



Role of Yoga in Diabetes

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Abstract

The science of yoga is an ancient one. It is a rich heritage of our culture. Several older books make a mention of the usefulness of yoga in the treatment of certain diseases and preservation of health in normal individuals. The effect of yogic practices on the management of diabetes has not been investigated well.

We carried out well designed studies in normal individuals and those with diabetes to assess the role of yogic practices on glycaemic control, insulin kinetics, body composition exercise tolerance and various co-morbidities like hypertension and dyslipidemia. These studies were both short term and long term.

These studies have confirmed the useful role of yoga in the control of diabetes mellitus. Fasting and postprandial blood glucose levels came down significantly. Good glycaemic status can be maintained for long periods of time. There was a lowering of drug requirement and the incidence of acute complications like infection and ketosis was significantly reduced. There were significant changes in the insulin kinetics and those of counter-regulatory hormones like cortisol. There was a decrease in free fatty acids. There was an increase in lean body mass and decrease in body fat percentage. The number of insulin receptors was also increased. There was an improvement in insulin sensitivity and decline in insulin resistance. All these suggest that yogic practices have a role even in the prevention of diabetes. There is a beneficial effect on the co-morbid conditions like hypertension and dyslipidemia. ©

Antiquity of traditional medicine dates back to over 4000 years, as evidence in the Atharva Veda (the science of life). The aim of traditional medicine according to Charak is to maintain the health of healthy person and relieve the suffering.

**“Swasthasya swasthya rakshanam
athurasya vyadhi parimokshanam”**

- Charak

The ancient Indian physicians had a sound knowledge of Diabetes. They described the clinical features and complications of diabetes vividly. Both Sushruth and Charak emphasized the importance of diet and exercise in the management of diabetes. They categorised diabetes into 2 groups –the obese and the lean and prescribed strenuous exercises for the obese diabetics.

The science of yoga is an ancient one. It is a rich heritage of our culture. Several older books make a mention of the usefulness of yoga in the treatment of certain diseases and preservation of health in normal individuals. It has now become the subject of modern scientific evaluation.

Apart from its spiritual philosophy, yoga has been utilized as a therapeutic tool to achieve positive health

and cure disease. This concept is promoted in Hathayoga and Ghatasthayoga by the yoga preceptors. Interest has been evinced in this direction by many workers and studies on the effect of yoga on hypertension, diabetes, asthma, obesity and other common ailments have been carried out.

Does yoga cure diabetes? This question is posed by many. The claim of yogic exponents that yoga cures diabetes, is perhaps an expression of the good control of diabetes achieved among obese type 2 diabetes subjects, who also respond to diet and exercise.

Studies have been carried out in our country to evaluate the effect of yoga on diabetes. Most of these studies were done on small number of patients, over small periods of time and just relied on blood sugar estimations to assess the results. These studies had also combined Pranayama and several other yogic practices making it difficult to interpret their individual contributions.¹⁻³

We have carried out extensive well designed studies to assess the effect of yoga in the treatment of diabetes as well as other diseases during the period 1978-1995 at the Vemana Yoga Research Institute, Secunderabad. This is a review of the work done.

Postulations

Based on the results of previous studies we had postulated that yogic practices help in controlling

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diabetes by the following mechanisms: exercise effect, changes in biochemical and hormonal profile, elimination of stress and instilling a sense of discipline.

To assess these postulations normal individuals and diabetics were investigated with a carefully chalked out protocol for the effect of yogic practices on exercise tolerance, obesity, hypertension, insulin kinetics and lipid metabolism.

PROTOCOL

The protocol for our studies was as follows. The diagnosis of diabetes was established. A detailed clinical examination was carried out and recorded. Patients with complications like retinopathy, nephropathy were not included in the study, patients selected were explained the outline and aim of the studies and their consent taken. They were given advice regarding diet, those on treatment were advised to continue on the same drugs. New patients were not prescribed any drugs.

Patients were recalled after 10 days for baseline investigations so as to exclude the effect of dietary therapy. The investigations included anthropometric data, GTT (75 gm oral glucose tolerance test), serum insulin estimation, plasma cortisol, blood urea, serum creatinine, serum lipid profile, serum lactates and pyruvates. ECG and exercise tolerance test (in willing patients) were carried out. Clinical evaluation was done at periodic intervals and the tests were repeated regularly as per the protocol. Minor modifications by way of additional investigations and changes in frequency of investigations were done as per the particular study. In all these studies, yogic practices were not carried out on the day of the investigation.

Analysis of results : The results were expressed as mean \pm 1 SD and student's 't' test was done between the initial and subsequent values at each time point.

Studies in normal healthy subjects were carried out to assess the effect of yogic practices on biochemical and hormonal parameters, exercise tolerance and on the performance of athletes. Studies were also carried out in the obese and diabetics with hypertension. In diabetics the effect of individual yogic practices were assessed and useful asanas were identified. Table 1 summarizes the various studies done by us.

Our earliest study⁴ assessed the effect of Pranayama on blood sugar level in 50 normal individuals. This study showed a significant fall in the blood sugar level soon after the practice of Pranayama (Table 2). This prompted us to study the effect of Pranayama on diabetics.⁴

Twenty eight type 2 diabetics and 4 type1 diabetics, were studied for one month. They practised 4 types of Pranayama for 30 minutes followed by Shavasana for 15 minutes. Patients developed a sense of well being within 7 to 10 days and showed a significant fall in fasting and post-prandial blood glucose values.⁴ In 17 patients the

Table 1 : Summary of studies on yoga and diabetes

In Normal Vounteers	In Diabetics
Biochemical changes and hormonal changes	Pranayama Yoga asanas (Four groups)
Effect of exercise tolerance	Individual asanas
Effect on performance of athletes	Acute experiments
Effect on obesity and hypertension	Exercise tolerance Long term follow up
Effect on lean body mass and percentage body fat	of cases Studies in lean type 2 diabetics Studies in elderly diabetics

Table 2 : Immediate effect of pranayama on blood glucose in normal volunteers

	Before	After
Fasting Glucose (mg%)	89.05	55.23*

* P < 0.001

Table 3 : Effect of pranayama on blood glucose levels in type 2 diabetics (n=28)

Blood glucose (mg/dl) mean \pm SD	Before	After
Fasting	148.19 \pm 43.13	108.19 \pm 21.05
Post prandial	278.50 \pm 43.13	188.50 \pm 79.37*

*p < 0.001

Table 4 : Blood glucose in type 1 diabetic subjects before and after pranayama

Blood glucose (mg/dl) mean \pm SD	Before (n=4)	After (n=4)
Fasting	254.75 \pm 179.13	128.25 \pm 88.02
Post prandial	414.50 \pm 175.78	275.00 \pm 81.34

requirement of drugs came down significantly (Tables 3 and 4). Insulin assays were done in 5 of these 28 type 2 diabetic patients. There was normalization of the /IG ratios (Tables 5 and 6).

GROUPS OF ASANAS

Based on earlier studies done by other workers, we selected the asanas which were found to be useful for diabetic subjects. Since they were earlier studied together and the role of individual asanas was not identified, we selected 8 asanas which could be performed by subjects of all age groups, for assessing their effectiveness.

In order to asses the effect of individual asanas, patients were randomly allotted to different groups and they performed yogic practices of that group for 45 minutes each day followed by relaxation practices i.e. Shavasana and Makrasana.

Table 7 illustrates the different groups of asanas and their effect on blood sugar both fasting and post-prandial. These studies revealed that optimum control of diabetes was achieved by practising Dhanurasana, Ardhamatsayendrasana (group D). While Halasana,

Table 5 : Effect of pranayama on glucose values during OGTT in type 2 diabetics

Hours (n=5)	0	½	1	1½	2
Before pranayama	120.4±35.7	222.4±85.6	241.8±68.8	251.8±91.8	243.0±100.7
After pranayama	112.2±41.3	192.0±53.7	217.8±53.3	199.8±83.3	197.8±95.2

Table 6 : Effect of pranayama on insulin /glucose values during OGTT in type 2 diabetics

Hours (n=5)	0	½	1	1½	2
Before pranayama	0.86±0.3	0.18±0.07	0.25±0.13	0.34±0.3	0.18±0.15
After pranayama	0.22±0.07	0.24±0.15	0.28±0.13	0.20±0.08	0.3±0.23

Table 7 : Effect of different groups of asanas on blood glucose levels

	Fasting		Postprandial	
	Before	After	Before	After
Group A				
Naukasana	118.8± 13.8	98.8± 9.3	223.8±14.8	184.8±15.3*
Bhujangasana				
Group B				
Halasana	135.8±21.8	121.8±15.7	271.9±38.3	187.8±38.0**
Vajrasana				
Group C				
Yogamudra	94.8±14.8	108.2±10.9	217.8±24.8	189.1±16.7
Shalabasana				
Group D				
Dhanurasana	188.7±19.3	120.8±9.2	322.0±40.3	194.0±19.8
Ardhamatsyendrasana				

Vajrasana (Group B); Bhujangasana, Naukasana (Group A) were also effective, Yogamudra and Shalabasana (Group C) worsened the diabetic status. When studied individually Dhanurasana was the most effective.⁶ Why some of these asanas had a deleterious effect is not clear. Therefore in all our subsequent studies we have incorporated the following asanas Dhanurasana, Ardhamatsyendrasana, Bhujangasana, Naukasana, Halasana, Vajrasana and Pachimotanasana along with Pranayama⁵.

Effect of Yogic Practices on Body Composition

In normal healthy volunteers the skin fold thickness was significantly reduced with increase in the lean body mass, without any significant change in the weight of the individuals.⁶

One hundred eight patients with Type 2 diabetes were studied for a period of 6 months. All these patients developed a sense of well being and showed a significant fall in the fasting and post-prandial blood sugar values with smooth control of blood sugar and significant fall in the glycosylated hemoglobin and the drug requirements (Table 8). In these patients there was a significant decrease in the body fat and increase in the lean body mass.^{7,8}

Effect of Yogic Practices on Response to OHA

Patients who were in poor control in maximum dose of sulphonylurea or a combination therapy were subdivided into 2 groups according to the duration of diabetes, below or above 6 years. Patients in both the groups showed improvement in their glycaemic

Table 8 : Effect of yoga on HbA_{1c} and drug score

(n=108)	Before	After 3 months
HbA _{1c}	10.41	8.45*
Drug score	1.71	1.06**

*p <0.05, **p<0.001

control with reduction in the dose requirement (Table 9). The mechanism involved could be either correction of insulin resistance alone or additional improvement in beta cell function. Further, studies are required to unravel this.

Effect of Yogic Practices on Elderly Type 2 Diabetics

Study in elderly diabetics 20 subjects aged more than 60 years with a mean age of 66 years were followed up for a period of 7 years. They achieved good glycaemic control which was maintained over the period of 7 years. No long term complications of diabetes were encountered in them (Table 10).

Studies on Lean Diabetics

A subset of lean diabetics with a BMI of less than 18 were studied. There was improvement in their glycaemic control with reduction in body fat content and improvement in lean body mass. There was reduction in their cholesterol triglyceride, LDL and free fatty acid levels and an increase in the HDL levels⁷ (Table 11).

Long Term Follow up

Long term follow-up studies: 32 type 2 and 3 type 1 diabetic patients who attended the institute regularly were studied for a period ranging from 2 to 7 years.

Table 9 : Effect of yogic practices on response to OHA
n=10, mean duration of diabetes 5.45±4.0 yrs, BMI 22.62±4.32

	Initial	30 days	60 days	90 days
Fasting glucose	146.10±38.61	113.34±34.23	109.29±28.65	101.29±28.85
Postprandial glucose	240.30±58.94	173.00±55.07	154.00±30.07	150.20±27.57
Drug score	1.8±1.6			0.85±0.79

Table 10 : Effect of yogic practices in rlderly type 2 diabetics
(n=20, mean age 66.44 ± 5.84 yr, mean duration of diabetes 12.79 ± 5.18 yr)

Mean ±1SD	Initial	1yr	2yr	3yr
Fasting glucose	137.16 ± 29.80	91.42 ± 18.98	82.53 ±15.08	85.30 ± 15.98
Postprandial glucose	199.79 ± 33.86	139.04 ± 27.55	139.04 ± 27.55	142.00 ± 28.00
Drug score	1.47 ± 0.84	0.55 ± 0.91	0.50 ± 0.91	0.34 ± 0.47

Table 11 : Effects of yogic practices in lean type 2 diabetics
(mean age = 44.0 ± 9.89 yrs)

Mean ± SD	Before Yoga	After Yoga
BMI (kg/m ²)	18.96 ± 0.96	18.70 ± 1.34
Fasting glucose (mg/dl)	156.10 ± 62.02	95.94 ± 31.39 **
Postprandial glucose (mg/dl)	259.20 ± 82.51	151.60 ± 44.69 **
HbA _{1c} (%)	10.56 ± 3.82	9.07 ± 3.34
Serum cholesterol (mg/dl)	208.70 ± 38.27	194.67 ± 20.0
Triglycerides (mg/dl)	130.50 ± 22.22	105.33 ± 17.74
HDL (mg/dl)	44.30 ± 6.25	47.83 ± 5.42
LDL (mg/dl)	136.30 ± 42.03	121.17 ± 29.06
VLDL (mg/dl)	26.73 ± 4.74	22.50 ± 6.83
FFA (μ mol/L)	482.20 ± 82.02	420.20 ± 64.63

* p < 0.05; ** p < 0.01

All of them showed a significant fall in the fasting and post-prandial blood glucose values within 3 months and continued to have a smooth and good control of diabetes during the period of the study as evidence by a normal glycosylated hemoglobin and blood glucose levels. The drug requirements were significantly reduced. There was a significant increase in the maximum treadmill time from 8 mets to 12 mets.⁸ Data from some patients who discontinued yogic practices for sometime and then restarted showed poor control when yogic practices were missed, which confirms the 'cause and effect' relationship between yogic practices and glycaemic control.

The Type 1 diabetic subjects who had a brittle diabetic control prior to yogic practices had improvement in their glycaemic status. These patients were free from episodes of diabetic ketoacidosis, hypoglycaemia and did not develop any vascular complications. Intercurrent infection rate was also negligible.

All these studies show that in different subsets of patients - obese, lean, elderly with different durations of diabetes there was improvement in glycemic control which persisted over long periods of time with protection from long term complications.

Effect on Co-Morbid Conditions

Hypertension is commonly encountered in patients with diabetes and it has a significant role in the development of both microvascular and macrovascular complications. Along with hypertension dyslipidemia is also equally common. Hence in our studies we assessed the impact of yogic practices on these co-morbidities.^{7,11}

Effect of Yogic Practices on Hypertension

Patients with hypertension were advised pranayama and shavasana. 20 non-diabetic patients with moderately elevated BP had reduction in both systolic and diastolic blood pressure after 3 weeks of yogic practices and the blood pressure was maintained at normal levels with significant reduction in the dosage requirement of anti-hypertensive drugs. Similar reduction in the systolic and diastolic blood pressure and the fasting and post-lunch blood sugar was observed in patients with diabetes and hypertension (Table 12). The blood pressure came under control in 15 days and the effect was sustained even in studies upto 3 months.^{7,12} Patients were free from cerebrovascular, cardiovascular and renal problems without any adverse effects on the lipid profile.

Effect of Yogic Practices on Lipid parameters

The impact on lipids was studied in the different groups of patients. The effect of yogaasanas on lipoprotein profiles was studied. There was a significant decrease in the free fatty acids, LDL and VLDL cholesterol, with increase in HDL cholesterol^{7,9} (Table 13). These changes suggest improvement in the insulin sensitivity following yogic practices.

Effect of Yogic Practices on Exercise Tolerance

Comparative studies of the effect of Yoga and physical exercise on the exercise tolerance in normal healthy volunteers as well as athletes showed improved exercise tolerance and postponement of the anaerobic threshold with both, but with yogic practices this occurred with a significant reduction in the minute ventilation and oxygen consumption.^{10,11}

Our diabetic patients also showed an improvement in

Table 12 : Effect of yogic practices on hypertension on diabetics and non-diabetics

	Initial	30 Day	60 Day	90 Day
Effect of Pranayama (n=14) diabetics				
Systolic BP	144.00±18.14	136.00±7.50*	135.00±11.10*	130.70±10.10*
Diastolic BP	95.70±6.44	90.00±3.77*	88.50±4.90*	86.90±5.03*
Other Yogic Practices (n=30) non-diabetics				
Systolic BP	147.67±11.65	132.67±9.80	130.33±6.69	130.67±6.91
Diastolic BP	101.50±4.38	91.00±4.03	90.13±3.79	88.93±2.86
Drug score	1.17±1.06	1.13±0.97	1.07±0.97	1.00±0.91

Table 13 : Effect of yogic practices on lipid parameters

	Before	After
Serum cholesterol (mg/dl)	189.70±30.27	188.80±25.42
Triglycerides (mg/dl)	129.45±44.00	106.10±39.73*
HDL (mg/dl)	44.44±4.95	46.55±5.05 **
LDL (mg/dl)	118.68±35.45	117.90±31.78
VLDL (mg/dl)	25.87±8.98	21.22±7.83
FFA (µmol/L)	416.3±83.97	399.0±89.89

* p <0.05 ** p<0.01

their exercise tolerance after 2 months of yogic practices as noted by their ability to carry out exercise for longer period of time

Effect of Yogic Practices on Insulin Kinetics

There was a reduction in the fasting insulin levels and a shift of the peak level of insulin to the left. There was a normalization of the I/G ratio with a reduction in the free fatty acid levels, suggesting a better peripheral utilization of insulin and reduction in insulin resistance.¹²

In a small subgroup of 5 patients with uncontrolled diabetes, the effect of yogic practices on the insulin receptors was studied. At the end of 4 weeks there was a significant rise in the insulin receptors although the blood sugar values did not yet normalize, indicating a reduction in insulin resistance and improvement in insulin sensitivity⁷ (Table 14).

Effect of Pranayama on Lung Functions in Diabetics

Lung functions (FEVI, FVC, PEFR, FEVI/FVC and FEVI/Transfer factor) in 20 diabetics both type 1 and type 2 were carried out before and after 3 months of practice of pranayama and were compared with 5 diabetic subjects who did physical exercise instead of yoga for 3 months. The analysis of the data showed that the lung functions improved significantly while blood sugar and glycated hemoglobin reduced significantly in the study group as compared to the control group of

Table 14 : Effect of yogic practices on insulin receptors

	Before Yoga	After Yoga
Blood glucose (mg/dl)		
Fasting	155±23	138±50
Postprandial	213±20	
HbA _{1c} (%)	12.59±5.45	11.74±2.83
Insulin receptors (ng)	3.74	5.81

diabetics of comparable age and severity who did other physical exercise instead of yoga.¹³

Effect of Yogic Practices on CMI in Type 2 Diabetics

Cell mediated immunity is defective in patients with type 2 diabetes, particularly with poor glycaemic control. The defective cell mediated immunity predisposes the diabetics to various infections. Our studies have shown that yogic practices have a favourable effect on the lymphocyte migration test, suggesting an improvement in the cell mediated immunity⁷ (Fig. 1).

Effect of Yogic Practices in Prevention of Type 2 Diabetes

Yogic practices in all these studies have produced an increase in the lean body mass and decrease in the body fat percent. This leads to an improvement in insulin sensitivity and reduction in insulin resistance. Insulin resistance is the major abnormality in type 2 diabetes and precedes the development of overt diabetes by several years. The reduction in free fatty acid levels also reduces the lipotoxicity, which has now been shown to have a significant effect on beta cell function. Therefore it is reasonable to postulate that the beneficial effect of yogic asanas on the insulin kinetics and the lipid metabolism, prevents the beta cell exhaustion and the development of a beta-cell secretory defect, thereby preventing the development of type 2 diabetes.¹⁴

SUMMARY AND CONCLUSIONS

These studies have confirmed the useful role of yoga in the control of diabetes mellitus. Fasting

SL - Stimulation Index to mitogen

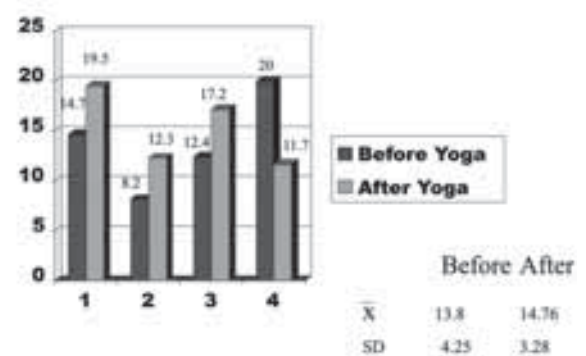


Fig. 1 : Effect of yogic practices on CMI in NIDDM (Lymphocyte Transformation Test)

and postprandial blood glucose levels came down significantly. Good glycaemic status can be maintained for long periods of time. There was a lowering of drug requirement and the incidence of acute complications like infection and ketosis was significantly reduced. There were significant changes in the insulin kinetics and those of counter-regulatory hormones like cortisol. There was a fall in free fatty acids suggesting a better insulin sensitivity and decrease in insulin resistant, with a probable protective effect on beta cell function. There is a beneficial effect on the co-morbid conditions like hypertension and dyslipidemia.

Yogic practices are useful in all age groups and can be performed in all seasons and are useful for people who travel frequently.

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