EVALUATING THE SYNERGISTIC EFFECTS OF YOGA AND A PLANT-BASED DIET ON GLYCEMIC CONTROL AND INSULIN SENSITIVITY IN TYPE 2 DIABETES MANAGEMENT

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Introduction

Diabetes mellitus is taken from the Greek word *diabetes*, meaning siphon - to pass through and the Latin word *mellitus* meaning sweet. A review of the history shows that the term "diabetes" was first used by Apollonius of Memphis around 250 to 300 BC. Ancient Greek, Indian, and Egyptian civilizations discovered the sweet nature of urine in this condition, and hence the propagation of the word Diabetes Mellitus came into being. Mering and Minkowski, in 1889, discovered the role of the pancreas in the pathogenesis of diabetes. In 1922 Banting, Best, and Collip purified the hormone insulin from the pancreas of cows at the University of Toronto, leading to the availability of an effective treatment for diabetes in 1922. Over the years, exceptional work has taken place, and multiple discoveries, as well as management strategies, have been created to tackle this growing problem. Unfortunately, even today, diabetes is one of the most common chronic diseases in the country and worldwide. In the US, it remains as the seventh leading cause of death. The world's diabetes capital is now our nation, India, whose rapid rise in the disease is ascribed to changes in our way of life.

Terms of definition

1. **Yoga:** Yoga is a holistic practice originating from ancient India, combining physical postures (asanas), breathing exercises (pranayama), meditation, and ethical principles to promote physical, mental, and spiritual well-being. It aims to harmonize the body, mind, and spirit, enhancing flexibility, strength, relaxation, and mindfulness.
2. **Diabetic:** A diabetic is a person who has diabetes, a chronic condition where the body either doesn't produce enough insulin or cannot effectively use the insulin it does produce, leading to high blood sugar levels. There are two primary types of diabetes: Type 1
3. **Plant-based diet**: A plant-based diet focuses primarily on foods derived from plants, including fruits, vegetables, grains, legumes, nuts, and seeds, while minimizing or excluding animal products.

Living with diabetes presents a unique set of challenges, one of the most significant being the management of stress. Stress not only affects the overall well-being of individuals but can also have a direct impact on blood sugar levels and the effectiveness of diabetes management strategies. For diabetic patients, finding effective stress management techniques is crucial, and yogic practices have emerged as a promising avenue in this regard. However, emerging research and anecdotal evidence suggest that integrating yogic practices into daily routines can effectively mitigate both the physiological and psychological aspects of diabetes.

Common tests used to diagnose Diabetes

Diagnosing and managing diabetes typically involves a range of tests to assess blood glucose levels and determine how well the body is managing glucose. Here are the common tests used:

Fasting Blood Glucose Test: Measures blood glucose levels after fasting for at least 8 hours. Normal Range: 70-99 mg/dL (3.9-5.5 mmol/L).

Diagnosis: A fasting blood glucose level of 126 mg/dL (7.0 mmol/L) or higher indicates diabetes.

Oral Glucose Tolerance Test (OGTT)

Purpose: Measures how well the body processes glucose. Typically involves fasting overnight and then drinking a glucose-rich beverage. Normal Range: Blood glucose levels should be below 140 mg/dL (7.8 mmol/L) two hours after drinking the glucose solution.

Diagnosis: A 2-hour glucose level of 200 mg/dL (11.1 mmol/L) or higher indicates diabetes.

Hemoglobin A1c Test

Purpose: Provides an average blood glucose level over the past 2-3 months by measuring the percentage of hemoglobin that is glycated (bound to glucose).Normal Range: Below 5.7%.

Diagnosis: An A1c level of 6.5% or higher indicates diabetes.

Random Blood Glucose Test

Purpose: Measures blood glucose levels at any time, regardless of when you last ate. Normal Range: Values below 140 mg/dL (7.8 mmol/L) are considered normal.

Diagnosis: A random blood glucose level of 200 mg/dL (11.1 mmol/L) or higher may suggest diabetes, especially if accompanied by symptoms of diabetes.

C-Peptide Test

Purpose: Measures the level of C-peptide, a substance produced in the pancreas that indicates how much insulin is being produced.

Normal Range: Varies, but typically between 0.5 and 2.0 ng/mL.

Diagnosis: Low levels of C-peptide can indicate type 1 diabetes or a lack of insulin production, while high levels can indicate type 2 diabetes.

Autoantibody Testing

Purpose: Determines the presence of autoantibodies that attack insulin-producing cells in the pancreas.Types: Includes tests for GAD65 (glutamic acid decarboxylase) antibodies, ICA (islet cell antibodies), and IAA (insulin autoantibodies).

Diagnosis: Positive results suggest type 1 diabetes.

Urine Glucose Test

Purpose: Measures glucose levels in the urine. It's less commonly used for diagnosis but can help in monitoring blood glucose control.Normal Range: No glucose should be present in urine.

Diagnosis: Persistent glucose in urine can suggest uncontrolled diabetes

Urine Ketone Test

Purpose: Measures ketones in the urine, which can indicate diabetic ketoacidosis (a serious complication of diabetes). Normal Range: No ketones should be present.

Diagnosis: Presence of ketones in urine may suggest poor glucose control or a need for medical intervention.

Total cholesterol levels are measured in milligrams per deciliter (mg/dL) of blood and are calculated by adding a person's HDL cholesterol, LDL cholesterol, and 20% of their triglyceride levels. A blood test called a lipid panel can provide these numbers

The triglyceride level is a blood test to measure the amount of triglycerides in your blood. Triglycerides are a type of fat. Your body makes some triglycerides. Triglycerides also come from the food you eat. Triglyceride levels usually fall into the following categories: Healthy: Below 150 milligrams per deciliter (mg/dL) for adults; lower than 90 mg/dL for children and teens (ages 10-19) Borderline high: Between 150 and 199 mg/dL. High: Between 200 and 499 mg/dL

A normal triglyceride (TGL) level for adults is less than 150 milligrams per deciliter (mg/dL). For children and teens between the ages of 10 and 19, a normal level is less than 90 mg/dL

Here are some other TGL level categories:

- Borderline high: 150–199 mg/dL
- High: 200–499 mg/dL
- Very high: 500 mg/dL or higher

A blood test can determine if your TGL levels are healthy. High TGL levels can increase your risk of heart disease.

LDL Cholesterol Ranges

Less than 100 milligrams per deciliter (mg/dL): Optimal. 100-129 mg/dL: Near or above optimal. 130-159 mg/dL: Borderline high. 160-189 mg/dL: High

Low-density lipoprotein (LDL) cholesterol is a type of cholesterol in your blood that's often called "bad" cholesterol because it can lead to plaque buildup in your arteries and heart disease. LDL cholesterol levels are measured in milligrams per deciliter (mg/dL) and can be used to assess your risk of cardiovascular disease or monitor changes in cholesterol over time

According to Johns Hopkins Medicine, the normal range for LDL cholesterol in adults is:

- Optimal: Less than 100 mg/dL
- Near optimal: 100 to 129 mg/dL
- Borderline high: 130 to 159 mg/d

These tests help in diagnosing diabetes, monitoring blood glucose levels, and managing treatment plans. It's important to work with a healthcare provider to interpret these tests and determine the most appropriate treatment and management strategies.

Study Design

In this study, twelve volunteers diagnosed with Type 2 diabetes were selected to participate in a 90-day yoga intervention. The participants, ranging in age from 40 to 60, were chosen based on predefined inclusion criteria and underwent both pre-test and post-test assessments to evaluate the effects of the prescribed yogic practices. The yoga sessions were designed to manage diabetes holistically, considering physical inactivity, illness, and overall health status. Each participant's progress was closely monitored by both a yoga teacher (guru) and an allopathic physician.

Ethical Considerations

Prior to the commencement of the study, ethical clearance was obtained from the relevant institutional review board to ensure that the study met all ethical standards and protected the well-being of the participants.

Duration and Structure

The participants practiced yoga for 60 minutes per day, six days a week, under the direct supervision of the yoga teacher and with regular consultations with the allopathic physician**.**

The program was tailored for a 90-day intervention, and blood glucose levels, as well as other health parameters, were regularly monitored.

Data Collection and Analysis

- **Pre-test**: Prior to the intervention, baseline data was collected from the volunteers, including blood sugar levels, body mass index (BMI), and other key health indicators.
- **Post-test**: After completing the 90-day yoga regimen, the same data points were collected again.
- The results of the pre-test and post-test were analyzed using a paired t-test to determine the
- statistical significance of the changes observed.

Results

The statistical analysis through the paired t-test aimed to assess the effectiveness of the yoga practices in managing Type 2 diabetes, with a focus on changes in blood glucose levels and overall well-being of the participants.

To identify the mean difference in pre-test and post-test Total Cholesterol (T.Cho), a paired t-test is employed."

Null Hypothesis (H_0):

There is no significant difference in the mean T.Cho levels before and after the test intervention.

Paired Samples Statistics

Test	Mean	N	Std. Deviation	Paired t value	P value
Pre Test	303.6667	12	54.79936	13.720	.000
Post Test	130.0000	12	24.84131		

The table presents the results of a paired samples t-test comparing the mean levels of T.Cho (Total Cholesterol) measured in mg/dl before and after a test intervention.

Interpretation:

- **Pre-Test**: The mean T.Cho level before the intervention was 303.67 mg/dl (with a standard deviation of 54.80), based on 12 participants.
- **Post-Test**: The mean T.Cho level after the intervention was 130.00 mg/dl (with a standard deviation of 24.84), based on the same 12 participants.
- **Paired t-value**: The t-value is 13.720, indicating a significant difference between the pre-test and post-test means.
- **P-value**: The p-value is 0.000, which is less than 0.01, indicating that the difference between the pre-test and post-test T.Cho levels is statistically significant.

The intervention significantly reduced the T.Cho levels in participants, as evidenced by the large t-value and the highly significant p-value. Since the p-value is 0.000, which is less than the significance level of 0.05, we reject the null hypothesis (H_0). This means there is a statistically significant difference in the mean T.Cho levels between the pre-test and post-test, indicating that the intervention had an effect on reducing T.Cho levels.

TGL.Mg/dl

"To identify the mean difference in pre-test and post-test Triglycerides (TGL, mg/dl), a paired t-test is employed."

Null Hypothesis (H_0):

There is no significant difference in the mean Triglycerides (TGL) levels before and after the intervention.

Paired Samples Statistics

Test	Mean	N	Std. Deviation	Paired t value	P value
Pre Test	455.00	12	233.02282	5.421	.000
Post Test	125.50	12	55.37065		

Interpretation:

- **Pre-Test Mean**: 455.00 mg/dl
  The mean TGL level before the intervention was 455.00 mg/dl, with a standard deviation of 233.02, indicating considerable variability in triglyceride levels among the 12 participants.
- **Post-Test Mean**: 125.50 mg/dl
  After the intervention, the mean TGL level dropped significantly to 125.50 mg/dl, with a smaller standard deviation of 55.37, indicating a significant reduction and less variability in triglyceride levels.
- **Paired t-value**: 5.421
  The t-value of 5.421 indicates a substantial difference between the pre-test and post-test TGL means.
- **P-value**: 0.000
  The p-value is less than 0.01, suggesting that the difference between the pre-test and post-test TGL levels is statistically significant.

The intervention significantly reduced the TGL level in participants, as evidenced by the large t-value and the highly significant p-value. Since the p-value is 0.000, we reject the null hypothesis. This indicates a statistically significant reduction in Triglycerides (TGL) levels after the intervention, demonstrating that the intervention was effective in lowering triglyceride levels among participants.

LDL.Mg/dl

"To identify the mean difference in pre-test and post-test Low-Density Lipoprotein (LDL, mg/dl), a paired t-test is employed."

Null Hypothesis (H_0):
There is no significant difference in the mean Low-Density Lipoprotein (LDL) levels before and after the intervention.

Paired Samples Statistics

Test	Mean	N	Std. Deviation	Paired t value	P value
Pre Test	227.1667	12	155.88273	3.783	.003
Post Test	60.0833	12	22.18295		

Interpretation:
Pre-Test Mean: 227.17 mg/dl
The average LDL level before the intervention was 227.17 mg/dl, with a large standard

- deviation of 155.88, indicating substantial variability in LDL levels among the 12 participants.
- **Post-Test Mean**: 60.08 mg/dl
  After the intervention, the mean LDL level dropped significantly to 60.08 mg/dl, with a much smaller standard deviation of 22.18, suggesting a major reduction and less variability in LDL levels.
- **Paired t-value**: 3.783
  The t-value of 3.783 suggests a substantial difference between the pre-test and post-test LDL means.
- **P-value**: 0.003
  Since the p-value is less than 0.01, this result is statistically significant, indicating a meaningful difference between pre-test and post-test LDL levels.

Conclusion

The intervention significantly reduced the LDL level in participants, as evidenced by the large t-value and the highly significant p-value. As the p-value is 0.003, we reject the null hypothesis. The intervention significantly reduced LDL levels in the participants, as evidenced by the drop in mean LDL from 227.17 mg/dl to 60.08 mg/dl. This suggests the intervention was effective in lowering LDL cholesterol.

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