Effects of the Yogic Practice of Surya Namaskar and the Little Millets Diet on the Management of Type-2 Diabetes Mellitus

Research Article

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Abstract

Introduction: Excess blood glucose levels are a hallmark of diabetes mellitus, a metabolic disease that affects the body's metabolism. This illness has the potential to seriously damage the heart, blood vessels, kidneys, eyes, nerves, and heart over time. Aim: The aim of present study is to find how Surya namaskar and little millet affected the quality of subjects with type 2 Diabetes mellitus. Methodology: A randomised control study at SSH Hospital, BHU, Varanasi was conducted in three groups of participants with type 2 diabetes: Surya namaskar alone (Group A) and Surya namaskar with little millet (Group B) as a diet in the management of Diabetes mellitus in comparison to control group in which no intervention is provided (Group C). Study has assessed the subjective (increased thirst, frequent urination, increased hunger, weight loss, fatigue, blurred vision, and healing) and objective parameters (Blood sugar, Fasting, Random, Postprandial and HbA1c). Result: According to study, the combined use of Surya namaskar and little millet diet has been found to be highly significant in lowering symptoms of increased thirst, frequent urination, increased hunger, weight loss, fatigue, blurred vision, and healing. The results showed that, after a month, both Group A and B were able to lower their fasting blood sugar levels significantly. But random and postprandial glucose levels and HbA1c are significantly decreased in Group B only. Conclusion: The study results concluded that if both the Surya namaskar and little millets are intervened to Diabetes mellitus patient, it plays a significant role in managing diabetes.

Keywords: Diabetes mellitus, *Ayurveda, Yoga, Surya namaskar,* Little millets, Diet.

Introduction

Diabetes is a metabolic disease that impacts the body's metabolism and is characterised by excessive blood glucose levels (also known as blood sugar levels). Over time, this condition can cause major harm to the heart, blood vessels, eyes, kidneys, and nerves. Type 2 diabetes, which often affects adults, is the most prevalent type and develops when the body stops producing enough insulin or becomes resistant to it. Type 2 diabetes prevalence has sharply increased during the past three decades in nations of all income levels. Juvenile diabetes or insulin-dependent diabetes, often known as type 1 diabetes, is a chronic illness in which the pancreas produces little to no insulin on its own. For those who have diabetes, having access to inexpensive medical care, particularly insulin, is essential to their survival. According to World Health Organization (WHO) by 2025, it is the goal that has been universally agreed upon to stop the rise in diabetes and obesity. Moreover, according to WHO report 2023, majority of the approximately 422 million people with diabetes

worldwide reside in low- and middle-income nations, and also diabetes has become directly accountable for 1.5 million deaths annually. Over the past few decades, there has been a consistent rise in both the incidence and prevalence of diabetes(1).

By the year 2050, more than 131 billion people worldwide may have diabetes, according to recent estimates that were published this week in The Lancet. With high death rates, life-altering morbidity, and interactions and exacerbations with numerous other diseases, it translates to 131 billion people living with a disease. It is anticipated that rises in type 2 diabetes, which would be brought on by an increase in the prevalence of obesity and by demographic changes, will be the main factors behind the increase in prevalence (up from 529 million in 2021). 90% of all cases of diabetes in 2021 were type 2 diabetes. The majority of this burden can be attributed to social risk factors, which include low physical activity, high BMI, food risks, environmental and occupational risks, tobacco use, and alcohol consumption (2).

Type 2 Diabetes mellitus is caused by a complex interaction of factors, including obesity, a sedentary lifestyle, physical inactivity, a diet high in sugar and low in fibre, vitamin inadequacy, smoking, and alcohol consumption (3). Type 2 Diabetes mellitus is linked to a lot of issues. Due to its subtle and enduring nature, hyperglycemia, a typical feature of Type 2 Diabetes mellitus, has the potential to result in severe

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consequences (4). Vascular problems result from the continuous rise of blood glucose levels, which harms blood vessels. Neuropathy, nephropathy, and retinopathy are examples of microvascular consequences. Cardiovascular disease, which can cause myocardial infarction, and cerebrovascular disease, which can cause strokes, are examples of macrovascular complications (5). One of the common consequences in long-term diabetes patients is diabetic gastroenteropathy. Heartburn, stomach discomfort, nausea, vomiting, constipation, diarrhoea, and faecal incontinence are just a few of the symptoms it causes(6). Diabetes complications are regarded as major issues since they adversely affect patients' quality of life and increase their risk of morbidity (7).

Diabetes mellitus is known as *madhumeha* in Ayurveda (madhu means "sweetness" and meha means "excessive urination"). This illness and its treatment are thoroughly detailed in ancient Ayurvedic writings that were written in Sanskrit. The Sanskrit word *Prameha* is a combination of the words *Pra* and *Meha*. *Meha* signifies maturation, and *Pra* means excess in both quantity and frequency. This *Prameha* denotes the creation of too much urination. Lack of exercise, stress, exerting oneself beyond one's capabilities, and poor eating habits, overeating, and chronic excess of food are the aetiology (predisposing causes) of *Prameha,* which directly raise *Kapha, Medhas,* and *Mutra*. As a result of its similarities to fat, this aggravated Kapha spread throughout the body and altered its composition. With its characteristics of stickiness and weight, Kapha vitiates and turns into *Kleda*, changing the quantity and viscosity of body tissue and modifying the body's lipid metabolism. Due to the body's increased temperature, the tissues will also deviate from their ideal state and become less adherent and liquified, which will further vitiate the body and the muscles (*Mamsa Dhatu*). In brief, a multifaceted and individualised approach is used to manage the condition, including lifestyle modification (including diet), Ayurvedic detoxifying and purifying therapies (like Panchakarma), and Ayurvedic medications (containing ingredients from plants, animals, or minerals, either alone or in combination). Many of these medications are thought to function through extra pancreatic as well as pancreatic actions (8)(9).

Ayurveda, system, incorporates yoga as a vital component of its treatment of many diseases. Through consecutive historical eras, texts, and teachers, the idea of yoga has expanded to encompass a wide variety of disciplines, ideas, and practises. Surya Namaskar, a kind of yoga, aims to enhance both physical and mental wellness (10). Surya means "Sun" and Namaskar means "Salutation" or "to greet," hence Surya Namaskar is a classic yoga pose that is performed to honour the Sun. As a result, it is often referred to as Surya Namaskar or Sun Salutation. The renowned "Patanjali" and his or her followers invented this specific breathing and posture routine thousands of years ago. For optimum health, endurance, mental and physical stability, and strength, they advised everyone to practise it in the morning, facing the rising sun, on an empty stomach(11). A series of dynamically synchronised yoga positions called Surya namaskar are done in synchronisation with the breath. A series of 12 physical postures known as Surya Namaskar contain several bends in both the forward and backward directions (10) . Surya namaskar has a variety of health benefits that are mostly related to the respiratory, cardiovascular, endocrine, musculoskeletal, nervous, and gastrointestinal systems of the body. Additionally, Surya namaskar has been shown to be particularly useful for the backbone, spinal cord, legs, throat, lungs, heart, liver, stomach, intestines, and skin, among other organs. Experts advise practising Surya namaskar on a regular basis for a healthy life since it causes all of the body's cells and tissues to regenerate and revitalise (12). Additionally, the American Diabetes Association suggests regular physical activity as a component of the recommended course of therapy for Type 2 Diabetes mellitus(13). Even though the Surya namaskar has been practised since ancient times and is based on science, there is still a need for modern scientific advancements to support its widespread use.

In addition, it's crucial to remember that, in addition to a sedentary lifestyle and obesity, the type of food consumed represents an essential component in diabetes. Up to 80% of the energy consumed in developing nations comes from main staples including refined rice, refined wheat, and maize. To control and prevent diabetes, it's crucial to diversify and mainstream traditional nutritive and lower-glucogenic staples in the majority of developing nations; Little millets are included in this list (14). It is an excellent source of nutraceuticals and micronutrients, which have medicinally advantageous qualities. Because it contains bio-active nutraceuticals including phenolic compounds, tocopherols, and carotenoids, as well as having a low glycaemic index, Little millet (*Panicum sumatrense*), a minor cereal, is known for its numerous health benefits, particularly for people with diabetes. In addition to being a good supply of phosphorus, it also contains fibre, which lowers body fat levels. The antioxidant and low-calorie content found in Little millet aids in maintaining a healthy weight and diet that can aid in weight loss (15).

However, many studies show the effect of the millets, and has no side effect which are produce due to modern medicine. But still there is a need of comprehensive study which evaluate it's antidiabetic action. So, in this study little millet and Surya namaskar was taken in consideration and evaluate for its diabetic effect in clinical patients for the first time.

## Materials and Methods of Clinical study
Approval of ethical committee and CTRI registration

The trial was approved by Institutional Ethics Committee, Institute of Medical Sciences Banaras Hindu University, Varanasi with Reference No. Dean/2022/EC/3342 dated 06/06/2022. Further the trial was also registered with Clinical Trail Registry of India (CTRI) vide no. CTRI /2022/11/047092 dated 7th November 2022.

Study type: Randomised Control Trail by continuing pre-existing medication.

- Group -1-30 patients of Type-2 Diabetes Mellitus will be studied by adapting Surya namaskar for one-month period early in the morning at 5 AM for 30 minutes.
- Group 2- 30 patients of Type-2 Diabetes Mellitus will be studied by adapting Surya namaskar for one-month period early in the morning at 5 AM for 30 minutes followed by intake of little Millets.
- Group-3-30 patients of Type-2 Diabetes Mellitus will be studied for control group with their existing medications if any. No intervention was done from the research part.
- In all the three groups patients' regular treatment was continued.

Figure 1: Showing the different figures of clinical studies procedures followed
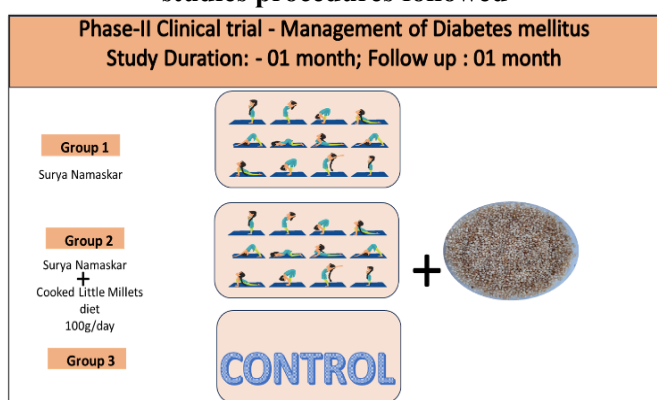
Inclusion criteria

Participants with type 2 Diabetes mellitus of both sex (male and female) and between the age group of 25years to 65 years will be included for the study.

Exclusion criteria

Subjects with age less than 25 years, pregnant woman, people who are cognitively impaired/ having mental disorder, menstruating women, suffering from malignancy, advance liver or kidney diseases, wrist injury, heart problems, high blood pressure, back problem, and arthritis were excluded.

Assessment criteria
Objective parameters

Blood sugar: Fasting, Random, Postprandial, Hb A1c.

Subjective parameters

When signs and symptoms are present, they may include; increased thirst**,** frequent urination**,** increased hunger, weight loss, fatigue**,** blurred vision, slow healing sores**,** frequent infection**,** areas of darkened skin usually in armpits and neck. The assessment criteria includes patients socio-demographic detailed (Name, Age, Sex, Religion, Occupation, O.P.D./Hospital Number, Address, Education, Monthly Income, Marital Status, Habitat (Rural/Urban)), vital signs, history of diabetes mellitus and current medications (Table 5).

Place of study

This study was conducted at OPD and Department of Rasa shastra and Bhaishajya Kalpana, Sir Sundar Lal Hospital, B.H.U., Varanasi.

Statistical method

All the subjective and objective data were collected in tabulated form and shown in graphic representation. The intra-group comparison was done to see the effect of treatment using paired t test and Friedman test. For the inter-group comparison between different groups one-way ANOVA (Analysis of Variance) was applied for objective data and value of F test was determined. And Mann Whitney test was used for inter-group comparison between different groups to evaluate subjective.

Results

In this clinical study 90 cases were registered out of which 90 cases turned up for full follow-ups. The observations are as follows:

Demographic profile

This section deals with the patients basic details, which are most important information to have in order to rule out the disease prevalence in the general community. It comprises the patients' distributions according to sex, age, occupation status, weight, and BMI. Moreover, the type and history of the treatment they are taking. Also, we had evaluated the prevalence of some major symptoms in the diabetes patients such as- increase thirst, increased urination, increased hunger, weight loss, fatigue, blurred vision, slow healing sores, frequent infection and area darkened black. The aforementioned Table 1 displays the gender incidence for the current study, where predominant were male. The data clearly shows that, among the 90 instances in the current series, the largest number of patients in the 51–60 age range. In occupational study the incidence of Pre-diabetes, was found to be higher in-service man followed by businessman and Housewife. Weight group of 61–70 kg, had the highest incidence of patients. The above table shows that the incidence of patient in the normal group of 18.5-24.9 kg/m2 was the highest, followed by overweight group of 25.00-29.9 kg/m2.

Diabetic post complications

Data observed increased thirst of Grade 2 in major number of patients. Major of the population of patients were suffering from increased urination i.e. up to 7-10 times in a day and 3-4 times at night. Major of the population of patients had no weight loss. Major of the population of patients had no feel of fatigue. Major of the population of patients had mild blurred vision. Major of the population of patient's wounds were not healing. Major of the population i.e., 96.67% of patients had no darkened areas in skin armpits and neck (Table 2).

Effect on Subjective criteria

Result of the study shows that both Group A and B has significantly helpful in reducing the symptom of frequent urination. Patients with symptoms at Grade 3 has reduced from 33.33% to 13.33% in Group A; 36.66% to 0% of patient in Group B; and in Group C. Result of the study shows that Group A and C has significantly helpful in increasing the symptom of hunger. Patients with symptoms of reduce hunger at Grade 0 has decreased from 83.33% to 36.67% in Group A; 83.33% to 50% of patient in Group C; and in Group B i.e., has shown no improvement in this symptom. Result of the study shows that both Group A has significantly helpful in reducing the symptom of weight loss. Result shows that Group B has shown significant effect in reducing the fatigue symptom. Patients at Grade 0 has increased from 20% to 80%. Result shows that Group B has shown significant effect in reducing the blurred vision symptom. Result shows that no Group has shown significant effect on wound healing, frequent infection, areas of darkened skin armpits and neck (Table 3).

Effect on Objective criteria

On analysing the FBS data, it was drawn out that both the Group A and B has shown no significant effect in reducing FBS after 15 days. But it found that Group A and B has significant effect in reducing FBS after 30 days. Group A and B has shown non-significant difference results i.e., have shown same effect. On analysing the RBS data, it was drawn out that both the Group A and B has shown no significant effect in reducing RBS after 15 days. But it was drawn out that both the Group A and B has shown significant effect in reducing RBS in 30 days. Group A and B has shown non-significant difference results i.e., have shown same effect. On analysing the PPBS data, it was drawn out that both the Group A and B has shown no significant effect in reducing PPBS after 15 days. Although, in t paired test Group A has shown no significant effect in reducing PPBS before and after treatment. Group A and B has shown non-significant difference results i.e., have shown same effect. As per paired t test Group A has shown mild significant effect in reducing HBA1C after treatment. Whereas Group B has shown significant effect in reducing HBA1C after treatment (Table 4).

Table 1: Demographic profile: Gender, age, occupation status, weight, and BMI (Body mass Index)

Gender Incidence	
Gender	**No. of Patients**
Male	66
Female	24
Total	**90**

Age Incidence			
Age (in years)	**No. of Patients**		
	Male	**Female**	**Total**
30-40	12	2	14
41-50	17	6	23
51-60	33	12	45
60-65	5	3	8
Total	**47**	**28**	**90**

Occupational Status	
Occupation	**No. of Patients**
Service/Job	61
Govt. Job	3
Businessman	13
Housewife	13
Total	**90**

Incidence of weight	
Weight	**No. of Patients**
30-40 kg	1
41-50 kg	3
51-60 kg	13
61-70 kg	44
71-80 kg	22
> 80 kg	7
Total	**90**

Incidence of BMI	
B.M.I. (kg/m2)	**No. of Patients**
< 18.5 (Underweight)	3
18.5-24.9 (Normal)	44
25.0-29.9 (Over weight)	38
30.0-39.9 (Obese)	5
> 40 (Severe Obese)	Nil
Total	**90**

Table 2: Diabetic post complications: Increased thirst, Frequent urination, Increased hunger, Weight loss, Fatigue, Blurred vision, Healing, Frequent infection, and Areas of darkened skin armpits and neck.

Diabetic post complications: Increased thirst				
Increased thirst (24 hrs)	**No. of patients**			
	Group A	**Group B**	**Group C**	**Total**
1.5 to 2.5 lit / day- 0	1	8	5	14
2.5 to 3.0 lit / day- 1	8	4	14	26
3 to 3.5 lit / day- 2	11	9	8	28
3 lit and more- 3	10	9	3	22
Total	**30**	**30**	**30**	**90**
Diabetic post complications: Frequent urination				
Frequent urination	**No. of patients**			
	Group A	**Group B**	**Group C**	**Total**
3 to 5 times / day, rarely at night – 0	4	9	3	16
5 to 7 times / day, 1-2 times at night – 1	6	4	12	22

7 to 10 times / day,3-4 times at night – 2	10	6	15	31
10 to 12 times / day, 3-4 times at night- 3	10	11	0	21
Total	**30**	**30**	**30**	**90**

Diabetic post complications: Increased hunger

Increased hunger	No. of patients			
	Group A	Group B	Group C	Total
Not fell hungry- 0	25	17	25	67
Mild hunger – 1	5	4	5	14
Moderate hunger – 2	0	9	0	9
Increased hunger – 3	0	0	0	0
Total	**30**	**30**	**30**	**90**

Diabetic post complications: Weight loss

Weight loss	No. of patients			
	Group A	Group B	Group C	Total
No weight loss- 0	24	10	28	62
Mild weight loss- 1	6	1	1	8
Moderate weight loss- 2	0	10	1	11
Severe weight loss- 3	0	9	0	9
Total	**30**	**30**	**30**	**90**

Diabetic post complications: Fatigue

Fatigue	No. of patients			
	Group A	Group B	Group C	Total
No feel of fatigue – 0	20	6	26	52
Mild feel of fatigue – 1	5	2	1	8
Moderate feel of fatigue – 2	5	12	3	20
Severe feel of fatigue – 3	0	10	0	10
Total	**30**	**30**	**30**	**90**

Diabetic post compilations: Blurred vision

Blurred vision	No. of patients			
	Group A	Group B	Group C	Total
No blurred vision – 0	9	8	14	31
Mild blurred vision- 1	17	15	16	48
Moderate blurred vision- 2	4	7	0	11
Severe blurred vision- 3	0	0	0	0
Total	**30**	**30**	**30**	**90**

Diabetic post compilations: Healing

Healing	No. of patients			
	Group A	Group B	Group C	Total
No wound healing– 0	30	26	30	86
Mild healing – 1	0	0	0	0
Moderate healing – 2	0	1	0	1
Fast healing – 3	0	3	0	3
Total	**30**	**30**	**30**	**90**

Diabetic post compilations: Frequent infection

Frequent infection	No. of patients			
	Group A	Group B	Group C	Total
Absent (No frequent infections)- 0	23	19	30	72
Mild frequent infection- 1	2	3	0	5
Moderate frequent infection- 2	3	3	0	6
Severe frequent infection-3	2	5	0	7
Total	**30**	**30**	**30**	**90**

Diabetic post compilations: Areas of darkened skin armpits and neck

Areas of darkened skin armpits and neck	No. of patients			
	Group A	Group B	Group C	Total
Absent – 0	30	28	29	87
Mild areas of darkened skin armpits and neck- 1	0	0	1	1
Moderate areas of darkened skin armpits and neck – 2	0	2	0	2
Severe areas of darkened skin armpits and neck	0	0	0	0
Total	**30**	**30**	**30**	**90**

Table 3: Effect on: Increased thirst, Frequent urination, Increased hunger, Weight loss, Fatigue, Blurred vision, Healing, Frequent infections and Areas of darkened skin usually in armpits and neck BT- Before Treatment; F1 – Follow up after 15 days; F2/AT -Follow after 30 days/ After Treatment; * - Very- very significant; ** - Very significant; * - Significant; N. S. - Non significant**

Increased thirst of Diabetic patients								
Group	Grade	Treatment protocol						Within the group comparison (Friedman Test)
		BT		F1		F2/AT		
		No	%	No	%	No	%	
A	Grade 0	1	3.33	3	10	12	40	X^2= 6.45, p > .05
	Grade 1	8	26.67	6	20	7	23.33	
	Grade 2	11	36.66	17	56.67	2	6.67	
	Grade 3	10	33.33	4	13.33	9	30	
B	Grade 0	8	26.67	10	33.33	15	50	X^2= 21.1167, p<0.0001
	Grade 1	4	13.33	9	30	12	40	
	Grade 2	9	30	10	33.33	3	10	
	Grade 3	9	30	1	3.33	0	0	
C	Grade 0	5	16.67	1	3.33	0	0	X^2= 35.2667, p<0.0001
	Grade 1	14	46.67	7	23.33	1	3.33	
	Grade 2	8	26.66	15	50	10	33.33	
	Grade 3	3	10	7	23.33	19	63.33	
Between the group Z, p (Mann Whitney Test)		A vs B						Z=1.67803; p <0.05
		B vs C						Z=-6.29077; p <0.0001
		A vs C						Z=-3.68871; p <0.001
Effect on Frequent urination of Diabetic patients								
Group	Grade	Treatment protocol						Within the group comparison (Friedman Test)
		BT		F1		F2/AT		
		No	%	No	%	No	%	
A	Grade 0	4	13.34	4	13.34	11	36.67	X^2= 14.6167, p< .05
	Grade 1	6	20	10	33.33	9	30	
	Grade 2	10	33.33	14	46.67	6	20	
	Grade 3	10	33.33	2	6.67	4	13.33	
B	Grade 0	9	30	10	33.33	13	43.33	X^2= 14.6167, p<0.001
	Grade 1	4	13.33	7	23.33	12	40	
	Grade 2	6	20	10	33.33	5	16.67	
	Grade 3	11	36.66	3	10	0	0	
C	Grade 0	3	10	0	0	0	0	X^2= 35.2667, p<0.0001
	Grade 1	12	40	5	16.67	0	0	
	Grade 2	15	50	15	50	5	16.67	
	Grade 3	0	0	10	33.33	25	83.33	
Between the group Z, p (Mann Whitney Test)		A vs B						Z=1.1384; p >0.05
		B vs C						Z=-6.46079; p <0.0001
		A vs C						Z=-5.38892; p <0.0001
Effect on hunger of Diabetic patients								
Group	Grade	Treatment protocol						Within the group comparison (Friedman Test)
		BT		F1		F2/AT		
		No	%	No	%	No	%	
A	Grade 0	25	83.33	17	56.67	11	36.67	X^2= 19.4667, p<0.0001
	Grade 1	5	16.67	5	16.67	6	20	
	Grade 2	0	0	8	26.67	6	20	
	Grade 3	0	0	0	0	7	23.33	
B	Grade 0	17	56.67	27	90	29	96.67	X^2= 7.2667, p<0.05
	Grade 1	4	13.33	3	10	1	3.33	
	Grade 2	9	30	0	0	0	0	
	Grade 3	0	0	0	0	0	0	
C	Grade 0	25	83.33	19	63.33	15	50	X^2= 37.9167, p<0.0001
	Grade 1	5	16.67	6	20	2	6.67	
	Grade 2	0	0	4	13.33	9	30	

| | Grade 3 | 0 | 0 | 1 | 3.33 | 4 | 13.33 | |

Between the group Z, p (Mann Whitney Test)	A vs B	Z=4.0805; p <0.0001
	B vs C	Z=-3.19344; p <0.001
	A vs C	Z=0.78357; p >0.05

Effect on Weight loss of Diabetic patients

Group	Grade	Treatment protocol						Within the group comparison (Friedman Test)
		BT		F1		F2/AT		
		No	%	No	%	No	%	
A	Grade 0	24	80	17	56.67	11	36.67	X²= 17.9167, p<0.001
	Grade 1	6	20	7	23.33	4	13.33	
	Grade 2	0	0	5	16.67	10	33.33	
	Grade 3	0	0	1	3.33	5	16.67	
B	Grade 0	10	33.33	14	46.67	20	66.67	X²= 17.0667, p<0.001
	Grade 1	1	3.33	6	20	6	20	
	Grade 2	10	33.33	8	26.67	4	13.33	
	Grade 3	9	30	2	6.67	0	0	
C	Grade 0	28	93.33	26	86.67	26	86.67	X²= 10.95, p<0.01
	Grade 1	1	3.33	1	3.33	0	0	
	Grade 2	1	3.33	3	10	1	3.33	
	Grade 3	0	0	0	0	3	10	

Between the group Z, p (Mann Whitney Test)	A vs B	Z=2.68337; p <0.01
	B vs C	Z=1.05709; p >0.05
	A vs C	Z=3.01602; p <0.01

Effect on Fatigue of Diabetic patients

Group	Grade	Treatment protocol						Within the group comparison (Friedman Test)
		BT		F1		F2/AT		
		No	%	No	%	No	%	
A	Grade 0	20	66.67	20	66.67	20	66.67	X²= 0.45, p>0.05
	Grade 1	5	16.67	3	10	3	10	
	Grade 2	5	16.67	5	16.67	5	16.67	
	Grade 3	0	0	2	6.67	2	6.67	
B	Grade 0	6	20	19	63.33	24	80	X²= 25.0167, p<0.0001
	Grade 1	2	6.67	5	16.67	4	13.33	
	Grade 2	12	40	6	20	2	6.67	
	Grade 3	10	33.33	0	0	0	0	
C	Grade 0	26	86.67	25	83.33	21	70	X²=0.95, p>0.05
	Grade 1	1	3.33	1	3.33	4	13.33	
	Grade 2	3	10	3	10	2	6.67	
	Grade 3	0	0	1	3.33	3	10	

Between the group Z, p (Mann Whitney Test)	A vs B	Z=1.07187; p >0.05
	B vs C	Z=-0.79097; p >0.05
	A vs C	Z=0.22916; p>0.05

Effect on Blurred vision of Diabetic patients

Group	Grade	Treatment protocol						Within the group comparison (Friedman Test)
		BT		F1		F2/AT		
		No	%	No	%	No	%	
A	Grade 0	9	30	10	33.33	10	33.33	X²= 0.7167, p>0.05
	Grade 1	17	56.67	17	56.67	19	63.33	
	Grade 2	4	13.33	3	10	1	3.33	
B	Grade 0	8	26.67	8	26.67	13	43.33	X²= 4.8667, p<0.01
	Grade 1	15	50	22	73.33	17	56.67	
	Grade 2	7	23.33	0	0	0	0	
C	Grade 0	14	46.67	11	36.67	8	26.67	X²= 1.8, p, <0.01
	Grade 1	16	53.33	16	53.33	15	50	

Grade 2	0	0	3	10	7	23.33	

Between the group Z, p (Mann Whitney Test)	A vs B	Z=0.78357; p >0.05
	B vs C	Z=-1.98111; p <0.05
	A vs C	Z=-1.32321; p >0.05

Effect on Healing of Diabetic patients

Group	Grade	Treatment protocol						Within the group comparison (Friedman Test)
		BT		F1		F2/AT		
		No	%	No	%	No	%	
A	Grade 0	30	100	28	93.33	28	93.33	X²= 0.2167, p>0.05
	Grade 1	0	0	2	6.67	1	3.33	
	Grade 2	0	0	0	0	1	3.33	
	Grade 3	0	0	0	0	0	0	
B	Grade 0	26	86.67	26	86.67	26	86.67	X²=0.95, p>0.05
	Grade 1	0	0	0	0	4	13.33	
	Grade 2	1	3.33	4	13.33	0	0	
	Grade 3	3	10	0	0	0	0	
C	Grade 0	30	100	29	96.67	28	93.36	X²=0.2167, p>0.05
	Grade 1	0	0	1	3.33	1	3.33	
	Grade 2	0	0	0	0	1	3.33	
	Grade 3	0	0	0	0	0	0	

Between the group Z, p (Mann Whitney Test)	A vs B	Z=-0.40657; p >0.05
	B vs C	Z=0.40657; p >0.05
	A vs C	Z=0.00739; p >0.05

Effect on Frequent infection of Diabetic patients

Group	Grade	Treatment protocol						Within the group comparison (Friedman Test)
		BT		F1		F2/AT		
		No	%	No	%	No	%	
A	Grade 0	23	76.67	25	83.36	26	86.67	X²= 1.0167, p>0.05
	Grade 1	2	6.67	2	6.67	3	10	
	Grade 2	3	10	3	10	1	3.33	
	Grade 3	2	6.67	0	0	0	0	
B	Grade 0	19	63.33	21	70	26	86.67	X²= 5.2167, p>0.05
	Grade 1	3	10	4	13.33	3	10	
	Grade 2	3	10	5	16.66	1	3.33	
	Grade 3	5	16.67	0	0	0	0	
C	Grade 0	30	100	28	93.33	28	93.33	X²= 0.2, p>0.05
	Grade 1	0	0	2	6.67	2	6.67	
	Grade 2	0	0	0	0	0	0	
	Grade 3	0	0	0	0	0	0	

Between the group Z, p (Mann Whitney Test)	A vs B	Z= 0.00739; p >0.05
	B vs C	Z= 0.45092; p >0.05
	A vs C	Z= 0.45092; p >0.05

Effect on Areas of darkened skin armpits and neck of Diabetic patients

Group	Grade	Treatment protocol						Within the group comparison (Friedman Test)
		BT		F1		F2/AT		
		No	%	No	%	No	%	
A	Grade 0	30	100	28	93.33	28	93.33	X²= 0.2, p>0.05
	Grade 1	0	0	2	6.67	2	6.67	
	Grade 2	0	0	0	0	0	0	
B	Grade 0	28	93.33	29	96.67	30	100	X²= 0.2167, p>0.05
	Grade 1	0	0	1	3.33	0	0	
	Grade 2	2	6.67	0	0	0	0	
C	Grade 0	29	96.67	28	93.33	24	80	X²= 1.4, p>0.05
	Grade 1	1	3.33	1	3.33	5	16.67	
	Grade 2	0	0	1	3.33	1	3.33	

Between the group Z, p (Mann Whitney Test)	A vs B	Z= 0.43614; p >0.05
	B vs C	Z=-1.32321; p >0.05
	A vs C	Z=-0.89446; p >0.05

Table 4: Effect on: FBS, RBS, PPBS, and HBA1c of 90 patients of Diabetes BT- Before Treatment; F1 – Follow up after 15 days; F2/AT -Follow after 30 days/ After Treatment; FBS - Fasting blood sugar; RBS - Radom blood sugar; PPBS - Postprandial blood sugar; * - Very- very significant; ** - Very significant; * - Significant; N. S. - Non significant**

FBS					
Parameters	**Group**	**Mean±SEM**			**Within the group Comparison paired t test (BT v/s AT)**
		BT	**F1**	**F2/AT**	
FBS	A	163.6667±8.1926	157.4333±5.8649	149.6667±5.9610	t= 2.3433 p < .05*
	B	190.0333±7.5478	170.4333±6.9568	133.5667±6.4414	t= 13.3694 p< .0001***
	C	153.3000±6.5783	168.0333±6.0461	179.4000±6.0638	t= 6.6226 p< .0001***
Among the group comparison ANNOVA test	A v/s B v/s C		F= 1.2029 p > 0.05 N.S.	F= 14.2537 p < 0.0001 ***	F= 14.2537 p < 0.0001 ***
Tukey's Honest Significance test	A v/s B		p > 0.05 N.S.	p > 0.05 N.S.	
	B v/s C		p > 0.05 N.S.	p < 0.01**	
	A v/s C		p > 0.05 N.S.	p < 0.0001***	
RBS					
Parameters	**Group**	**Mean±SEM**			**Within the group Comparison paired t test (BT v/s AT)**
		BT	**F1**	**F2/AT**	
RBS	A	202.9333±12.7828	196.6333±10.7400	189.8000±10.9774	t= 1.3644 p > 0.05 N.S.
	B	248.3000±11.6552	221.7667±9.7744	179.7000±8.8630	t= 10.0283 p< .0001***
	C	183.8333±10.0550	205.0667±10.8241	229.4333±12.8023	t= 4.1498 p< .001***
Among the group comparison ANNOVA test	A v/s B v/s C		F= 1.4963 p > 0.05 N.S.	F= 5.7118 p < 0.01 **	
Tukey's Honest Significance test	A v/s B		p > 0.05 N.S.	p > 0.05 N.S.	
	B v/s C		p > 0.05 N.S.	p < 0.01**	
	A v/s C		p > 0.05 N.S.	p < 0.05*	
PPBS					
Parameters	**Group**	**Mean±SEM**			**Within the group Comparison paired t test (BT v/s AT)**
		BT	**F1**	**F2/AT**	
PPBS	A	219.7000±13.5714	209.8333±10.2667	202.133±11.0167	t= 1.7175 p > 0.05 N.S.
	B	270.3333±11.6163	239.8667±10.0494	188.7333±7.8779	t= 9.3348 p< .0001***
	C	199.1333±10.9131	218.2000±11.6053	244.0000±14.0559	t= 3.8513 p< .001**
Among the group comparison ANNOVA test	A v/s B v/s C		F= 2.1131 p > 0.05 N.S.	F= 6.5444 p < 0.01 **	

Tukey's Honest Significance test	A v/s B	p > 0.05 N.S.	p > 0.05 N.S.	
	B v/s C	p > 0.05 N.S.	p < 0.01**	
	A v/s C	p > 0.05 N.S.	p < 0.05*	

		HBA1c		
Parameters	**Group**	**Mean±SEM**		**Within the group Comparison paired t test (BT v/s AT)**
		BT	**AT**	
HBA1c	A	7.6967±0.2937	7.4300±0.2393	t= 1.2664 p > 0.05 N.S.
	B	9.2400±0.3655	8.1633±0.3438	t= 4.2417 p< .001**
	C	7.3200±0.3012	8.4367±0.3502	t= 6.3503 p< .0001***

Effect on Blood sugar levels

Figure 2: From day 1 to 15th day Comparative effect on: a) FBS; b) RBS; and c) PPBS of 90 patients in three groups of the study (ANNOVA and Tukey's Honest Significance test) is presented	Figure 3: From day 16th to 30th day Comparative effect on: a) FBS; b) RBS; and c) PPBS of 90 patients in three groups of the study (ANNOVA and Tukey's Honest Significance test) is presented
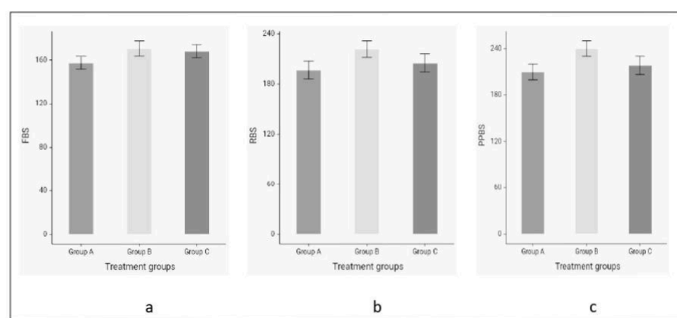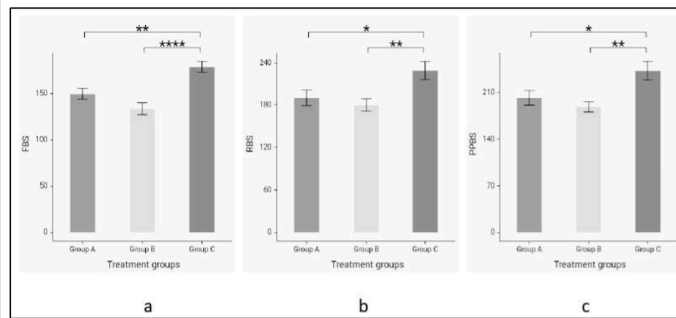
Discussion

Diabetes requires early detection, treatment, and lifestyle changes(16). Psychological stress increases the likelihood of developing diabetes and making it worse (17). Sedentary lifestyles have been found to raise the risk of diabetes by three times and coronary heart disease by 2.4 times (17) Many yoga postures have been demonstrated to aid in the management of type 2 diabetes; nevertheless, their cautious application is only recommended following a comprehensive assessment of the patient's overall health, individual needs, associated risk factors, and contraindications(18). When doing the Surya namaskar, a series of challenging yoga poses are performed in a certain order. A forceful, rapid Surya namaskar increases the quantity of glucose and oxygen required by cells. To address these needs, brain signalling promotes the production of insulin(19). Mindfulness may be helpful in elevating binge-eating patterns and in meditating. It has been shown that improving food consumption and practicing mindful eating can help diabetics manage their blood sugar levels and achieve modest weight loss (20). In most developing countries, it is vital to mainstream traditional, nutrient-dense, and less glucogenic staples and diversify dietary mainstays to control and prevent diabetes; millets are at the top of this list(21). Furthermore, the phytochemical and HRMS analysis of little millets were performed in our earlier study.

Nutrient qualities are evident, containing essential components such as protein, phosphorus, carbohydrates, niacin, magnesium, phosphorus, and fibres (22). According to the HRMS study, many antidiabetic substances including Hispidin, Caffeine, Aicar, Ketotifen, Maltitol, Tacrolimus, and Pipemidic Acid were founded in Little millet (23). Thus, the impact of Surya namaskar and small millets was assessed in this study on several subjective and objective measures of diabetes in 90 individuals with the disease.

In present Randomised Control Trail study by continuing pre-existing hypoglycemic medication subjects were treated by giving diet of cooked little millets and followed by Surya namaskar as part of intervention is studied for one month duration and it is observed that the study participants benefited therapeutically which is noticed by the observation of subjective and objective parameters.

Demographic findings

Diabetes has been found more frequently in men, with the age range of 41 to 50 years old having the highest number of cases. Though the condition is caused by a sedentary lifestyle, individuals who commute to work are the ones who get it most frequently. However, prolonged periods of sitting at work can be the cause. Additionally, there is a higher incidence rate among those who are having weight

more than 60 Kg and have a high BMI. The majority of diabetics already were taking allopathic medications.

Effects on subjective parameters (Increased thirst, Frequent urination, Increased hunger, Weight loss, Fatigue, Blurred vision, Healing, Frequent infections and Areas of darkened skin usually in armpits and neck)

According to present research, the combined therapy of Surya namaskar and Little millet diet has been found to be highly beneficial in lowering symptoms of increased thirst, frequent urination, increased hunger, weight loss, fatigue, blurred vision, and healing. This effect was particularly noticeable in the groups that received both interventions. Yet, there has been no discernible improvement in the areas of darker skin, typically on the neck and armpits, and in recurrent infections. Obesity and weight management are important variables in the management and prevention of diabetes. Because millets have less energy density and more fiber than processed grains, they can aid with weight management. Previous clinical researches have also shown that millet can aid in weight loss or maintenance by lowering caloric intake and increasing feelings of fullness(24).

Effect on Fasting blood sugar and Random blood sugar levels

After a month, the study's findings showed that both the Surya namaskar and little millets intervention group and the Surya namaskar group were effective in lowering fasting blood sugar levels. The Little millet group that is administered by following with Surya namaskar, however, has demonstrated the most notable impact. Further it is noticed that the intervention group in which little millet diet followed by Surya namaskar has demonstrated a substantial impact on lowering the random blood sugar levels. The reason for reduction of random blood sugar levels could be because the Little Millets contains a lot of dietary fibre, which is important for regulating blood sugar. Fibre assists in preventing abrupt spikes in blood glucose levels by postponing the digestion and absorption of carbohydrates. More specifically, soluble fibre forms a gel-like substance in the digestive tract that inhibits the stomach's emptying and the release of glucose into the bloodstream. This slower release of glucose promotes better glycemic control and more stable blood sugar levels. Furthermore, one feels satisfied for diet and is less prone to overeat or consume large quantities of high-glycemic foods due to the satiety that comes from the fibre in millets(25).

Effect on Postprandial sugar levels

According to previous studies, adding millets to meals in addition to Surya namaskar can significantly lessen the postprandial glucose response which is defined as a delayed and less noticeable rise in blood glucose levels following a meal when compared to the control group and Surya namaskar alone. Millets are thought to have a positive influence because of their high fiber content, low GI, and good phytochemical content. By altering the postprandial glucose response, millet can help diabetics maintain more consistent blood sugar levels throughout the day. This may minimise the need for excessive insulin secretion and enhance the control of blood sugar over the long run(25).

Effect on HbA1c

According to the present study, both intervention groups in one month duration of treatment are effective in lowering HBA1c values after treatment. Group A (followed Surya namaskar) has shown mild effect in reducing HBA1c after treatment. Whereas Group B (Little millet diet followed by Surya namaskar) has shown significant effect in reducing HBA1c after treatment. However, in Group C i.e., Control group increase of HBA1c after one month duration of study is observed.

Limitations of the study

We are aware of several limitations of our study, as due to limited period of study and less number of subjects did not provide sufficient power to confirm the superior effect of HbA1c. Given that the trial lasted for a month. Thus, that could be the cause of the HbA1c lack of considerable reduction in relation to other parameters (26).

Conclusion

The present study concluded Antidiabetic effect of Surya namaskar and Little millet diet. Over the course of the four weeks of treatment, a number of indices in the intervention group decreases, indicating its role in diabetes control. According to present study, the combined therapy of Surya namaskar and little millet diet has been found to be highly beneficial in lowering symptoms of diabetes. Further observation reveals that the only group intervention that significantly lowers random blood sugar, postprandial levels and HbA1c is the millet group intervention with Surya namaskar. The study results concluded that if both the Surya namaskar and millets are intervened to diabetic patient, it plays a significant role in managing diabetes indicating that both physical activity (Surya namaskar) and diet (Little millets) will help managing the diabetes. In future more studies may be conducted in large sample size, multicenter, and also intervention period can be increased for more days to validate the results accurately.

Conflict of interest

The authors have declared that no competing interests exist.

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