

Role of Yoga on Glycaemic Control and Other Health Parameters in Type 2 Diabetes Mellitus (T2DM) – A Review of Controlled Studies

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ABSTRACT

It is reported that about 1 in 11 adults have diabetes mellitus (DM) globally. A total of 415 million people have DM and an estimated 193 million people have undiagnosed DM worldwide. Where, type 2 diabetes mellitus (T2DM) accounts for around 90% of patients with DM. Yoga interventions appeared to be more effective in T2DM as compared to physical exercise interventions which may be because of various aspects of yoga other than the physical one. The yoga intervention involves subtle components such as mindfulness, relaxation, breath regulation, and notional corrections. The mechanism through which yoga works may be the down-regulation of the sympathetic nervous system and the hypothalamic-pituitary-adrenal axis which may lead to the improvement in psychological health, quality of sleep, autonomic balance, and reduction in insulin resistance. Lifestyle modification programs such as yoga interventions on a regular basis for long duration have potential to manage and cure T2DM. The government and the concerned bodies should pay attention to this area.

Key words: *Diabetes Mellitus; Glycaemic Control; Lifestyle; Meditation; Yoga.*

INTRODUCTION

Diabetes mellitus (DM) is a common metabolic disorder characterised by a chronic hyperglycaemic condition. DM can be diagnosed by one or more of the below criteria: HbA1c \geq 6.5 %, Fasting plasma glucose \geq 126 mg/dL, Random plasma glucose \geq 200 mg/dL, 2-hour plasma glucose \geq 200 mg/dL.¹ The autoimmune destruction of pancreatic beta cells leads to a deficiency of insulin secretion in type 1 diabetes mellitus, whereas, Type 2 diabetes mellitus (T2DM) is characterised by increased insulin resistance and impaired insulin secretion.² In another language, T2DM is defined as a hyperglycaemia not caused by autoimmune destruction or other known conditions.³ It is reported that about 1 in 11 adults have DM globally.⁴ A total of 415 million people have DM and an estimated 193

million people have undiagnosed DM worldwide.⁵ Where, T2DM accounts for around 90% of patients with DM.^{4,5} The Prevalence of T2DM is increasing rapidly in Asia, where India and China are reported to be the top two epicentres.⁴ Yoga therapy is considered to be effective in improving positive health. Studies have demonstrated the effectiveness of yoga in the management of various lifestyle diseases.⁶

The current article reviewed controlled study to investigate role of Yoga on Glycaemic Control and Other Health Parameters in Type 2 Diabetes Mellitus (T2DM)

RISK FACTORS ASSOCIATED WITH T2DM

Studies demonstrated that obesity⁷, sedentary lifestyle⁷, lack of exercise⁸, poor diet habits⁸, smoking⁹, genetic

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factors⁷ and stress² are the major risk factors associated with T2DM. Where, stress was found to be one of the major risk factors associated with number of chronic disorders, including T2DM.¹⁰ Similarly, it is reported that the adults with depression have a 37% increased risk of developing T2DM¹¹ and people with T2DM have a 24% increased risk of developing depression.¹² Further, coexisting depression and T2DM together is associated with poor metabolic control, higher risk of complications, decreased quality of life, increased healthcare cost, and increased mortality rate.¹³ Similarly, a significant and positive association of T2DM with anxiety disorders and elevated anxiety symptoms were found.¹⁴ The symptoms of anxiety also affect mortality risk in individuals with T2DM independently of symptoms of depression.¹⁵ Some other studies also suggest that a poor sleep quality is also positively correlated with poor glucose homeostasis and increased risk of T2DM.¹⁶ Patients with T2DM are at high risk for both microvascular complications (retinopathy, nephropathy, neuropathy etc.) and macrovascular complications (cardiovascular comorbidities).^{5,17,18} Those complications put a huge burden on patients, their caregivers and health-care systems.⁵

TREATMENT OPTIONS FOR T2DM

Biguanides (Metformin), Sulfonylureas, Meglitinides, Thiazolidinediones, Alpha-Glucosidase Inhibitors, Incretin-Based Therapies, Dipeptidyl-Peptidase IV Inhibitors, Insulin, Insulin analogues etc. are commonly adopted modern medication strategies for the management of diabetes mellitus.¹⁹ Where, Metformin is the first choice for the management of most of the T2DM patients²⁰, however, no any permanent cure has yet been discovered for T2DM in the mainstream medical system.¹⁹ Other alternative therapies such as yoga therapy, dietary supplements, acupuncture, hydrotherapy etc. are also used for T2DM and they are less likely to have the side effects and complications.²¹ Lifestyle modification program including physical activities, healthy diet, maintaining healthy body weight, stopping smoking etc. has also been appeared to be effective strategy for the prevention and management of T2DM.^{4,22} A randomised controlled trial (RCT), conducted with 3234 nondiabetic persons with elevated fasting and post-load plasma glucose concentrations, published in the New England Journal of Medicine, reported that the lifestyle intervention (healthy low-calorie low-fat diet, physical activity of moderate intensity for at least 150 minutes per week, and behaviour modification) was significantly more effective than metformin (850 mg twice daily) to prevent the incidence of T2DM.²³ Physical exercise²⁴ and healthy diet (Mediterranean diet, low-carbohydrate/high-protein diet, vegan/vegetarian diet)²⁵ both were found to be effective individually to improve glycaemic control in T2DM.

YOGA THERAPY

Yoga is not only a combination of physical postures and breath regulation, it is an art of holistic living for the integrative development of the body, mind and soul.²⁶ Yoga is an ancient technique developed to unite the individual consciousness with the universal consciousness, however, several recent studies have demonstrated the vast therapeutic benefits associated with it for the management and cure of various lifestyle disorders.^{6,27-30} Yoga, traditionally, involves eight limbs namely restraints, observances, physical postures, breath regulation, withdrawal of the senses, focused meditation, meditation, and absorption³¹, however, the physical postures, breath regulation, and meditation have been used commonly for therapeutic purposes nowadays.³²

YOGA INTERVENTION FOR T2DM

Many literatures have reported the effectiveness of yoga in the prevention and treatment of many lifestyle disorders, and in the preservation of positive health.³³ For the better management of T2DM, it is necessary to involve in yoga-based lifestyle program on regular basis for long duration.³⁴ Many studies have demonstrated the effectiveness of yoga on metabolic disorders including T2DM. A study concluded that yoga-based intervention program is a possible risk reduction option for the adults with high risk for T2DM.³⁵ Similarly, an 8-week yoga intervention showed a positive effect on behavioural health outcomes in patients with T2DM.³⁶ In a recent meta-analysis conducted with a total of 12 RCTs on T2DM, the pooled weighted mean reduction was 0.47 for HbA1c.³⁷ The results of a recent study reported that the yoga is effective in reducing the blood glucose levels in patients with T2DM.³⁸ An important RCT has reported that the HbA1c levels reduced significantly by 14.17% in yoga group after nine months of interventions (the HbA1c reduced 0.50 % in exercise group). The study also reported that yoga was better than physical exercise in decreasing oral hypoglycaemic medication requirement in T2DM.³⁹ In this study, Fasting Blood Sugar (FBS) level reduced significantly by 9.64 mg/dl (7.20%) in yoga group and it reduced insignificantly by 5.11 mg/dl (3.92%) in exercise group. Similarly, the Post-prandial Blood Sugar (PPBS) reduced significantly in yoga group by 14.6% in yoga group and by 8.9% in exercise group after 9 months of intervention.³⁹ Another study conducted in Cuba demonstrated that mean FBS reduced by 29.48% in yoga group and 27.43% in exercise group after six months of intervention.⁴⁰ Further, an 8-week yoga intervention appeared to be an effective lifestyle intervention to reduce weight-related T2DM risk factors and to improve psychological well-being.⁴¹

Yoga interventions have multiple benefits for individuals with or at risk for T2DM as yoga intervention was found

to be effective in improving the blood glucose levels in patients with T2DM.^{42,43} A 40-day yoga intervention resulted in reduced Body Mass Index (BMI), improved well-being and reduced anxiety in patients suffering from T2DM.⁴⁴ Yoga interventions can also be used as an effective therapy in reducing oxidative stress along with BMI in T2DM.⁴⁵ Yoga-based lifestyle intervention including exercise and stress management training can also reduce elevated lipid levels in patients with T2DM.⁴⁶ Yoga postures can also be practised with proper diet and regular drugs in the management of T2DM.⁴⁷ Yoga-based interventions not only improved glycaemic control but also improved nerve function in patients suffering from mild to moderate T2DM with sub-clinical neuropathy.⁴⁸ *Table 1* provides the details of controlled studies on yoga for Type 2 Diabetes Mellitus.

Table 1. Controlled studies on yoga for Type 2 Diabetes Mellitus

SN	Author	Year	Sample	Design	Assessment	Intervention	Control	Results
1	Jyotsna et al.	2012	49 Patients having HbA1c between 6% and 9% for at least 3 months with lifestyle modification and oral antidiabetic medication	Prospective randomised controlled trial	FBS, PPBS, HbA1c, electrocardiogram, ocular tension measurement, blood urea and serum creatinine	Sudarshan Kriya Yoga (SKY) for three months (1 hour every week at hospital visit, 25-35 minutes every day at home)	Standard treatment for the same duration	There was a trend of improvement in glycaemic control in the yogic breathing group compared with the standard treatment group. There was significant improvement in physical, psychological variables in yogic breathing program as compared with the control. ⁴⁹
2	Shantakumari et al.	2012	100 patients with Type 2 diabetes and hypertension in the age group of 35 to 55 years	Randomised parallel trial	Fasting blood sugar (FBS), post prandial blood sugar (PPBS) and blood pressure levels	1 hour yoga intervention daily with oral hypoglycaemic drugs for 3 months	Only oral hypoglycaemic drugs for 3 months	Significant reduction in systolic blood pressure, diastolic blood pressure and fasting blood pressure in yoga group. Control group did not show any significant changes. ⁵⁰
3	Vaishali et al.	2012	60 elderly with more than 15 years of type 2 diabetes mellitus	Randomised controlled Trial	HbA1c, fasting glucose level, and serum lipid profile	Yogasana and pranayama, 6 days a week for 12 weeks.	Health education on maintaining a general healthy lifestyle	Significant improvement in HbA1c, Fasting glucose level, and serum lipid profile in Yoga group compared to Educational group ⁵¹

SN	Author	Year	Sample	Design	Assessment	Intervention	Control	Results
4	Nagarathna et al.	2012	277 patients type 2 diabetics of both genders aged above 28 years	Prospective randomised controlled study	Fasting plasma glucose (FPG), postprandial plasma glucose (PPPG), HbA1c, blood pressure (BP), waist circumference, waist-hip ratio and BMI	Yoga based Lifestyle modification Program for 9 months (one hour/day 5 days /week)	Exercise based Lifestyle modification Program (one hour/day 5 days /week)	There was better reduction in oral hypoglycaemic medication and increase in HDL in Yoga as compared to the control group. There was significant reduction within groups in FBG, PPBG, HbA1c, Triglycerides, VLDL and total cholesterol. ³⁹
5	Hegde et al.	2011	123 type 2 diabetics aged between 40 and 75 years (60 for yoga and 63 for control)	Non-randomized controlled study	Malondialdehyde, reduced glutathione, superoxide dismutase, vitamin C & E, Oxidative stress, antioxidant status, BMI, waist-hip ratio, blood pressure, FBS, PPBS and HbA1c	Yoga intervention, 3 days per week for 3 months	General oral and written information about diet and exercise	Yoga group showed significant improvements in BMI, FBS, PPBS, HbA1c, malondialdehyde, glutathione, and vitamin C at 3 months compared with the controlled group. ⁵²
6	Hegde et al.	2012	123 participants with type 2 diabetes, aged between 40 and 75 year	Non-randomized controlled study	Malondialdehyde, reduced glutathione, superoxide dismutase, vitamin C & E, oxidative stress, antioxidant status, FBS, PPBS, HbA1c, BP, waist-hip ratio and BMI	15 to 20 minutes Diaphragmatic breathing with standard care, twice a day, for 3 months	Only standard care for the same duration	Significant reduction in body mass index, waist-hip ratio, BMI, FBS, PPBS, HbA1c, malondialdehyde, superoxide dismutase and improvement in glutathione and vitamin C compared to standard care group ⁵³
7	Beena & Sreekumaran	2013	143 elderly patients with type 2 diabetes mellitus in the age group of 60 to 70 years	Non-randomized controlled study	A1c, FBS, lipid profile, cortisol, ferritin, malondialdehyde (MDA) and catalase activity	Yoga intervention, 90 minutes every day for 3 months.	Daily activities such as walking and other non-specific exercises	There was significant decrease in FBS, HbA1c, lipids, cortisol, ferritin, MDA and significant increase in catalase activity after yogic practice. ⁵⁴

SN	Author	Year	Sample	Design	Assessment	Intervention	Control	Results
8	McDermott et al.	2014	41 patients with type 2 diabetes mellitus	Randomised controlled pilot study	Weight, waist circumference, BMI, fasting blood glucose, postprandial blood glucose, insulin resistance	75-minute yoga intervention, six days a week for eight weeks	Monitored walking, 6 days per week for the same duration	Significant reduction in weight, waist circumference and BMI among yoga group compared to the control group ⁴¹
9	Gordon et al.	2008	231 patients with T2DM without severe complications of the disease (Hatha Yoga group; 77, PT group; 77 and control group; 77)	Prospective randomised controlled trial	Fasting blood glucose, Serum total cholesterol, Triglycerides, LDL, VLDL, HDL, Oxidative stress indicators and oxidative status	Hatha yoga for 2 hours, once a week for 24 weeks	Physical training exercises (for PT group) for the same duration	FBG decreased significantly by 29.48% and 27.43% respectively in yoga group and conventional PT exercise group compared to a reduction of 7.48% in the control group. Significant improvement on lipid profile, oxidative stress markers and antioxidant status in yoga group. ⁵⁵
10	Khatri et al.	2007	101 patients with T2DM (usual care; 46 and yoga intervention in addition to usual care; 55)	Randomised case control study	BMI, Waist circumference, Blood pressure, Fasting blood sugar, HbA1c, Serum triglyceride & HDL cholesterol	Three months of yoga intervention in addition to usual care	Usual care for three months	Waist circumference, Systolic blood pressure, Diastolic blood pressure, Fasting blood sugar, HbA1c and serum triglyceride decreased significantly, and serum HDL increased significantly in study group after 3 months. ⁵⁶
11	Skoro-Kondza et al.	2009	59 people with Type 2 diabetes not taking insulin (mean age; 60±10)	Randomised controlled trial	HbA1c, body mass index, waist-hip ratio, systolic and diastolic blood pressure, lipid levels, risk score, and scores on the psychometric instruments	90-minute yoga class, twice a week for 12 weeks	Encouragement for healthy lifestyle with exercise or the same duration	In the intervention group, HbA1c reduced slightly from 7.06 to 6.86 immediately after the intervention. HbA1c reduced from 7.03 to 6.95 in the control group. None of these differences were statistically significant. ⁵⁷

SN	Author	Year	Sample	Design	Assessment	Intervention	Control	Results
12	Amita et al.	2014	41 middle aged patients with type 2 diabetes mellitus	Randomised controlled trial	Fasting blood glucose and postprandial blood glucose	30-minute yoga-nidra daily for 90 days along with oral hypoglycaemic agents	Only oral hypoglycaemic agents or the same duration	Significant reduction of fasting blood glucose and postprandial blood glucose levels the experimental group after 90 days of intervention ⁵⁸
13	Kerr et al.	2002	37 patients with poorly controlled diabetes (14 with type 1 diabetes)	Randomised control trial	HbA1c, Total cholesterol, Triglycerides, HDL, LDL, Cholesterol ratio, Blood Pressure, Weight, QOL, Pulse rate, daily insulin requirement & Quality of life.	90 minutes bi-weekly hatha yoga for 16 weeks (32 sessions)	simple exercises for the same duration	Insulin requirement in the yoga group remained same where as it got increased in the exercise group. Yoga could not improve the quality of life in subjects but it improved mood and well-being with greater effect compared to exercises. ⁵⁹
14	Singh et al.	2008	60 patients with T2DM in the age range of 35 to 60 years (30 in yoga group & 30 in group Yoga)	Non-randomized controlled study	Weight, BMI, Fasting blood glucose, post prandial blood glucose, Lipid profile and Serum insulin levels	Yoga postures and pranayama for 45 minutes for 45 days along with conventional hypoglycaemic medicines	Conventional medicines for the same duration	Yoga group showed significant decrease in weight, blood glucose, serum insulin and improvement in lipid profile. Control group showed increase in weight and non-significant improvement in other parameters. ⁶⁰
15	Gordon Lorenzo et al.	2008	231 patients with T2DM without severe complications of the disease (Hatha Yoga group; 77, PT group; 77 and control group; 77)	Prospective randomised controlled trial	Weekly systolic and diastolic blood pressures, Body mass index (BMI), Weekly blood glucose, Serum creatinine, microalbuminuria and HbA1c (at baseline & every 3 months)	Hatha yoga for 2 hours, once a week for 24 weeks	Physical training exercises (for PT group) for the same duration	There was a significant reduction in the weekly blood glucose, systolic and diastolic blood pressures, HbA1c, and microalbuminuria in Hatha yoga and PT group compared to control group. PT group showed more clinical features of hypoglycaemia and hyperglycaemia when compare to the yoga group. ⁶¹

SN	Author	Year	Sample	Design	Assessment	Intervention	Control	Results
16	Mahapure et al.	2008	40 patients with type 2 diabetes mellitus aged 40–55 years	Non-randomized controlled study	superoxide dismutase (SOD), HbA1c and fasting blood glucose levels	Yogic practices for an hour every day for 6 days a week for six weeks	Regular diet and anti-diabetic drug or the same duration	Significant changes were found between the groups and within groups. SOD levels improved, HbA1c and glucose levels decreased in yoga group compared to control group. ⁶²
17	Kyizom et al.	2010	60 patients diagnosed as type 2 diabetes mellitus (age range; 35-65 years)	Matched controlled study	Basal recordings of P300, Fasting blood glucose and postprandial blood glucose	yoga (asana and pranayama) intervention for 45 days	only conventional medical therapy	Significant improvement in the latency and the amplitude of N200, P300 in the yoga group as compared to the control group. ⁶³

Abbreviations: SKY; Sudarshan Kriya Yoga, FBS; Fasting Blood Sugar, PPBS; Post Prandial Blood Sugar, FPG; Fasting Plasma Glucose, PPPG; postprandial plasma glucose, BP; blood pressure, LDL; Low Density Lipoprotein, VLDL; Very Low Density Lipoprotein, HDL; High Density Lipoprotein, BMI; Body Mass Index, QOL; Quality of Life, SOD; Superoxide Dismutase

DISCUSSION

Yoga intervention appeared to be more effective in T2DM as compared to physical exercise intervention which may be because of various aspects of yoga other than the physical one. The yoga intervention involves subtle components such as mindfulness, relaxation, breath regulation, and notional corrections. Those components would have enhanced the mood and the state of mind of the patients with T2DM.^{64,65} Whereas the patients in the physical exercise group would have done so more mechanically which would have led to the benefits at the body level only.

The mechanism through which yoga works may be the down-regulation of the sympathetic nervous system and the hypothalamic-pituitary-adrenal axis⁶⁶ which may lead to the improvement in psychological health, quality of sleep, autonomic balance, and reduction in insulin resistance. The components of yoga such as mindfulness and relaxation may be the major contributors for the down-regulation of the sympathetic nervous system and the hypothalamic-pituitary-adrenal axis. Further, pranayama (breath regulation) also has the capacity to bring the mind in the present moment which helps to reduce the stress level.⁶⁷ The reduction of stress level may result in better glycaemic control in patients suffering from T2DM as the stress has strong effects on metabolic activity by stimulating different hormones.⁶⁸

WAYS FORWARD

Yoga and physical exercise both appeared to be effective in improving glycaemic control in T2DM, however, yoga intervention appeared to be more effective than physical exercise intervention. Lifestyle modification programs such as yoga interventions on a regular basis for long duration have potential to manage and cure T2DM. The government and the concerned bodies should pay attention to this area.

CONFLICT OF INTEREST

None

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