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Effect of Yogic Breathing and Intermittent Breath Holding on Reaction Time and Cognitive Function among Diabetics: A Randomized Controlled Trial

Bhandarkar Vishaka P[1], Prasad Ganesh[2], Shetty Shivaprasad[3], Shetty Prashanth[4], Abinav Sugash M[5]

[1]Student of MD (Clinical Yoga), SDM College of Naturopathy and Yogic Sciences, Ujire, Karnataka, India. Affiliated to Rajiv Gandhi University of Health Sciences, Bangalore, Karnataka.
[2]Dean, Division of Fasting Therapy and Dietetics, SDM College of Naturopathy and Yogic Sciences, Ujire, Karnataka.
[3]Dean, Division of Yoga Therapeutics, SDM College of Naturopathy and Yogic Sciences, Ujire, Karnataka.
[4]Principal, SDM College of Naturopathy and Yogic Sciences, Ujire, Karnataka.
[5]Lecturer, Department of Anatomy, Excel Medical College for Naturopathy and Yoga, Tiruchengodu, Tamil Nadu

Abstract

Type 2 Diabetes Mellitus (T2DM) is a globally prevalent chronic metabolic disorder characterized by hyperglycemia, relative insulin deficiency due to beta-cell dysfunction, sub-chronic inflammation and peripheral insulin resistance. Assessing and controlling the non-glycemic risk factors such as hypertension, dyslipidemia, and obesity is vital in the prevention and management of cardiometabolic risk in T2DM individuals. Yogic Breath Holding (YBH) and Yoga Breathing with Breath Awareness (YBA) are yogic techniques that enhance response inhibition, previously done on healthy individuals. This study aims to evaluate its effect on cognitive flexibility, processing speed, and reactivity of cognition before and after the practice in volunteers with T2D. This Randomized control trail study was conducted between the ages of 30 and 60 years, and 68 volunteers were gathered. The experiment employs a counterbalanced design where participants were randomized to the experimental and control group. Electrophysiological data, neuropsychological assessments, and blood samples were collected at baseline [1st day] and post-intervention [10th Day]. Data was analyzed in SPSS - V.20 [IBM]. The blood samples (FBG, PPBG, and HbA1c), neuropsychological assessments (TMT A & B and SDMT), and electrophysiological data (ART and VRT) demonstrated a significant decrease in all measures with deemed significance $p<0.05$. The results showed that YBH and YBA practice for 20 minutes impacted cognitive flexibility, processing speed, and reactivity of cognition before and after the practice in diabetics therapeutically.

Keywords: Blood sugar, Yoga, Reaction Time, Cognitive Function, Yogic Breath Holding

1. Introduction

Type 2 Diabetes(T2D) is a global health issue fueled by genetic predisposition and lifestyle factors like obesity, poor diet, and physical inactivity[1–3]. It is marked by insulin resistance and β-cell dysfunction, leading to chronic hyperglycemia and complications such as cardiovascular disease, neuropathy, and cognitive decline[4–6]. Nerve damage in the elderly, results in delayed reaction times, making self-care more challenging[7,8]. Complementary and Alternative Medicine(CAM), particularly yoga, has shown promise in improving glycemic control, autonomic balance, and cognition[9–11]. This study is crucial as it explores the potential of yoga to enhance cognition, through a holistic approach to managing T2D.

2. Aim

To study the effect of yogic intermittent breath holding on reactivity and cognition among patients with type 2 diabetes individuals.

2.1 Objectives

- To assess the effect of yogic intermittent breath holding on auditory reaction time.
- To assess the effect of yogic intermittent breath holding on visual reaction time.
- To evaluate the effect on auditory and visual reaction time without any intervention.
- To assess the cognitive flexibility and processing speed.
- To quantify and correlate reactivity and cognition, before and after the practice of yogic intermittent breath-holding.

2.2 Subjects and Methods:

Total number of participants were 68, who were allotted to 2 groups n=34 per group;
Group 1 – Intervention group [T2DM subjects with Yogic Breath Holding (YBH) and Yogic Breathing with Breath Awareness (YBA)] & Group 2 – Control group [T2DM subjects with Conventional treatment].

2.3 Method of Collection of Data

The study subjects were screened with a closed-end questionnaire and were included after obtaining a duly signed informed consent. The institutional ethical clearance was obtained prior to the conduct of the study. The electrophysiological data and blood samples were collected at baseline [1st day] and post-intervention [10th Day].

2.4 Inclusion Criteria

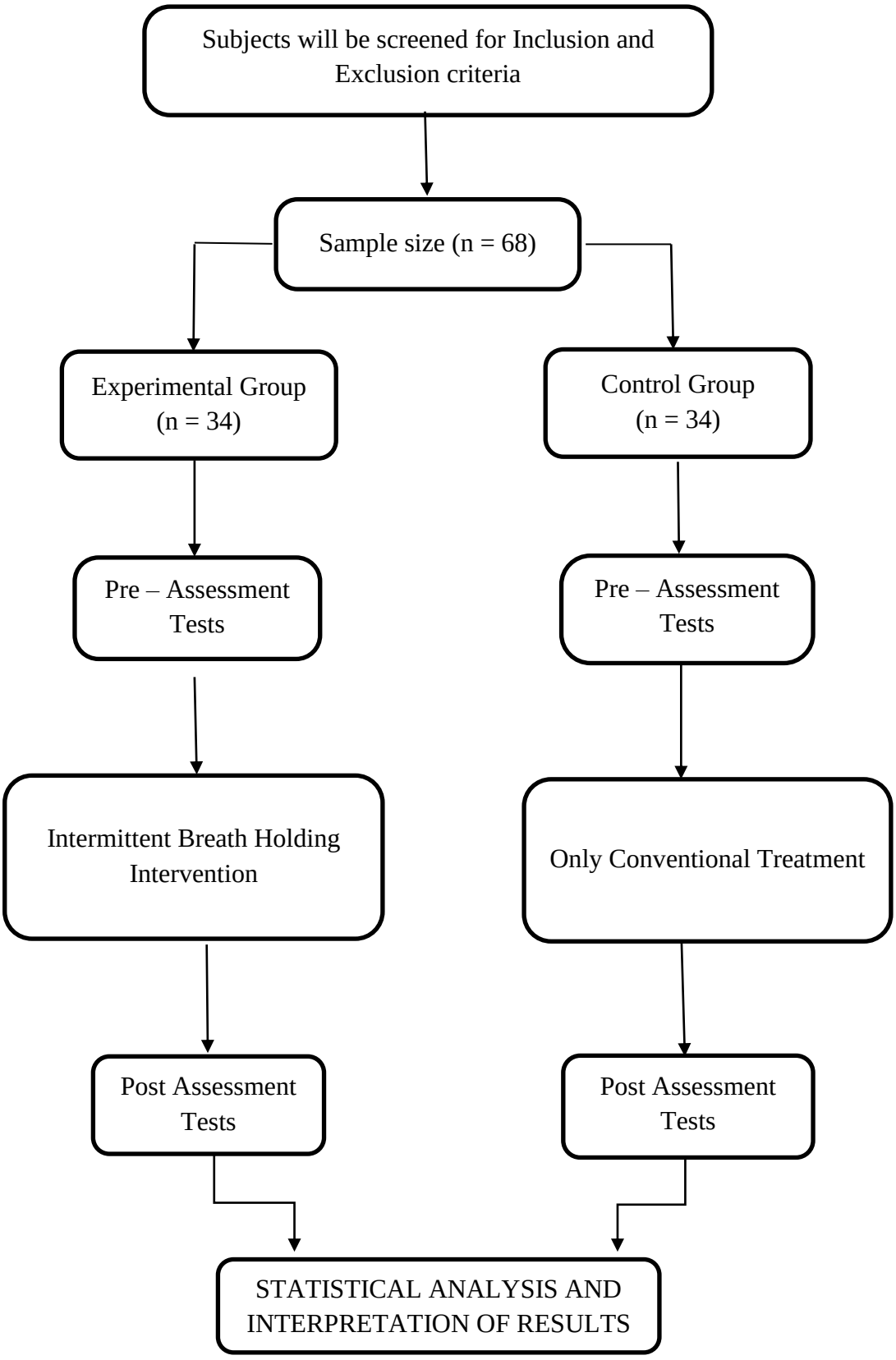
- Age: 30 to 60 years.
- Both males and females.
- Subjects with type 2 diabetes mellitus meeting the American Diabetic Association diagnostic criteria and those on oral anti-diabetic therapy.

2.5 Exclusion Criteria

- Uncontrolled diabetes mellitus and Type 1 diabetes mellitus.
- Type 2 diabetes mellitus individuals with associated complications.
- History of kidney or liver failure.
- Subjects who are Underweight and with morbid obesity.
- T2DM individuals with autoimmune or established CAD or any organic vascular disease, history of neurological / thyroid disorders, nutritional disorders and any other acute illness.
- T2DM individuals who are on insulin therapy, corticosteroids and antiepileptic drugs.

- History of alcohol or drug abuse.

2.6 Illustration of the study plan



3. Assessments

Subjects were divided into two groups: Intervention (intermittent breath-holding) and Control (conventional treatment) for 10 days. ART, VRT, Trail Making Test (TMT A & B), Symbol Digit Modalities Test, and biochemical tests were conducted before and after the intervention.

3.1 Electrophysiological Parameters

Reaction Time (RT): RT, an indicator of CNS processing speed, was measured using auditory (high/low frequency) and visual (monochromatic light) stimuli. The fastest of three responses was recorded.

3.2 Neuropsychological Assessments

Trail Making Test (TMT):

TMT-A assessed scanning and processing speed, while TMT-B measured cognitive flexibility. Poor performance on TMT-B indicated impaired executive control in T2DM patients.

Symbol Digit Modalities Test:

This test evaluated attention, visual scanning, and processing speed. T2DM patients showed greater impairment compared to normative scores.

3.3 Biochemical Parameters

Sample Collection

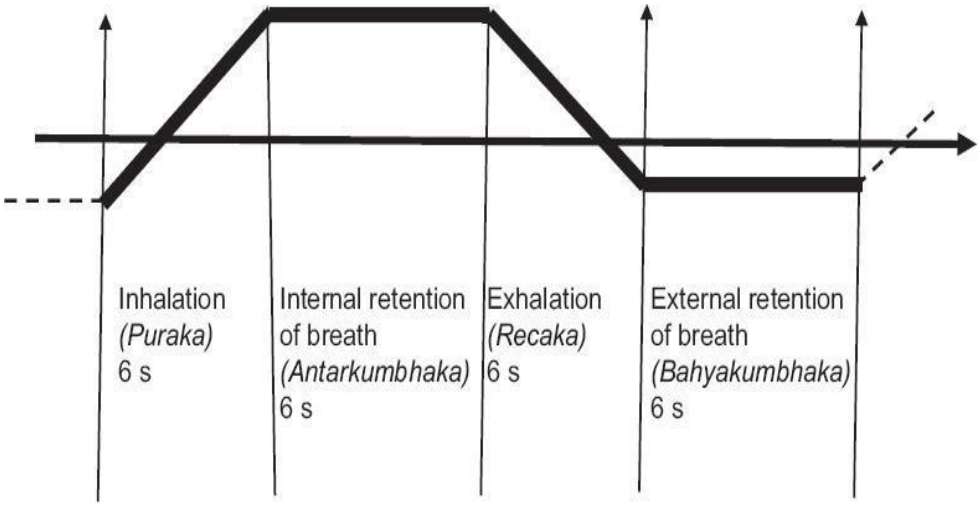
Fasting and postprandial blood samples were collected, processed, and stored for analysis. Fasting blood sugar, HbA1c, and PPBG were measured using standard methods.

Fasting blood sugar, postprandial blood sugar, and serum insulin were measured pre and post intervention and recorded for analysis.

4. Intervention

Participants underwent a 10-day yogic breathing with breath-holding (YBH) intervention. They sat erect with closed eyes, focusing on their breath. The YBH session involved 20 minutes of regulated breathing, with 6-second phases of inhalation (puraka), internal retention (antar-kumbhaka), exhalation (recaka), and external retention (bahya-kumbhaka) in a 1:1:1:1 ratio, guided by verbal cues from a pre-recorded audio track. This method followed classical pranayama techniques from yoga texts[12] and was based on a previous study using a 6-second interval[13]. The control group performed normal breathing with breath awareness for 20 minutes in the same environment, using audible cues[14].

Figure 1: The schematic representation of the breathing practice



5. Statistical Analysis

Data was analysed in SPSS [Software Statistical Package for Social Sciences] V.20 [IBM]. All results were expressed as mean +/- Standard deviation for Normal distribution or Median and Interquartile range for Skewed data. Individual groups were compared using an unpaired t-test or Mann-Whitney U-test. Within the group comparison [pre & post] was done by paired t-test or Wilcoxon Signed rank test. Categorical variables will be analyzed by using Fischer's exact test. P<0.05 will be considered significant.

Intervention Group (n=34)

Table 1. Statistical Analysis of Intervention group (Within the Group comparison)

Group-1	Pre-test		Post-test		Changes		P-value
	Mean	SD	Mean	SD	Mean	SD	
FBS	198.03	73.74	160.79	66.86	37.24	6.88	0.001
PPBS	260.97	104.91	222.09	98.82	38.88	6.09	0.001
ART	594.14	61.94	540.84	42.84	53.30	19.10	0.001
VRT	171.80	65.71	110.87	49.90	60.94	15.82	0.001
A	15.06	8.65	8.12	2.97	6.94	5.69	0.001
B	17.65	8.34	10.56	4.10	7.09	4.24	0.001
SDMT	66.85	28.42	41.35	21.62	25.50	6.80	0.001

Control Group (n=34)

Table 2. Statistical Analysis of Control Group (Within the Group comparison)

Group-2	Pre-test		Post-test		Changes		P-value
	Mean	SD	Mean	SD	Mean	SD	
FBS	163.94	37.27	162.41	36.16	1.53	1.11	0.126
PPBS	256.79	64.25	251.59	63.69	5.21	0.56	0.000
ART	606.69	94.09	561.60	71.45	45.09	22.64	0.008
VRT	170.56	73.50	161.96	63.96	8.60	9.54	0.423
A	17.47	9.36	14.68	7.83	2.79	1.53	0.000
B	21.50	11.26	17.47	9.38	4.03	1.88	0.000
SDMT	61.97	24.03	52.12	21.33	9.85	2.69	0.000

6. Results

The intervention group (n=34, mean age 51.76) showed significant improvements in Auditory (ART) and Visual Reaction Time (VRT), fasting (FBS), and postprandial blood sugar (PPBS) compared to the control group (n=34, mean age 46.58). ART decreased from 594.14ms to 540.84ms and VRT from 171.8ms to 110.87ms (p<0.001). Control group changes were insignificant. Cognitive and neurophysiological parameters, including Trail Making Test (TMT) and Symbol Digit Modalities Test (SDMT), also improved significantly. Biochemically, FBS and PPBS showed greater reductions in the intervention group, confirming a statistically significant benefit (p<0.001).

Figure 2: Bar Chart representing pre FBS & post FBS by Group

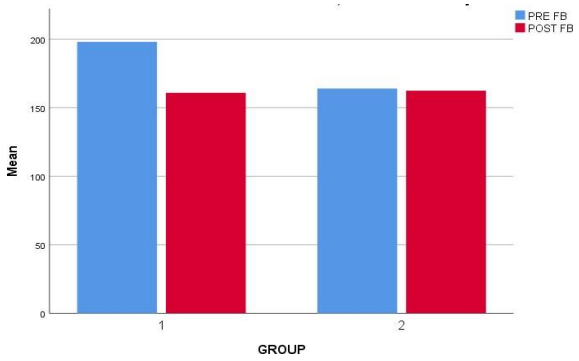


Figure 3: Bar Chart representing pre PPBS & post PPBS by Group

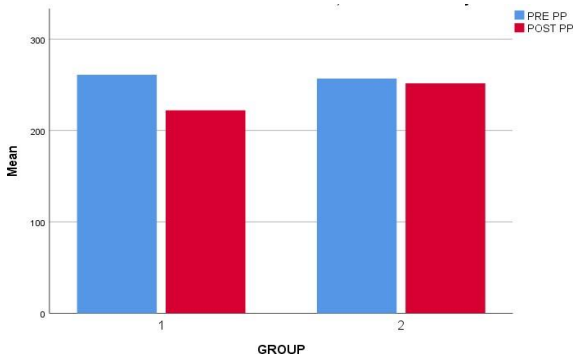


Figure 4: Bar Chart representing pre ART & post ART by Group

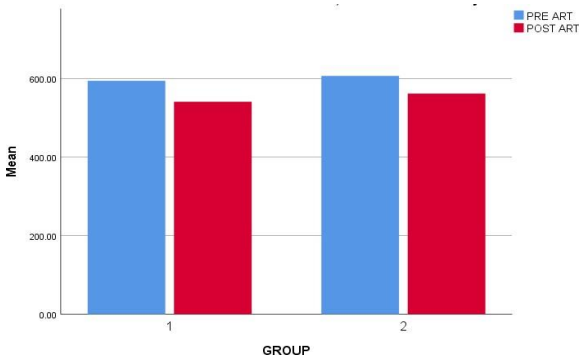


Figure 5: Bar Chart representing pre VRT & post VRT by Group

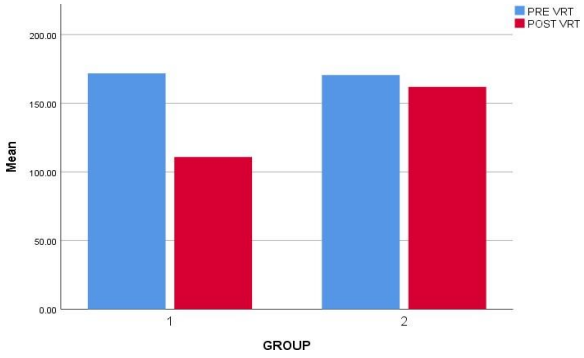


Figure 6: Bar Chart representing pre A & post A by Group

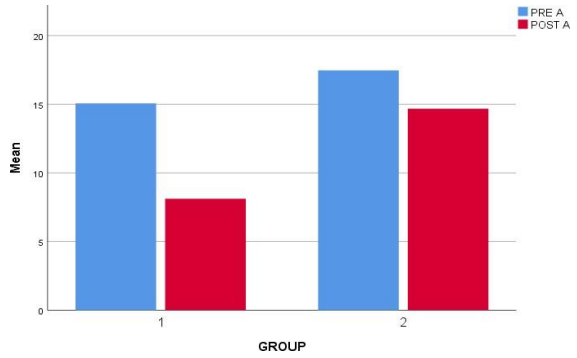


Figure 7: Bar Chart representing pre B & post B by Group

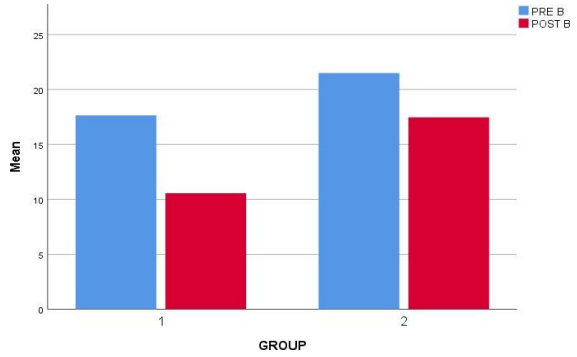
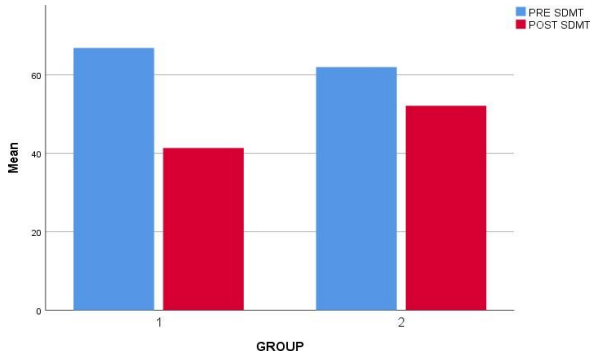


Figure 8: Bar Chart representing pre SDMT & post SDMT by Group



7. Discussion

T2DM individuals who practiced Yogic Breath Holding (YBH) and Yoga Breathing with Breath Awareness (YBA) showed positive effects on the Auditory Reaction Time (ART), Visual Reaction Time (VRT), Trail Making Test (A and B), Symbol Digit Modalities Test, and biochemical tests compared to the individuals allotted to the Control group – before and after comparison within the groups. The significant results for ART and VRT, indicate the improvement in cognitive function after the practice of YBH and YBA. Similar studies have been done to improve cognitive function for the 42 healthy volunteers.[15]

There was a statistically significant result in TMT A, TMT B, and SDMT in neuropsychological assessment tests after YBH and YBA. Data points of TMT A, TMT B and SDMT had increased after the intervention, indicating parasympathetic dominance. These breathing techniques are described as meditation because during these practices practitioners ideally assume a meditative state of mind characterized by interoception, awareness of body sensation and relaxation[16] Here practitioners

remain seated and be as still as possible, but the mental state in both practices is comparable.

The goal of the current study was to determine whether YBH practice had an impact on the response inhibition demonstrated by RT performance. The findings indicate a significant reduction in SSRT following both YBH and YBA, which corresponds to our initial hypothesis that YBH and YBA may have improved effects on response inhibition.

A noteworthy decrease in RT indicates that the use of YBH and YBA practices led to improved response inhibition. [16] Participants also slowed down their go responses, albeit statistically insignificantly following both conditions, which may be due to a proactive response strategy to achieve a balance between competing goals, suggesting a flexible cognitive control.[17] We present our findings in parallel with a previous SST paradigm study on yoga breathing.[18] Better inhibitory control can be seen in the increased RT and slowed go RT patterns. In a go/no-go challenge, a study on yoga among inmates revealed improved response inhibition.[19] Research has demonstrated comparable outcomes when ADHD drugs are administered to healthy participants.[20,21]

The observed results may be attributed to relaxation and the autonomic balance attained through the practice, which is indicated in earlier studies on yoga breathings[13] There was enhanced response inhibition following both YBH and YBA conditions. The parietal cortex and thalamus, insula, frontal cortex, basal ganglia, and pons were among the bilateral network of cortical and subcortical areas that exhibited activity in a blood oxygen level-dependent manner functional magnetic resonance imaging study conducted to investigate neural correlates of the voluntary breath holding.[22] Prefrontal-caudate and striato-thalamic activity play a role in mediating response inhibition in the SST paradigm.[23] Furthermore, it was discovered that in epileptic patients, stimulation of the vagus nerve improved response inhibition.[24] Therefore, we speculate that YBH may enhance the response inhibition through delayed breathing causes increased vagal tone and cortical and subcortical brain region activation.

Many meditation practices, like Sudarshan Kriya, Vipasana, and mindfulness, are based on the awareness of one's breath. Current information in publications indicates that breath awareness may contribute to good physiological and cognitive functioning by fostering relaxation and increasing self-consciousness.[25] Accordingly, the concentrated attention on breathing and the calm that resulted from it may be responsible for the outcomes after the YBH and YBA session. The precise processes behind the neurocognitive modulation elicited by yoga breathing practices may become clearer through additional research utilizing neuroimaging techniques.

The current study was not designed to evaluate the long-term benefits of yoga breathing on reaction inhibition. Since our study included population of diabetic adults, the results may not be generalized to clinical populations at this stage. It may be investigated further to learn how various yoga breathing techniques could affect response inhibition. The current study's inability to pinpoint the precise mechanism of action for the observations constituted a significant shortcoming. To learn more about the fundamental processes of action, it would be fascinating to incorporate neuroimaging approaches into future research. Altered response inhibition is observed in patients with ADHDs,[26] schizophrenia,[27] epilepsy,[28] obsessive-compulsive disorders,[29] as well as stressful situations.[30,31] It would therefore be interesting to observe whether yoga breathing could influence the response inhibition in such population.

By practicing YBH and YBA as intervention results show a positive impact in them by improving the parasympathetic dominance, which leads reduction in stress levels and hence is considered as a safe, cost cost-effective and beneficial tool in helping T2DM patients.

8. Conclusion

The pre-post results of our study indicated that Yogic Breath Holding and Yoga Breathing with Breath Awareness practice led to a marked improvement in blood sugar variables (FBG, PPBG), Trail Making Test (A and B), Symbol Digit Modalities Test, and biochemical tests. On the contrary, auditory reaction time was improved. Whereas in control group, except for SDRR, SD rate and PRR50 all other time domain indices were significantly improved. In the frequency domain there SD1 alone was improved. Hence, Short term cyclic meditation practice could have a beneficial impact on autonomic variables among T2DM patients.

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