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Evaluating the efficacy of yogic practices and mud therapy in influencing biochemical parameters among middle aged women with type 2 diabetes mellitus – A randomized controlled trial study

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Type 2 diabetes mellitus is one of the more prevalent long term metabolic disorders creating a formidable health hazard globally, especially in middle-aged women. This study evaluates the effectiveness of complementary holistic practices like the yoga and mud therapy on biochemical variables' levels, such as glycated haemoglobin (HbA1c), fasting blood sugar (FBS), post prandial blood sugar (PPBS), and Triglyceride (TG) among the middle-aged women suffering with Type 2 Diabetes Mellitus of Chennai district. 90 subjects, aged between 45 to 55 years, were selected through randomized sampling and grouped into three, such as Group A (Yoga and Mud Therapy), Group B (Yoga) and Group C (Control Group), with 30 participants in each category. Group A had 1.5 h session per day, which includes 1 h of structured yoga program comprising Sukshma Vyayama, Surya Namaskar, Asanas, Pranayama, Dhyana and 30 min of mud therapy and Group B had 1 h of structured yoga five days a week, for a time span of 12 weeks, wherein Group C were in active rest. Pre and post intervention biochemical variable levels were recorded to assess changes in glycemic control. Paired t-test and ANOVA were implemented to understand the changes of the glycemic levels. The results indicated a significant reduction in all biochemical variables level under consideration in Group A ($p<0.001$) in comparison to the other groups. The results imply that yoga and mud therapy practiced regularly could benefit middle-aged women in the management of T2DM. A longer period of intervention could provide more confirmation on the effect of these practices on reducing levels of proposed biochemical variables.

Keywords: Biochemical variables, Biomarkers, Diabetic women, Middle aged, Mud therapy, Yoga

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T2DM, often known as diabetes mellitus, is a collection of long-term metabolic nutritional disease or ailment, characterized by persistent hyperglycemia because of deficiency in the secretions of insulin hormone action, or both[1]. Diabetic retinopathy, nephropathy, neuropathy, and cardiovascular diseases are the major complications associated with this disease condition. This may eventually cause damage to the organs, hence declining life quality and increasing rate of mortality. Polyphagia, polyuria, polydipsia, increased thirst, frequent urination, impaired vision, exhaustion and weight loss are typical symptoms and signs of Diabetes. The typical fasting blood glucose threshold is 109 mg/dL[1], at the point where serious implications including cardiovascular disease, renal failure, neuropathy, and others emerge. Diabetes is classified into two types: Type 1 Diabetes, a form of an autoimmune disease requiring insulin therapy for living, and insulin-sensitive tissues' incapacity to react and the pancreatic β-cells' insufficient synthesis of insulin are the two main causes of type 2 diabetes[2]. The IDF has assessed that worldwide, 422 million of all types are suffering from type 2 diabetes. It further projects the number may blow up to 600 million by the year 2030[3]. Diabetes mellitus has caused 5.1 million deaths in 2013 and every six seconds a person dies from DM[4]. T2DM is a disease resultant of pathophysiological interplay between the pancreas, liver, skeletal muscle, and adipose tissue. The majority of Type 2 diabetes people aged 40 to 59 are anticipated to exceed 592 million by around 2035,

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representing a global prevalence of 10.1%[5]. Up to this date, administration remains imperative to curb these kinds of problems. They mostly entail lifestyle modifications that include adjustments to food consumption and exercise routines.

In order to manage both type 2 diabetes and other chronic diseases, many people at present choose complementary therapies like yoga and naturopathy because of its comprehensive approach that emphasizes overall well-being rather than merely treating symptoms. Over several thousand years, yoga has emerged as a holistic approach to a well being for attaining development on all levels-physical, mental, and spiritual. In order to establish balance between the mind and body, the practices incorporate a variety of methods, such as physical postures (asanas), breath control (pranayama), and meditation (dhyana)[6]. The scientific community has recently shown an interest in learning more about yoga's therapeutic advantages. The accruable benefits of yoga practices are an increase in flexibility, strength, and cardiovascular health, as well as significant reductions in stress, anxiety, and depression[7]. The research findings also underline the integration of yoga into the contemporary model of health practices for better living in various spheres of life. With more research coming forward about its benefits, the applications of yoga in depth have become increasingly essential; it shows the deep interaction between our physical and mental body[8].

Emerging literature highlights the fact that yoga can be a useful adjunct therapy in managing T2DM. It has been proven that yoga practice improves glucose uptake, insulin sensitivity, and glycemic control in diabetic patients. Furthermore, yogic practices have been proven in the reduction of risk factors like cardiovascular conditions, lipid profiles or hypertension, and are important for diabetes management[9]. The advantages of the yogic practices that are part of consolidated pool of structural practices like Sukshma Vyayama (micro/subtle joint movements for upper/lower parts relieve joint stiffness muscle tension that bring about relaxation); and yoga asanas (help overcome weakness and reduce anxiety) and respiratory system that's specifically chosen for each patient to improve lung capacity and flexibility, enhance blood circulation, and bring about a profound sense of peace; some metabolic body activity and secretion of endocrine glands[10].

The interests were also grown towards naturopathy, because of its ability to control diabetes first. Yoga and Naturopathic intervention make it easier to clinical results in the treatment of diabetes mellitus 2. Naturopathy assists in traditional practices like the mud therapy, massage therapy or the cold hip bath and rejuvenates the body and can be useful for hyperglycaemic patients[11]. Mudpacks and mud baths are two main and popular forms of mud therapy. The unique mud properties are that it can absorb heat, dissolve toxins and also erase it. It also helps to degenerate morbid matter. Mud therapy was intended to alleviate tissues and organs that boost bodily capacity[12] and eliminate heat and overload, improve blood circulation in the abdominal and pelvic areas, and absorb poisonous chemicals. Mud therapy balances the digestive system with the endocrine organs, which diabetic patients do not use enough, causing toxins to build up. Additionally, mud therapy has a number of therapeutic benefits that make it an excellent choice for treating a wide range of other illnesses[13].

Mud from multiple regions of the world exhibits various features because of their unique composition, which has been generated by environmental and geological factors. The different rock varieties found in the area and the processes involved in the formation of soil influence the minerals that will be present in the mud. The flora and fauna of a region also had a main role in the characteristics of the mud. The mud used for the treatments should be treated well by drying it, grinding it, and sieving it to remove impurities such as stones and plant material[14].

Recent studies have accentuated the therapeutic values of different kinds of mud being used for the therapeutic process. Black mud, is enriched in mineral content and water-retention properties which promotes skin health and overall well-being[15]. Dead Sea mud contains a complex mixture of minerals like magnesium, calcium, potassium, bromide, silicates, and natural tar, useful for their therapeutic effect on various skin disorders, improving skin texture and blood circulation that result in radiant glow. Rich in fulvic acids, vitamins, amino acids, plant hormones, and humic acids, moor mud has been shown to be beneficial for post-trauma rehabilitation and the treatment of conditions like arthritis[16].

Despite the heightened interest in these alternative therapies, only very little scientific evidence exists

that examines their effectiveness in altering diagnostic biomarkers among middle-aged women with T2DM. The earlier studies were conducted on a more substantial population, and only few of them focused on middle-aged women. Although individual effects of yoga and mud therapy have been studied, it would be very useful to explore their combined impact on the clinical outcome such as HbA1c, FBS, PPBS and TG. Therefore, this study will contribute to the existing body of knowledge and can provide potential tactics for the incorporation of alternative therapies in diabetes management.

Materials and Methods

Study design

A study using randomized controlled trial study was implemented with the aim to evaluate the efficacy of yogic practices and also mud therapy that might bring positive changes in diagnostic biomarkers among middle-aged women diagnosed with T2DM of age ranging from 45 to 55 years residing in Chennai. The simple randomization method using lottery picking method of three groups namely the Group A, Group B and Group C. The Group A consists of yoga and mud therapy, Group B has yoga alone and Group C as the control group were followed. Each group consisted of 30 in each group, total of 90 subjects overall. The duration of the study was for 3 months, 5 days a week yoga and mud therapy sessions with one and half hour, yoga alone with one hour and no training protocol for control group, all under standard care with diabetic medication and current lifestyle conditions. Blood collection was done before the beginning of the training program, in the middle of 6th week and once after the 12th week program, except HbA1c, which was taken before the training program started and later after the interval period of 3 months after 12th week of intervention paired t-test, chi square and ANOVA were conducted for statistical analysis. The institutional ethical clearance to conduct this study was obtained from Meenakshi Medical College Hospital and Research Institute, Kanchipuram, Tamil Nadu (MMCH&RI/PhD/18/JAN/23) on 20.02.2023 and this trial was also registered with Clinical Trial Registry – India, New Delhi (CTRI/2023/06/053685) on 08.06.2023.

Study population

Inclusion criteria

1. Completion of the written consent form and willingness to take part in the study.
2. Women in their middle age who have Type 2 Diabetes mellitus
3. Women Aged ranging between 45 to 55 years.
4. No history of practicing yoga or other exercises.
5. Determined as suitable for practicing yoga therapy through physical exam.
6. Residing in Chennai city.

Exclusion criteria

1. Women in pregnancy or lactation period
2. Presence of any sort of heart, liver or renal complications
3. Active clinical surgery or another major illness or condition of clinical significance.
4. History of psychiatric illness
5. Patients on prolonged medication for any other morbid condition.
6. Person suffering with severe High Blood Pressure
7. Those do not give consent.

Sample size

The statistical calculation showed that the required sample size was 90. By randomised sampling, 90 samples were selected. Using computer-generated randomization sequence, these samples they were further assigned to three groups: Group A -Therapy yoga and mud, only Group B -yoga, Group C All the groups consisted of 30 samples in each group.

Duration of the study

The time duration of this yoga therapy session was 3 months (12 weeks), 5 days per week with each session lasting for 1 h for both Group A and B and additional 30 min mud therapy session for Group A alone. The control group remained under active rest, with standard care.

Measurement

For conducting the blood test to assess the level of HbA1c of selected samples, a Biorad apparatus was used adopting the HPLC method, Hexokinase Test method for fasting blood sugar, post prandial blood sugar and glycerol phosphate for tri glyceride.

Intervention

The one-hour structured yoga program was followed and delivered for Type 2 Diabetic middle-aged women in both Group A and Group B:

Yoga module

S. No	Yoga module	Duration
1.	Sukshma Vyayama (Loosening exercises)	5 min
2.	Surya Namaskar	10 min
3.	Asanas ➢ Tadasana ➢ Trikonasana ➢ Vipharita Karani ➢ Halasana, ➢ Matsyasana, ➢ Dhanurasana, ➢ Pavanmuktasana, ➢ Ardha Matseynedrasana, ➢ Paschimotasana ➢ Mandukasana	20 min (2 min for each Asana)
4.	Pranayama ➢ Bastrika ➢ Nadi Shodhana ➢ Bhramari	15 min
5.	Meditation ➢ Yoga Nidra	10 min

The above session was followed by 30 min of mud therapy session for Group A alone.

Preparation of mud

The abdominal mud packs were prepared from the best selected black soil extracted from a depth of 3-4 ft underground from ecological agricultural land near the water formation, because this generic black soil around water formations is considered suitable for mud therapy. It will be ensured that mud does not contain pebbles, compost or no dirt that was sent for laboratory analysis for further inspection before the treatment protocol.

Procedure

First, the mud was poured into the distilled water to turn it into a smooth paste. The mixture is left standing so that it cools down. Meanwhile, the abdominal region was fomented for about 5 or 10 min till it gets heated quite enough. Later the cooled mud was then poured from the vessel into a strip of cloth and made into a bandage. The prepared mud pack was then placed over the participant's abdomen for about 20 min and was protected with a blanket. The size of the mud pack used in the experiment varied according to the size of the participant's abdomen. However, the average size of the mud pack used was 20 * 10 * 2.5 cm in dimensions.

Statistical analysis

Data were analysed utilized by paired 't' - test to estimate the effectiveness of yogic practices and mud therapy on the bio-chemical variables (HbA1c, FBS, PPBS and TG) among the T2DM middle aged women and ANOVA was used to find out the difference of the effect on the value between the three groups on efficacy of yogic practices and mud therapy among middle aged women diagnosed with type-2 diabetes mellitus. Chi square test was carried out in case of demographic variables.

Results

Demographic distribution in (Table 1) states that between 90 samples, there are 60% of participants of 50 years and older in yoga with a group of mud therapy; While 53.5% of yoga participants and 60% of those in the control group are under 50 years of age. Approximately 93.3% of the yoga group with the mud therapy group, 86.7% in the yoga group and 96.7% in the control group. Only 10% of yoga participants worked with the mud therapy group and 30% in yoga and control groups. Almost 100% of women in the yoga with a group of mud therapy, 93.3% of women who are in the yoga group and 70% respondents in the control group reached the level of higher secondary education. Most participants, *i.e.;* 76.7% of women in yoga with mud therapy and control group and 83.3% of women in the yoga group are in the phase of menopause.

Table 2, 3, 4 & Table 5, showed that the HbA1c level was significantly reduced in yoga and mud

Table 1 — Demographic distribution of the samples

Characteristics	Group A (%)	Group B (%)	Group C (%)
1. Age in years			
a. < 50 years	40.0	53.5	60.0
b. ≥ 50 years	60.0	46.7	40.0
2. Marital status			
a. Married	93.3	86.7	96.7
b. Unmarried	3.3	0.0	0.0
c. Divorced	3.3	13.3	3.3
3. Occupation			
a. Working	10.0	30.0	33.3
b. Non-working	90.0	70.0	66.7
4. Education			
a. Secondary	0.0	6.7	30.0
b. Higher secondary	100.0	93.3	70.0
c. College	0.0	0.0	0.0
5. Menopause status			
a. Pre-menopause	23.3	16.7	20.0
b. Menopause	76.7	83.3	76.7
c. Post-menopause	0.0	0.0	3.3

Group A – Yoga with mud, Group B – yoga, Group C – control group

therapy group (Group A) after 12 weeks of treatment. While in yoga group alone (Group B) the change in HbA1c value was moderately reduced. The control group (Group C) showed no changes in the value of HbA1c. The fasting blood sugar was reduced significantly after the 12th week of treatment in the Yoga and Mud therapy group, while in the 6th week showed only moderate change in the FBS. However, the fasting blood sugar did not reach the standard normal level. The postprandial blood sugar levels have significantly reduced to normal value in the Group A and B after the 12th week of treatment. However, the reduction of PPBS was found to be gradual as shown after the 6th week of treatment in both A and B groups. The triglyceride level was slightly reduced in both Groups A and B as compared with the Control group as shown in the Table 2,3,4 & Table 5.

Table 2 — Descriptive statistics for biochemical variables and among middle aged type 2 diabetic women in pre-test for yoga with mud, yoga and control group

Biochemical Variables	Yoga with Mud (n = 30)	Yoga (n = 30)	Control group (n = 30)	F test value and p value
	Mean (S.D)	Mean (S.D)	Mean (S.D)	
HbA1c	7.30	7.71	7.29	F = 3.526
	(0.54)	(0.82)	(0.73)	p= 0.034*
FBS	159.10	155.30	168.97	F = 2.700
	(22.12)	(23.37)	(24.96)	p= 0.073(N.S)
PPBS	200.93	240.60	261.50	F = 12.485
	(36.37)	(53.14)	(51.73)	p= 0.000***
TG	214.53	217.93	227.60	F = 0.523
	(44.33)	(57.72)	(51.07)	p= 0.594***

* - p<0.05, *** - p<0.001 Level of Significant, N.S. – Not Significant
HbA1c- Glycated hemoglobin: FBS- fasting blood sugar; PPBS-post prandial blood sugar; TG-triglyceride

Table 3 — Descriptive statistics for biochemical variables and among middle aged type 2 diabetic women in post-test 1 for yoga with mud, yoga and control group

Biochemical Variables	Yoga with Mud (n = 30)	Yoga (n = 30)	Control group (n = 30)	F test value and p value
	Mean (S.D)	Mean (S.D)	Mean (S.D)	
HbA1c	Nil	Nil	Nil	F = 2.750
				p= 0.082 (N.S)
FBS	140.70	146.93	169.23	F = 15.718
	(16.00)	(20.72)	(24.56)	p= 0.000***
PPBS	174.07	213.83	261.53	F = 28.416
	(35.60)	(46.15)	(51.74)	p= 0.000***
TG	214.53	217.93	227.60	F = 0.523
	(44.33)	(57.72)	(51.07)	p= 0.594***

* - p<0.05, *** - p<0.001 Level of Significant, N.S. – Not Significant
HbA1c- Glycated hemoglobin: FBS- fasting blood sugar; PPBS-post prandial blood sugar; TG-triglyceride

Table 4 — Descriptive statistics for biochemical variables and among middle aged type 2 diabetic women in post-test 2 for yoga with mud, yoga and control group.

Biochemical Variables	Yoga with Mud (n = 30)	Yoga (n = 30)	Control group (n = 30)	F test value and p value
	Mean (S.D)	Mean (S.D)	Mean (S.D)	
HbA1c	6.62	7.04	7.29	F = 10.190
	(0.55)	(0.84)	(0.74)	p= 0.000***
FBS	124.90	134.47	169.43	F = 44.791
	(12.21)	(18.23)	(24.96)	p= 0.000***
PPBS	134.53	179.40	261.23	F = 81.335
	(12.17)	(41.79)	(51.69)	p= 0.000***
TG	181.87	195.63	228.93	F = 10.842
	(27.24)	(38.14)	(51.62)	p= 0.000***

*** - p<0.001 Level of Significant
HbA1c- Glycated hemoglobin: FBS- fasting blood sugar; PPBS-post prandial blood sugar; TG-triglyceride

Table 5 — Overall effectiveness of biochemical variables and comparison between yoga with mud, yoga and control Group among aged Type 2 Diabetic women.

Biochemical Variables	Yoga with Mud (n = 30)		Yoga (n = 30)		Control group (n = 30)		F test value and p value
	Mean (S.D)	Paired t test & p value	Mean (S.D)	Paired t test & p value	Mean (S.D)	Paired t test & p value	
HbA1c	0.67 (0.32)	t= 11.356 p=0.000 ***	0.31 (0.18)	t= 9.560 p= 0.000 ***	0.00 (0.10)	t=0.000 p= 1.000 (N.S)	F = 69.12 p= 0.000***
FBS	18.40 (8.87)	t=11.368 p=0.000 ***	8.37 (7.22)	t= 6.345 p=0.000 ***	0.27 (4.83)	t= 0.302 p= 0.765 (N.S)	F = 50.959 p= 0.000 ***
PPBS	26.87 (13.04)	t=11.285 p=0.000 ***	26.77 (20.52)	t= 7.144 p= 0.000 ***	0.03 (2.51)	t=1.073 p= 0.943 (N.S)	F = 36.201 p= 0.000 ***
TG	32.67 (28.46)	t=6.287 p=0.000 ***	22.30 (28.56)	t= 4.277 p= 0.000 ***	1.33 (4.51)	t= 1.621 p=0.116 (N.S)	F = 16.404 p= 0.000***

*** - p<0.001 Level of Significant, N.S. – Not Significant

Discussion

In present days, conventional and alternative medicine like yoga, naturopathy is gradually gaining popularity among healthcare consumers. People prefer to adopt these approaches for their holistic nature, minimum side effects, stress-reducing capabilities[17], improvement in insulin sensitivity[18], detoxification process[19] and cost-effectiveness[20].

The association of HbA1c with prolonged blood glucose control in the management of diabetes has been well documented. This biomarker essentially serves as an indicator of glycemic levels which reflects blood sugar averages above the preceding 2 to 3 months. For diabetic patients, it is more essential, since it is estimated that maintaining optimal levels of HbA1c reduce complications associated with this disease[21,22]. Various studies conducted on yoga interventions point out that there is a significant reduction in HbA1c levels among the subjects who practiced yoga[22-25]. The effectiveness is particularly true in cases where yoga was used with other treatment modes[26]. The current research work corroborated with the earlier reports. The revelations of the study imply that the combined approach of yoga and mud therapy are much more effective in reducing the level of HbA1c among middle aged women than practicing only yoga. These findings are further supported by the studies conducted by Shrivastava *et al.*[25] Saberipour *et al.*[26] Singh A, Tekur *et al.*[27] that states integrated approaches enhance lifestyle interventions for diabetes management, might have a better outcome regarding the control of glycemic index rather than yoga alone or with any other therapies.

This study also investigated whether the delivered intervention had an impact on blood sugar levels in response to a meal. Several studies have illustrated that habitual yoga practice may cause significant metabolic changes and promote effectiveness in lowering FBG levels of patients with type 2 diabetes[23,28,29]. However, results of this study have also demonstrated that yoga may be effective as a therapeutic intervention per se when combined with mud therapy, in the management of diabetes than practicing yoga alone, due to the greater reduction in fasting blood sugar levels in Group A (Yoga with Mud therapy) comparatively.

The PPBS is another important parameter in the management of diabetes since it demonstrates how well a person's body would assimilate glucose following the intake of a meal. As high postprandial glucose levels have a higher potential for diabetic complications, their control is considered as an essential aspect of effective diabetes care[30]. There are numerous reports of results that cite beneficial effects of yoga on improving insulin sensitivity along with the metabolism of glucose and decreasing the postprandial blood glucose levels and fasting rates in the body of the individual with type 2 diabetes[25,26,31]. Nevertheless, the conclusions of this study reveals that there is a substantial reduction in the level of PPBS post integrated intervention of yoga and mud therapy rather than practicing yoga alone.

Previous researchers have indicated that practicing yoga on regular basis helps diabetes patients to lower their lipid profile through lowering their triglycerides and total cholesterol while improving their glycemic control[25,31,32], it is evident from this study that the combined approach of yoga and mud therapy yields greater positive outcomes than the yoga group which was supported by the study conducted by Innes & Selfe[32] and Athira M S[33].

These research evidence suggests that Yoga in conjunction with mud therapy can significantly impact glycemic index. Statistical analysis of the current study reflects the effectiveness of this complementary intervention and proves that it can be helpful in the control of diabetes. This may be because of the nature of yogic practices, which encompass repeated exercises in breath work, postures, and meditation generally appear to improve metabolic fitness. To be specific, loosening exercises in yoga might warm the body, improve blood circulation, and prepare the muscles for more intense activities, thereby enhancing insulin sensitivity and glucose uptake by muscles[34]. The regulated breathing during the performance might enhance oxygen supply to the blood that aids in cellular function and glucose metabolism. Yoga may also enhance the posture and balance of an individual hence improves overall bodily activity and glucose metabolism[35]. It stimulates the abdominal organs and, therefore, aids in improvement of digestion and insulin function[35,36]. The relaxing nature of yoga can lead to stress reduction which in turn might lower blood sugar[36]. On the other hand, the cooling effect of abdominal mud pack on the body may ease inflammation and improve blood circulation which might enhance insulin sensitivity and glucose uptake by cells. Mud therapy also acts as detoxification process by sucking toxic substances from the body through skin. Thus, it may reduce the oxidants responsible for the development and exacerbation of diabetes[37]. According to Verma S Kumar and Meena's study, about 20% of people do yogic practices to cure certain diseases like blood pressure, diabetes as well to alleviate the individual's natural immunity[38]. Hence combining both of these approaches might have yielded greater effect on reduction of levels of biochemical variables.

Though the results are statistically significant, there are also some limitations in the study conducted, from which the results needed have to be interpreted and brought into view. The sample size is considerably low with 90 cases, thus limiting the generalization of the results[39]. An intervention period of 12 weeks is less for totally assessing the long-term effects of yogic practices and mud therapy on Type 2 Diabetes Mellitus. Moreover, participants' diet or medical regimens were not under control during the study, which may be the sources of confounding variables. By focusing exclusively on middle-aged women, this research provides limited knowledge about the impact of this intervention on other groups, such as men or individuals with different ages. Lastly, the sustainability of these improvements was not recorded. This can be done through long-term follow-up. Future studies shall overcome these limitations by recruiting larger and more diverse populations, longer durations of follow-up, and involving diverse set of populations.

Conclusion

This study examined the efficacy of yogic practices and mud therapy in influencing biochemical variables among the middle-aged type 2 diabetic women. Findings suggest that therapeutic benefit of yoga along with mud therapy showing greater improvement in biomarkers like HbA1c, FBS, PPBS, TG. Therefore, these results highlight the potential of non-pharmacological and holistic approaches in diabetes management and overall well-being.

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Conflict of Interest

The authors affirm that they have no conflicting interests.

Author Contributions

Both the authors contributed significantly to the study's conception, design, data collection, analysis, and manuscript preparation. B has designed the study and drafted the manuscript. D has conducted the statistical analysis, and helped with the overall editing and corrections of drafted manuscript. The authors have read and approved the final version of the manuscript before the submission and made some necessary changes after the reviewers' valuable suggestions too.

Ethics Approval

This study was conducted in accordance with the ethical principles Ethical approval was obtained from Institutional Human ethics Committee of Meenakshi Medical College Hospital and research Institute, Kanchipuram, Tamil Nadu (MMCH&RI/PhD/118/JAN/23) and Clinical Trial Registry Institute, New Delhi-CTRI/2023/06/053685) on 8th June, 2023.

Informed Consent

Written informed consent was obtained from all participants prior to their inclusion in the study. Participants were assured that their data would remain confidential and be used solely for research purposes.

Data Availability

The datasets generated and analyzed during the current study are available from the corresponding author upon reasonable request due to privacy of research participants and ethical considerations.

References

1 American Diabetes Association, Diagnosis and classification of diabetes mellitus, *Diabetes Care*, 36 (Suppl 1) (2013) S67-S74.

2 Miser W F, The management of type 2 diabetes mellitus focus on quality, *Prim Care*, 34 (1) (2007) 1-38.

3 Mukhopadhyay A & Mondal Prosenjit MApplication of Nano-biotechnology for improvement in therapeutic approaches for the treatment of Diabetes, *J Clin Mol Endocrinol*, 3(2) (2018).47

4 Balakumar P, Implementation of fundamental signalling alterations in Diabetes Mellitus-associated cardiovascular disease, *Indian J Biochem Biophysics*, 51 (6) (2014) 444-448

5 Kharroubi A T & Darwish H M, Diabetes mellitus: The epidemic of the century, *World J Diabetes*, 6 (6) (2015) 850-67.

6 Gowri M M, Rajendran J, Srinivasan A R, Bhavanani A B & Meena R, Impact of an integrated yoga therapy protocol on insulin resistance and glycemic control in patients with type 2 Diabetes Mellitus, *Rambam Maimonides Med J*, 13 (1) (2022) e005. DOI: 10.5041/RMMJ.10462

7 Wibowo R A, Nurámalia R, Nurrahma H A, Oktariani E, Setiawan J, *et al*., The effect of yoga on health-related fitness among patients with type 2 Diabetes Mellitus: A systematic review and meta-analysis, *Int J Environ Res Public Health*, 19 (7) (2022) 4199.

8 Ross A & Thomas S, the health benefits of yoga and exercise: a review of comparison studies, *J Altern Complement Med*, 16 (1) (2010) 3-12.

9 Singh V P & Khandelwal B, effect of yoga and exercise on glycemic control and psychosocial parameters in type 2 Diabetes Mellitus: A randomized controlled study, *Int J Yoga*, 13 (2) (2020) 144-151.

10 Bentur S A, Mishra A, Kumar Y, *et al*., Integrative therapy based on yoga, ayurveda and modern western medicine for treatment of high-risk cases of COVID-19: A telemedicine-based case series, *Indian J Tradit Know*, 21 (3) (2022) p. 475-488

11 Semantic Scholar, Role of naturopathy on physical and biochemical parameters in patients with Type 2 diabetes mellitus, Available [Online] https://www.semanticscholar.org/paper/Role-of-naturopathy-on-physical-and-biochemical-in-Chawla-Nair/abdec12d51d17492790911db05b42a9d6a71c3ac accessed on 14-09-2024.

12 Rastogi R, Therapeutic uses of mud therapy in Naturopathy. Available online: https://www.semanticscholar.org/paper/Therapeutic-uses-of-Mud-therapy-in-NaturopathyRastogi/6ba707ff707ee130dd42f2a148b27738bc050ebb (Accessed on 14 September,2024)

13 Cozzi F, Carrara M, Sfriso P, Todesco S & Cima L, Anti-inflammatory effect of mud-bath applications on adjuvant arthritis in rats, *Clin Exp Rheumatol*, 22 (6) (2004) 763-766.

14 Sukenik S, Buskila D, Neumann L, Kleiner-Baumgarten A, Zimlichman S, *et al.*, Sulphur bath and mud pack treatment for rheumatoid arthritis at the Dead Sea area, *Ann Rheum Dis*, 49 (2) (1990) 99-102.

15 Britschka Z M N, Teodoro W R, Velosa A P P & De Mello S B V, The efficacy of Brazilian black mud treatment in chronic experimental arthritis, *Rheumatol Int*, 28 (1) (2007) 39-45.

16 Hahm S C, Shin H J, Lee M G, Lee S J & Cho H Y, Mud therapy combined with core exercise for chronic nonspecific low back pain: A pilot, single-blind, randomized controlled trial, *Evid-Based Complement Altern Med*, 2020 (2020) 7547452. doi: 10.1155/2020/7547452.

17 NCCIH, Yoga for Health: What the Science Says, Available [Online] https://www.nccih.nih.gov/health/providers/digest/yoga-for-health-science accessed on 14-09-2024.

18 Phutrakool P & Pongpirul K, Acceptance and use of complementary and alternative medicine among medical specialists: a 15-year systematic review and data synthesis, *Syst Rev*, 11 (1) (2022) 10. doi: 10.1186/s13643-021-01882-4

19 Walia N, Matas J, Turner A, Gonzalez S & Zoorob R, Yoga for substance use: A systematic review, *J Am Board Fam Med*, 34 (5) (2021) 964-973.

20 Colberg S R, Sigal R J, Yardley J E, Riddell M C, Dunstan D W, *et al.*, Physical activity/exercise and Diabetes: A position statement of the American Diabetes Association, *Diabetes Care*, 39 (11) (2016) 2065-2079.

21 Thind H, Lantini R, Balletto B L, Donahue M L, Salmoirago-Blotcher E, *et al.*, The effects of yoga among adults with type 2 diabetes: A systematic review and meta-analysis, *Prev Med*, 105 (2017) 116-126.

22 Gupta D B S & Singh D Y, To study the effect of yoga on blood sugar profile in Diabetics type-2 patients, *Int J Med Biomed Stud*, 3 (7) (2019) 270-272.

23 Sreedevi A, Gopalakrishnan U A, Ramaiyer S K & Kamalamma L, A randomized controlled trial of the effect of yoga and peer support on glycaemic outcomes in women with type 2 diabetes mellitus: a feasibility study, *BMC Complement Altern Med*, 17 (1) (2017) 100. doi: 10.1186/s12906-017-1574-x

24 Cui J, Effects of yoga in adults with type 2 diabetes mellitus: A meta-analysis, *J Diabetes Investig*, 8 (2) (2017) 201-209. https://onlinelibrary.wiley.com/doi/10.1111/jdi.12548.

25 Shrivastava N, Maheswari B K, Rath D & Sarkar D, Effects of yoga in modifying blood pressure in patients of type 2 diabetes mellitus, *Int J Res Med Sci*, 6 (9) (2018) 3080-3083.

26 Saberipour B, Gheibizadeh M, Maraghi E & Moradi L, Comparing the effect of walking and yoga on clinical and laboratory parameters in men with Type II Diabetes: A randomized controlled clinical trial, *Jundishapur J Chronic Dis Care*, 9 (2) (2020), e99977, https://doi.org/10.5812/jjcdc.99977.

27 Singh A, Tekur P, Metri K, Bhargav H, Raghuram N, *et al.*, Effect of a residential integrated yoga program on blood glucose levels, physiological variables, and anti-diabetic medication score of patients with type 2 Diabetes Mellitus: A retrospective study, *Integr Med Int*, 4 (34) (2018) 181-186.

28 Vijayakumari J, Punita P, Elangovan R, Efficacy of yoga practices on biochemical variable among type 2 Diabetic Middle-Aged Women, *Int J ZoolInvestig*, 08 (Special Issue) (2022) 324-329.

29 Kawamura K, Furukawa T & Gomyo T, Effects of Miso (Fermented Soybean Paste) intake on glycemic index of cooked polished rice, *Food Sci Technol Res*, 16 (3) (2010) 247-252.

30 Hongasandra N R, More P, Kumar V, Jagannathan A & Raghuram N, Effectiveness of yoga for patients with diabetes mellitus, *Curr Sci*, 113 (07) (2017) 1337-1353

31 Mahesh N K, Kumar A, Bhat K G & Verma N, Role of yoga therapy on lipid profile in patients of hypertension and prehypertension, *Int J Adv Med*, 5 (2) (2018) 321-326.

32 Innes K E & Selfe T K, Yoga for adults with type 2 diabetes: A systematic review of controlled trials, *J Diabetes Res*, (2016) 6979370. https://onlinelibrary.wiley.com/doi/ 10.1155/2016/6979370.

33 Athira M S, Sheel Joice P P, Varughese M & Sayana S B, Enhancing type 2 diabetes management: exploring the synergistic impact of vestibular exercise and yoga, *Cureus*, 15 (11) (2023). https://doi.org/10.7759/cureus.48539.

34 Very well health, can yoga reduce blood sugar levels for people with type 2 diabetes, Available Online: https://www.verywellhealth.com/yoga-reduces-blood-sugar-levels-type-2-diabetes-6751374 (accessed on 14 September 2024).

35 Ben's natural health, benefits of yoga for diabetes & practical poses, Available[Online] https://www.bensnaturalhealth.com/ blog/diabetes-health/yoga-for-diabetes/(accessed on 14 September-2024.

36 Raveendran A V, Deshpandae A & Joshi S R, Therapeutic role of yoga in type 2 diabetes, *Endocrinol Metab*, 33 (3) (2018) 307-317.

37 Huvin S, Shetty G B, Dinesh S & Shetty P, effect of abdominal mud pack on blood glucose level in patients with type 2 diabetes mellitus: A randomized placebo-controlled trial, *Int J Emerg Technol Innov Res*, 7 (10) (2020) 967-974.

38 VermaS, Kumar K & Meena R, Belief of Indian population on traditional yoga system during COVID-19 crisis, *Indian J Tradit Know*, 19 (2) (2020) p. 133-138

39 Pradeepa R & Mohan V, Epidemiology of type 2 diabetes in India, *Indian J Ophthalmol*, 69 (11) (2021) 2932-2938]