes in biomarkers are illustrated in the graph below:



Source: (Bhanpuri et al., 2018)

The results of the study by Hajifaraji et al. (2018) documented that probiotic supplements were found to have a significant effect on the improvement of oxidative stress and inflammation among women having gestational diabetes mellitus (p=0.03). It is also documented in the results that levels of erythrocyte glutathione peroxidase and malondialdehyde, glutathione reductase significantly improved with the consumption of probiotics as compared to non-intervention or control group as demonstrated in the figure below:

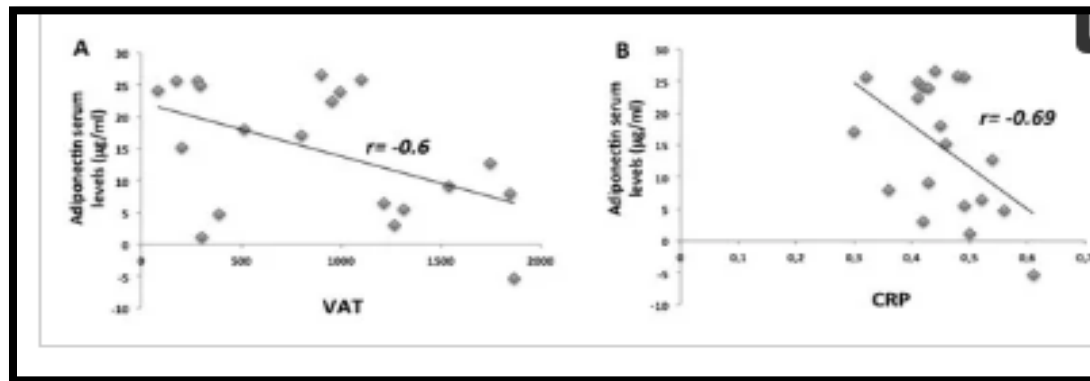
**Table 3.** Inter and Intra-group changes in oxidative stress indices compared for participants

Oxidative stress indices	Probiotic (n=29)	Placebo (n=27)
<b>Serum TAC (mmol/L)</b>		
Before study	1.51 (0.0403)	1.56 (0.0424)
After study	1.66 (0.0542)	1.55 (0.0691)
Mean differences	0.147 (0.0701) <sup>†</sup>	- 0.00741 (0.0706) <sup>†</sup>
p- value	0.038	0.992
<b>Serum MDA (nmol/mL)</b>		
Before study	4.84 (0.438)	4.11 (0.139)
After study	3.89 (0.245)	4.96 (0.323)
Mean differences	- 0.942 (0.429) <sup>†</sup>	0.848 (0.339) <sup>†</sup>
p- value	0.017	0.038
<b>Serum GSHR (ng/mL)</b>		
Before study	24.003 (2.02)	24.8 (2.95)
After study	28.38 (2.13)	22.6 (1.81)
Mean differences	4.38 (1.83) <sup>†</sup>	-2.21 (2.91) <sup>†</sup>
p- value	0.068	0.368
<b>Erythrocyte GPx (U/gHb)</b>		
Before study	42.3 (2.01)	44.7 (3.38)
After study	39.63 (2.12)	32.7 (1.91)
Mean differences	-2.67 (2.17) <sup>†</sup>	-12.002 (3.71) <sup>†</sup>
p- value	0.368	< 0.011
<b>Serum uric acid (mg/dL)</b>		
Before study	2.65 (0.111)	2.49 (0.118)
After study	2.46 (0.108)	2.67 (0.116)
Mean differences	-0.193 (0.114) <sup>†</sup>	0.178 (0.100) <sup>†</sup>
p- value	0.075	0.113
<b>Erythrocyte SOD (U/gHb)</b>		
Before study	2243.8 (80.3)	2290.9 (66.7)
After study	2278.5 (91.3)	2089.3 (86.5)
Mean differences	34.7 (66.5) <sup>†</sup>	-201 (98.7) <sup>†</sup>
p- value	0.673	0.021

Source: (Hajifaraji et al., 2018)

**Effect of Dietary Interventions on Biomarkers in Diabetic Patients**

Monda et al. (2020) reported that a low-caloric ketogenic diet contributes significantly to biomarkers of obesity leading to cause diabetes type 2. The study confirmed that adiponectin has an important role in metabolic diseases such as diabetes that can be reduced on a short-term basis through implementing low caloric ketogenic diet and adiponectin levels improved significantly after consuming low caloric ketogenic diet among diabetic patients (p<0.05).



**Source: (Monda et al., 2020)**

It is further reported in this literature review study that a low-caloric ketogenic diet contributes significantly to biomarkers of obesity leading to diabetes type 2 (Monda et al., 2020). The study confirmed that adiponectin has an important role in metabolic diseases such as diabetes that can be reduced on a short-term basis through implementing low caloric ketogenic diet. Nevertheless, research by Petroni et al. (2021) indicated that a nutrition-based diet such as fat, carbohydrates, protein, vitamins, and mineral substances is effective for maintaining metabolic homeostasis among patients with diabetes. A diet that contains hypoglycaemic agents is an effective way to control levels of blood glucose in the management of T2DM.

(Abu-Qamar, 2019). For instance, a diet containing protein and fiber helps in making changes in the high glucose levels and metabolism of glucose in diabetic patients. In this regard, the findings of a study by Sainsbury et al. (2018) reported that moderate intake of carbohydrates in a diet is found to be effective relative to a traditional diet in terms of reducing mean levels of glucose and increasing time in range and time above range.

It is further indicated by Thomsen et al. (2022) that caloric restriction in nutritional intervention is found to have a significant effect on glycaemic control as a biomarker of diabetes. The intake of vegetables, fruits, greens, legumes, grains, fish, oilseeds, and cereals can be used as caloric-restricted nutritional intervention to reduce the inflammatory response of biomarkers causing diabetes in patients such as fasting glycaemic, total cholesterol, low-density lipoprotein cholesterol, and HbA1c. As stated by Bekele et al. (2020), the high prevalence and incidence rates of diabetes are particularly attributed to inadequate lifestyles and nutritional management.

Inadequate nutritional management and lifestyle management may lead to the worsening of diabetes through the developing complexity of obesity.

The results of this literature review study also reported that high-density lipoprotein significantly increased and mean waist-to-height ratio and mean weight circumference significantly decreased at 12 months (Rahamon, 2020). The level of interleukin-10 also significantly declined at 12 months than 6 months. The findings also revealed that 12 months of dietary modification helped in improving high-density lipoprotein cholesterol and central adiposity among patients with T2DM but cannot be effective in prothrombosis. The findings of the study by Chiavaroli et al. (2021) are in line with the findings of the following systematic literature review and identified that caloric restriction in nutritional intervention is found to have a significant effect on glycaemic control as a biomarker of diabetes. The intake of vegetables, fruits, greens, legumes, grains, fish, oilseeds, and cereals can be used as a caloric-restricted nutritional intervention to reduce the inflammatory response of biomarkers causing diabetes in patients such as fasting glycaemic, total cholesterol, low-density lipoprotein cholesterol, and HbA1c.

The outcomes of the following literature review study also highlighted those patients who were on nutritional Ketosis-induced sustained carbohydrate restriction and reported a reduction in low-density lipoprotein, triglycerides, and apolipoprotein B (Bhanpuri et al., 2018). It asserts that nutritional ketosis intervention has a significant impact on biomarkers among patients with T2DM. In support, the findings of the study by Song and Lee (2018) indicated that dietary solutions contribute significantly to reducing the incidence of diabetes and its associated complications based on biomarkers such as low glycaemic control, high-density lipoprotein, and triglycerides. The results of the following study reported that probiotic supplements were found to have a significant effect on the improvement of oxidative stress and inflammation among women having gestational diabetes mellitus (Hajifaraji et al., 2018). It is also documented in the results that levels of erythrocyte glutathione peroxidase and malondialdehyde, glutathione reductase significantly improved with the consumption of probiotics as compared to the non-intervention or control group. It reflects that diet management and nutritional intake of protein diet have significant effects on insulin resistance glycaemic control, and maintenance of lean body mass among diabetic patients. These findings are supported by Ghaemi et al. (2021) who account that there is a significant

association between nutritional management and biomarkers leading to reduced prevalence of diabetes.

### **Conclusion**

The present study concluded that the biomarkers of diabetes can be improved significantly after the use of nutritional interventions among diabetic patients. It is also identified in this study that nutritional intervention such as long-term adherence to vegetable-protein, polyphenol-enriched, and high-fiber-based diet helps in the improvement of metabolic inflammation and glycaemic control among diabetic patients. Nutrition-based diets such as fat, carbohydrates, protein, vitamins, and mineral substances are effective for maintaining metabolic homeostasis among patients with diabetes. A diet that contains hypoglycaemic agents is an effective way to control levels of blood glucose in the management of T2DM. It is also iterated in this study that caloric restriction in nutritional intervention is found to have a significant effect on glycaemic control as a biomarker of diabetes.

The intake of vegetables, fruits, greens, legumes, grains, fish, oilseeds, and cereals can be used as caloric-restricted nutritional intervention to reduce the inflammatory response of biomarkers causing diabetes in patients such as fasting glycaemic, total cholesterol, low-density lipoprotein cholesterol, and HbA1c. The dietary solutions contribute significantly to reducing the incidence of diabetes and its associated complications based on biomarkers such as low glycaemic control, high-density lipoprotein, and triglycerides. The results of the following study also indicated that probiotic supplements were found to have a significant effect on the improvement of oxidative stress and inflammation among women having gestational diabetes mellitus. Diet management and nutritional intake of protein diet have significant effects on insulin resistance glycaemic control, and maintenance of lean body mass among diabetic patients. Nevertheless, future studies are required to evaluate the mechanism through which nutrition reduces the prevalence of diabetes based on its biomarkers.

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