

Effect of integrated approach of yoga therapy on autonomic functions in patients with type 2 diabetes

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ABSTRACT

Background and Objectives: Integrated approach of yoga therapy (IAYT) had shown beneficial effects in the management of type 2 diabetes mellitus (DM). Autonomic dysfunction is one of the major complications of type 2 DM. Research studies have demonstrated that yoga can modulate autonomic functions. Hence, the current study was designed to assess the effect of IAYT on autonomic functions in type 2 diabetics. **Materials and Methods:** 15 patients of type 2 DM with ages ranging from 35 to 60 years were recruited for the study. They were diagnosed with type 2 diabetes from 1-year to 15 years. Assessments were made on day 1 (before yoga) and day 7 (after 1-week of yoga practice). Heart rate variability (HRV), blood pressure (BP) response to the isometric handgrip and heart rate response to deep breathing were assessed before and after 1-week of IAYT. **Results:** There was a significant reduction in fasting plasma glucose from 154.67–130.27 mg/dL (Wilcoxon signed rank test, $P = 0.029$) following 1-week of IAYT. BP response to isometric hand grip improved significantly (Wilcoxon signed rank test, $P = 0.01$). There was no statistical significant change in HRV components and heart rate response to deep breathing test. However, there was a trend of increase in the low frequency power (41.07%), high frequency power (6.29%), total power (5.38%), and standard deviation of all NN intervals (SDNN) (6.29%). **Conclusion:** These findings suggest that, IAYT improved autonomic functions in type 2 diabetes patients.

Key words: Autonomic functions, heart rate variability, type 2 diabetes mellitus, yoga

INTRODUCTION

The prevalence of type 2 diabetes has been increasing rapidly all over the world in last few decades.

It has become a major global health problem with a prevalence of 366 million in 2011 that is projected to increase by 51%, reaching 552 million by 2030.^[1] India leads the world with the largest number of diabetics and being termed as “diabetes capital of the world” with a prevalence

of 60 million in 2011 that is projected to increase by 63%, reaching 98 million by 2030.^[1]

Years of poorly controlled hyperglycemia may lead to multiple, primarily vascular complications that affect small vessels (microvascular), large vessels (macrovascular), or both. Autonomic dysfunction is one of the major complications of type 2 diabetes. Diabetic autonomic dysfunction is 50% asymptomatic and has a devastating effect on the individual.^[2] The cardiac autonomic neuropathy is one of the leading causes of morbidity and mortality in diabetics.^[3] A recent study has shown the involvement of both sympathetic and parasympathetic nervous system in type 2 diabetes.^[4] Along with conventional medical treatment, yoga therapy plays an important role in the management of diabetes.

A study demonstrated effective management of insulin resistance and increase in insulin sensitivity following

Access this article online	
Quick Response Code:	Website: www.ijem.in
	DOI: 10.4103/2230-8210.163194

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long-term yoga practice in healthy volunteers.^[5] Integrated approach of yoga therapy (IAYT), which includes practice of yoga postures (asana), regulated breathing (pranayama), cleansing techniques (kriya), meditation and lectures on yoga (concept of yoga, streams of yoga and basis of yoga therapy) has shown to reduce medication scores, plasma glucose levels, HbA1C, and serum cholesterol levels in patients with T2 diabetes mellitus (DM).^[6] Though IAYT has shown beneficial effects in the managements of diabetes, the mechanisms are unclear.

Research studies substantiate the close association between stress and the onset of diabetes and its related complications.^[7] One possible explanation by which yoga works in diabetes may be by reducing stress and arousal (sympathetic over-activity). Reduction in stress is associated with improved glycemic control in T2 DM.^[8] Many studies have shown an increase in vagal tone and a reduction in sympathetic activity following yoga practice in normal volunteers.^[9,10]

There is a growing evidence in the field of yoga and type 2 DM.^[11-14] However, there were no studies available on IAYT on autonomic functions in patients with type 2 DM. Hence, this study was designed to assess the effect of IAYT on autonomic functions in type 2 diabetes patients. We have used standard autonomic functions tests viz., isometric hand grip and deep breathing test, which reflects sympathetic and parasympathetic nervous system activity respectively.^[15] Heart rate variability (HRV) was also included which is a commonly used tool to assess the functioning of cardiac autonomic regulation.

MATERIALS AND METHODS

Participants

Fifteen patients of type 2 DM with ages ranging from 35 to 60 years were recruited for the study. They were diagnosed with type 2 diabetes from 1-year to 15 years. We have used convenience sampling. T2 DM patients undergoing yoga therapy program (IAYT) at holistic health home of Swami Vivekananda Yoga Research Foundation Yoga (Yoga University) University, Bangalore were screened for inclusion criteria. Patients above 60 years were excluded for the study since, aging is known to reduce autonomic responsiveness and HRV.^[16] The other conditions to exclude participants from the trial were fasting blood glucose >270 mg/dl, renal dysfunction, diabetic retinopathy and neuropathy and any other major complications. The study was approved by the institution's ethics committee. The study protocol was explained to the participants, and their signed consent was obtained.

Design

Single group pre- post design was used. Assessments were made on day 1 (before the intervention) and day 7 (after 1-week intervention).

Pre assessment (Day 1)	IAYT (1-week)	Post assessment (Day 7)
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Assessments

Participants underwent fasting plasma glucose (FPG) and postprandial plasma glucose test before and after 1-week yoga practice. Electrocardiogram (ECG) and respiration were recorded using 16 channel polygraph (PowerLab 16/35, ADInstruments, Australia) and blood pressure (BP) was monitored using sphygmomanometer.

Heart rate variability

The ECG was recorded using a standard bipolar limb lead I configuration. The ECG was digitized using a 16-bit analog-to-digital converter at a sampling rate of 1 KHz and was analyzed off-line to obtain the HRV spectrum. Frequency domain and time domain analysis of HRV data were carried out.

Heart rate response to deep breathing

The deep breathing test reflects the activity of the parasympathetic nervous system. Respiration was recorded using a volumetric pressure transducer fixed around the trunk about 8 cm below the lower costal margin. ECG was recorded to calculate the heart rate. The subjects were asked to breathe maximally at six breaths/min (5 s in and 5 s out) based on verbal prompts from the investigator. The maximum and minimum heart rates during each breathing cycle was measured, and the mean of the differences during six successive breathing cycles was taken to give the maximum-minimum heart rate.

Blood pressure response to sustained handgrip

The isometric handgrip dynamometer (Anand Agencies, Pune, India) was used to measure sympathetic activity. The baseline BP was recorded in the subject. Then, the patients were asked to grip the handgrip dynamometer using maximum force with their dominant hand for a few seconds. The value was noted down, and the procedure was repeated thrice. The maximum value of the 3 readings was considered as their maximal voluntary contraction (MVC). A mark was made on the dynamometer at 30% of MVC. They were asked to maintain the grip on the dynamometer up to mark till 5 min. BP was measured on the contra-lateral arm. The difference between the diastolic BP just before the release of handgrip and before starting was taken as the measure of response.

Interventions

The IAYT includes yoga postures (asanas), breathing (pranayama), cleansing techniques (kriyas), meditation, devotional songs and lectures on yoga. It was a residential yoga therapy program for 1-week. Patients were engaged in different yoga practices from morning 5:30 am to night 9:00 pm. Counseling and diet were also part of the program.

Data extraction

The following data were extracted from the 16 channel polygraph. The heart rate in beats per minute was calculated by counting the R waves of the QRS complex in the ECG in 60 s epochs, continuously. Frequency domain and time domain analysis of HRV data were carried out. The analysis was done using the software Lab Chart 8 (AD instruments, Australia). The energy in the HRV series in the following specific frequency bands were studied viz., very low frequency (LF) (0.0–0.04 Hz), LF (0.04–0.15 Hz) and high-frequency (HF) band (0.15–0.5 Hz). According to guidelines, LF and HF band values were expressed as normalized units. The following components of time domain HRV were analyzed: (i) SDNN (the standard deviation of NN intervals), (ii) the square root of the mean of the sum of the squares of differences between adjacent NN intervals (RMSSD), (iii) the proportion derived by dividing NN50 by the total number of NN intervals (pNN50).

Heart rate response to deep breathing was calculated by the following method. The maximum and minimum heart rates during each breathing cycle was measured, and the mean of the differences during six successive breathing cycles was taken to give the maximum-minimum heart rate. BP response to sustained handgrip was calculated by counting the difference between the diastolic BP just before the release of handgrip and before starting.

Data analysis

Statistical analysis was performed using the software SPSS (Version 16.0, IBM Corporation, USA). Data were checked for normality using a Shapiro-Wilk test. Wilcoxon signed rank test was used to compare the “pre” and “post” values since data were not normally distributed.

RESULTS

The group mean values and standard deviations for heart rate and HRV were given in Table 1. Changes in the deep breathing test and isometric hand grip were presented in Table 2. Changes in the parameters of glycemic control were given in Table 3.

Table 1: Changes in resting heart rate and heart rate variability

Variables	Pre	Post	Percentage change
Resting heart rate (bpm)	81.92±12.25	79.85±8.03	2.53↓
Total power (ms ²)	673.85±542.65	710.11±469.30	5.38↑
LF power (ms ²)	204.56±217.52	288.57±285.84	41.07↑
HF power (ms ²)	174.38±214.33	185.34±144.69	6.29↑
LF n.u (Hz)	50.87±21.63	57.64±21.47	13.31↑
HF n.u (Hz)	49.24±21.22	42.39±20.09	13.91↓
LF/HF ratio	1.78±2.43	2.20±2.09	23.60↑
SDNN (ms)	24.82±10.67	26.83±7.17	8.10↑
RMSSD (ms)	16.71±9.20	17.84±7.75	6.76↑
pNN50%	1.89±5.28	2.08±3.69	10.05↑

LF: Low frequency band of HRV, HF: High frequency band of HRV, LF/HF: Ratio of low frequency to high frequency, n.u: Normalized units, SDNN: Standard deviation of all NN intervals, RMSSD: The square root of the mean of the sum of the squares of differences between adjacent NN intervals, pNN50%: NN50 count divided by the total number of all NN intervals, HRV: Heart rate variability

Table 2: Changes in deep breathing test and isometric hand grip test

Variables	Pre	Post
Heart rate response to deep breathing	10.52±7.85	10.93±6.91
Blood pressure response to sustained handgrip	2.13±2.97	5.33±3.83**↑

**P<0.01, Wilcoxon signed rank test

Table 3: Changes in parameters of glycemic control

Tests (mg/dL)	Pre	Post
FPG	154.67±62.20	130.27±60.20*↓
PPG	220.47±108.02	183.60±58.94

*P<0.05, Wilcoxon signed rank test. FPG: Fasting plasma glucose; PPG: Postprandial plasma glucose

Wilcoxon signed rank test was used to compare “post” values with “pre” values since data were not normally distributed (Shapiro-Wilk test, $P < 0.05$). There was a significant decrease in FBS from 154.67–130.27 (Wilcoxon signed rank test, $P = 0.029$). There was a significant increase in BP response to isometric handgrip test from 2.13–5.33 (Wilcoxon signed rank test, $P = 0.01$). The HRV components and heart rate response to deep breathing did not show a statistically significant change.

DISCUSSIONS

Changes in autonomic functions were assessed in fifteen type 2 DM patients before and after 1-week of IAYT. There was a significant decrease in FPG levels and an increase in BP response to isometric hand grip test. There was no significant change in heart rate response to deep breathing test and HRV.

Blood pressure response to the isometric handgrip and heart rate response to deep breathing test was used to assess

sympathetic and parasympathetic activity respectively. The increase in BP response to isometric handgrip test suggests improvement in the sympathetic nervous system (SNS) activity. In a previous study, similar results were observed following the practice of Sudarshan Kriya Yoga technique.^[11,12] The reason for the improvement in sympathetic activity and not an improvement in parasympathetic function is may due to the fact that development of autonomic neuropathy, which typically involves the parasympathetic fibers before the sympathetic nerve fibers.^[17,18]

Patients with type 2 diabetes are known to have low HRV, which is an indicator of dysfunction of cardiac autonomic regulation and an increased risk for cardiac events.^[19] In diabetes patients, reduction of total power (TP), LF power and HF power was also observed compared to healthy subjects.^[4,20] However, when the LF and HF were analyzed in normalized units, no significant difference was found as compared to healthy controls.

5 min TP mainly reflects the level of the autonomic nervous activities (both peripheral nervous system and SNS) and the clinical meaning of TP in frequency domain is similar to that of standard deviation of all NN intervals (SDNN) in time domain.^[20] LF power is correlated with the activity of sympathetic and parasympathetic nervous system where as HF power with parasympathetic activity.^[20] The SDNN reflects overall HRV. RMSSD and pNN50% are associated with the vagal tone. The current study did not show statistically significant change in the components of HRV. The reason for this may be the short duration of the intervention. In a previous study, exercise for 12 months did not show any change in the time domain as well as frequency domain measures in 24 h HRV recording.^[21] In contrast, in healthy individuals, increase in HRV and vagal tone has been observed following yoga practice in several studies.^[10] A research study has shown that, increased hyperglycemia is associated with decrease in HRV.^[22] In the present study, there is a trend of increase in the LF power (41.07%), HF power (6.29%), TP (5.38%), and SDNN (6.29%) though it was not statistically significant. The probable reason for this increase in HRV may be due to improved glycemic control.

The major limitations of the current study are small sample size and no control group. The other limitation is the short duration of intervention. In future, randomized controlled trial with large sample size could be studied. Studying the effect of the long-term practice of yoga on autonomic functions in diabetes patients would be helpful. It is known that, aging reduces autonomic responsiveness and HRV.^[16] The present study had a wide age range (35–60 years), which

is a confounding factor. Hence, it is worth investigating the effect of yoga in younger population with type 2 diabetes in future studies.

CONCLUSION

In summary, this study showed improvement in autonomic functions following 1-week IAYT. Further studies are needed to understand the autonomic changes following the long-term practice of yoga since the present study was limited to a single group, small sample size and short duration of the intervention.

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Cite this article as: Vinutha HT, Raghavendra BR, Manjunath NK. Effect of integrated approach of yoga therapy on autonomic functions in patients with type 2 diabetes. *Indian J Endocr Metab* 2015;19:653-7.

Source of Support: Nil, **Conflict of Interest:** None declared.