

Adherence to yoga and its resultant effects on blood glucose in Type 2 diabetes: A community-based follow-up study

Praveen Angadi, Aarti Jagannathan¹, Arun Thulasi², Vinod Kumar³, Umamaheshwar K⁴, Nagarathna Raghuram
 Division of Yoga and Life Sciences, S-VYASA, ¹Department of Psychiatric Social Work, Psychiatric Rehabilitation Services, NIMHANS, ³Integrated Centre for Yoga, NIMHANS, ⁴VASK Yoga Center, Hesaraghatta, Bengaluru, Karnataka, ²Yoga and Naturopathy Government Hospital, Pathanamthitta, Kerala, India

Address for correspondence: Dr. Aarti Jagannathan,
 Department of Psychiatric Social Work/Psychiatric Rehabilitation Services, NIMHANS, Bengaluru, Karnataka, India.
 E-mail: jaganaarti@gmail.com

ABSTRACT

Aim: To study the adherence to yoga and its effects on blood glucose parameters in patients with Type 2 Diabetes Mellitus.

Methods: A single group longitudinal study over 6 months was conducted at VASK yoga centre, Bangalore. Fasting Blood Sugar, Post Prandial Blood Sugar Levels and Glycosylated Hemoglobin and qualitative in-depth interview of the participants and therapist was conducted at baseline, end of 3rd month and end of 6 months; intermediate observations was conducted at the end of every month.

Results: Adherence to yoga in the community in Bangalore is around 50% over 6 months. Participants who completed the yoga programme had significantly lower HbA1c (end of 3rd month). At the end of 6 months yoga adherence was significantly negatively correlated with FBS and stress. Further there was a trend towards those who dropped out having higher FBS, controlling for medication intake, stress levels and diet pattern (OR = 1.027, $P = 0.07$). Qualitative data revealed that most of the participants joined and completed the yoga programme to help cure their diabetes. Participants who dropped out from the yoga programme gave reasons of travel, ill-health and increased work-load at office.

Conclusions: Adherence to yoga has an effect on the blood glucose parameters in diabetes. Hence, strategies to motivate participants to undergo 'lifestyle modification practices' including maximizing adherence to yoga should be the focus to experience any beneficial effects of yoga.

Key words: Adherence; community; diabetes; India; yoga.

INTRODUCTION

Diabetes mellitus (DM) is a chronic hyperglycemic condition due to insulin resistance or relative insulin deficiency or sometimes both. Although this is usually an irreversible disease, people with diabetes can lead a normal life by correcting their lifestyle.^[1] Ayurveda texts mention how lifestyle is responsible for "prameha" which is equivalent of DM.^[2,3] For Type 1 DM, the main etiological factors are genetic and environmental; however, etiologies of Type 2 DM are many including environmental factors, autoimmunity, genetic factors, insulin resistance, obesity,


high body mass index, malnutrition in utero, physical inactivity, and newer hormones.^[4]

In the last decade, research has shown that alternative therapies such as herbs and dietary supplements, acupuncture, hydrotherapy, and yoga therapy are beneficial for treatment of diabetes and have lesser side effects than western medicine.^[5-7] Yoga especially has been observed to prevent and treat diabetes through the practice of healthy diet and lifestyle which in turn balances the

This is an open access article distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 3.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as the author is credited and the new creations are licensed under the identical terms.

For reprints contact: reprints@medknow.com

How to cite this article: Angadi P, Jagannathan A, Thulasi A, Kumar V, Umamaheshwar K, Raghuram N. Adherence to yoga and its resultant effects on blood glucose in Type 2 diabetes: A community-based follow-up study. *Int J Yoga* 2017;10:29-36.

Access this article online	
Website: www.ijoy.org.in	Quick Response Code 
DOI: 10.4103/0973-6131.186159	

endocrine system, massages and tones up the abdominal organs, stimulates the nervous and circulatory systems, and reduces stress.^[8]

The efficacy of yoga as an intervention however depends heavily on the participants' adherence to yoga regime for the prescribed period of therapy. Studies have depicted the importance of adherence to yoga in bringing about positive changes in outcome parameters and other factors such as greater confidence and ability to perform the yoga exercises in class.^[9-12] Researchers have also opined that "decreased adherence to yoga has the potential to decrease the effect of the intervention because subjects who might sustain the greatest benefit will receive a lower dose of the intervention and subjects with higher adherence rates may be functioning closer to maximum ability before the intervention."^[13] In this context, strategies to maximize adherence among subjects at greater risk for low adherence require to be the focus to experience beneficial effects of yoga.^[13]

A review of scientific studies on efficacy of yoga for diabetes has shown that though yoga is observed to be effective in reducing body weight, blood pressure, glucose level, and high cholesterol, hardly any studies examined long-term adherence to yoga – an important parameter having a bearing on the outcome parameters.^[14] Only one study tested the efficacy of yoga for diabetes patients in the context of adherence^[15] where the reported attendance at yoga classes was around 50%, and there was only a small fall in glycosylated hemoglobin (HbA1c) in the yoga group (not statistically significant) which was not sustained 6 months later; no significant changes in other outcome measures were observed.^[15]

As there are very few studies which discuss the effect of long-term yoga in the context of adherence, the present study was designed to study this important relationship between adherence to yoga and its effects on outcome parameters (blood glucose) in patients with Type 2 DM.

Subjects

Sixty-six participants diagnosed with Type 2 diabetes as per the American Diabetes Association criteria, from both genders, aged 40 years and above, who were willing to participate in the study were included. The participants who have been practicing yoga regularly for the last 3 months and those with major comorbid illness for which they required separate intervention were excluded from the study analysis ($n = 14$). Hence, the final sample of the study was 52.

MATERIALS AND METHODS

The current study was cleared by the Institute Ethics Committee of Swami Vivekananda Yoga Anusandhana

Samsthana. The study was conducted at Vivekananda Adarsha Sadhana Kendra (VASK) yoga center, in the community of Hesaraghatta, Bangalore. For obtaining the participants for the camp, announcements were made in the community 15 days before the start date of the study. A total of two camps were conducted to recruit the participants.

A pre-post experimental research design to test the effectiveness of yoga in the context of adherence to monthly yoga practice over a period of 6 months was designed. Postscreening, participants were recruited for the study if they voluntarily provided written informed consent. Sociodemographic data sheet which contained information regarding personal details of the participants such as name, age, gender, marital status, occupation, and income was obtained.

Adherence to yoga sessions was assessed objectively based on the participant's daily attendance to yoga classes. A computerized attendance register was maintained where each participant had to check his/her attendance before entering the yoga session. Thus, adherence to yoga was assessed as the total number of sessions attended by the participant, out of the total number of sessions conducted in the yoga center in a month – cumulative over the 6-month period. Apart from adherence, fasting blood sugar (FBS), and postprandial blood sugar (PPBS) levels, test using the oral glucose tolerance test method was conducted at baseline and the end of 1st, 3rd, and 6th month. HbA1c test was conducted at baseline and the end of 3rd and 6th month of the study. In an attempt to measure life changes over the period of the study and its resultant effect on blood glucose, Holmes and Rahe's Life Events Scale was administered at the end of the study (at 6th month).^[16]

Qualitative assessments included a semi-structured preinterview schedule, which elicited qualitative responses from participants such as the problems for which they had come to attend yoga, why they chose yoga as a therapy for their situation, their understanding of yoga to treat their situation, their expectations about yoga treatment, and challenges they believe could be resolved by undergoing yoga therapy. The postinterview schedule elicited qualitative responses to questions related to their experience with the yoga program for diabetes, reasons that motivated them to complete the program/dropout of the yoga program (at the end of 3rd month and 6th month), challenges in attending the yoga program, what they most valued, positive changes or discomforts (physical/emotional) observed during practice, whether they can/have been incorporating yoga in their daily schedule/routine activities regularly at home, alone in group, and whether the yoga program fulfilled their health expectations. The interview schedule also extracted detailed information about the medication history

(whether the dosage of the medications had been changed, whether any medications had been stopped or added) and diet pattern (their food eating schedule, types of food eaten, intake of sweets and fruits, and their quantity per week) of the participants in the last 1 month. A similar interview was conducted with the yoga trainer to understand his feedback on the conduction of the yoga program at the end of 3rd and 6 months of the study. The researcher also conducted monthly nonparticipant observations using an observation checklist on how participants found the performance of yoga practice, how disciplined they were at yoga practice, how correct was the therapist in guiding the participant in the yoga therapy, how cooperative was the participant to the therapist's instructions, how long did the participant take to learn a particular yoga exercise, complaints of the therapist about the participant's yoga performance, was the participant attentive during the yoga practices or distracted, and any other factors that impeded the yoga performance of the participant.

The yoga module used in this study was scientifically developed and standardized [Table 1].^[17] Daily (one session per day) yoga classes were held for a total of 60 min in the morning, afternoon, and evening and participants could choose any one session they wanted to attend based on their convenience.

Quantitative data were analyzed using Statistical Package for Social Sciences (SPSS) version 10 (1995), IBM Corporation, Armonk, NY, United States of America. Effect of yoga (time effect) based on their adherence was conducted using the paired sample *t*-test (for normal data) and using Wilcoxon signed-rank test (for nonnormal data). Group differences between completers and dropouts (based on adherence to yoga) at baseline, 3rd month, and 6th month were conducted using the Independent sample *t*-test (for normally distributed data) or using the Mann–Whitney U-test (for nonnormal data). Predictors of adherence were assessed using either the Bivariate Correlation test (for continuous variables) or the Chi-square test (for categorical variables). To predict the outcome of categorical-dependent variable (adherence) based on the significant predictor covariates (FBS, HbA1c, stress, diet, and medication intake), logistic regression was conducted. The qualitative data collected from the interview schedule were process recorded, and content analysis was manually conducted. Prominent themes related to reasons for adherence/nonadherence were identified and substantiated with quotes of the participants/trainer.

RESULTS

The sociodemographic details of the participants of the study are depicted in Tables 2a and b. FBS, PPBS, and

Table 1: Yoga program followed during the 6 months camp

Practice	Time duration and rounds
Starting prayer (<i>Sahana vavatu</i>)	2 min
Loosening practices (neck movement, shoulder rotation, elbow movements, wrist movements, finger movements, waist rotation, knee rotation, ankle rotation, and toe movements)	10 min (5 rounds)
Surya namaskara (12 counts)	6 min (3 rounds)
Relaxation (in QRT)	5 min
Asanas (standing - Tadasana, Ardhakatichakrasana, Kati chakrasana; sitting - Vajrasana, Janu sirsasana, Vakrasana; supine – Viparita karani, Pavanamuktasana, prone - Bhujangasana)	9 min (15 s to 1 min each)
Relaxation (in DRT)	10 min
Pranayama (in sitting- Kapalabhati, abdominal breathing, Nadi Suddhi, Bhramari)	12 min
OM meditation	5 min
Closing prayer (<i>Sarve Bhavantu Sukhinah</i>)	1 min
Total time duration	60 min

QRT = Quick relaxation technique, DRT = Deep relaxation technique

Table 2a: Sociodemographic data of participants with Type 2 diabetes mellitus who attended the yoga camp (continuous data) (n=52)

Variable	Mean (SD)
Age (in years)	50.40 (9.32)
Educational status (in years)	11.6 (4.23)
Monthly income (in rupees)	18351.17 (18699.3)
Duration of type 2 diabetes (months)	77.13 (73.07)
Frequency of physical activity in a day	0.73 (0.52)
Duration of physical activity in a day (in min)	38.6 (31)
Body mass index	26.81 (4.02)

SD = Standard deviation

HbA1c were found to be normally distributed ($P > 0.05$) on Shapiro–Wilk test of normality.

Fifty percent was the predetermined cutoff value for yoga adherence based on similar research study.^[15] It depicted that the average adherence required for obtaining desirable outcomes was 50%. In this context, we considered participants who attended a minimum 50% of classes as adherent to yoga. However, the average attendance of the participants over the 6 months was 86.92 (42.61%) days of 178 total days, i.e. 48.83%. As the analysis found that the number of completers who had above 48% and above 50% adherence to the yoga program was the same; hence, participants who had a minimum attendance of 50% were considered as “Completers” and those who attended <50% of the classes were considered as “Dropouts.” Table 3 depicts the adherence pattern over 6 months of the study period.

Paired sample *t*-tests analysis showed that completers had significantly lower HbA1c at the end of 3rd month as compared to baseline (baseline – mean standard deviation [SD]: 9.01 [1.96], 3rd month – mean [SD]: 8.32 [1.85], $t = 2.92$; $P = 0.01$; there was no significant difference over

Table 2b: Sociodemographic data of participants with Type 2 diabetes mellitus who attended yoga camp (categorical data) (n=52)

Variable	n	Percentage
Gender		
Male	36	69.2
Female	16	30.8
Occupation		
Employed	32	61.5
Unemployed	3	5.8
Retired	7	13.5
Homemaker	10	19.2
Marital status		
Currently married	50	96.2
Divorced/separated	2	3.8
Family type		
Nuclear	30	57.7
Joint	22	42.3
System of treatment adopted by participant		
Modern medicine	31	59.6
Ayurveda	5	9.6
Homoeopathy	1	1.9
Multiple	7	13.5
None	8	15.4
Medication compliance		
Good	38	73.1
Irregular	5	9.6
Discontinued	2	3.8
Not applicable	7	13.5
Family history of DM		
Yes	30	57.7
No	22	42.3
Co-morbid illness in participant		
Hypertension	12	23.1
Thyroid illness	3	5.8
Others	2	3.8
Multiple	7	13.5
Nil	28	53.8
Diet		
Vegetarian	25	48.1
Nonvegetarian	27	51.9
Habits		
Smoking	5	9.6
Alcohol	8	15.4
Multiple	5	9.6
Nil	34	65.4
Physical activity		
Exercise	22	42.3
Multiple	16	30.8
None	14	26.9

DM = Diabetes mellitus

Table 3: N and percentage of participants who completed/dropout (adherence pattern) over the 6 months period of study (n=52)

Status	0-1 months, n (%)	0-3 months, n (%)	0-6 months, n (%)
Completers	45 (86.53)	32 (61.5)	27 (51.9)
Dropouts	7 (13.46)	20 (38.5)	25 (48.1)

time in dropout group). Between groups analysis at the end of 6th month using Mann–Whitney U-test (as sample in two groups was <30) showed a trend toward lower FBS in completers as compared to dropouts (completers – mean

[SD]: 165.88 [42.77]; dropouts: 222.73 [89.32]; $U = 86.0$; $P = 0.08$).

Bivariate correlation analysis depicted that at the baseline, there was a positive trend between duration of physical activity and adherence, indicating that more duration of time the participants indulged in physical activity more likely they were to adhere to the yoga sessions ($r = 0.26$, $P = 0.07$). Similarly, there was a significant positive correlation between frequency of physical activity indulged in a day and adherence to yoga ($r = 0.36$, $P = 0.01$). At the end of 6 months, adherence to yoga was significantly negative correlated FBS (Pearson $r = -0.38$, $P = 0.02$) [Table 4]. Further, Chi-square analysis showed that significantly more number of participants who experienced mild-moderate stress completed the study as compared to participants who experienced high-very high stress and who dropped out of the study at the end of 6 months ($\chi^2 = 4.95$, $P = 0.03$).

As stress, diet, and medication intake play an important part in determining the reasons for change in blood glucose levels of patients with Type 2 diabetes along with their adherence to yoga/exercise pattern, additional subgroup analysis of outcome variables (FBS, PPBS, and HbA1c) with stress, diet, and medication intake as grouping variable was conducted at the end of 6 months. Results showed that participants with mild-moderate stress had significantly lower FBS (mean [SD]: 164.89 [40.92]) and HbA1c (mean [SD]: 8.89 [1.55]) values as compared to those who experienced high-very high stress (FBS – mean [SD]: 247.50 [93.13]; HbA1c – mean [SD]: 11.26 [2.76]) at the end of 6th months (FBS Mann–Whitney U-test = 51.0, $P = 0.02$; HbA1c Mann–Whitney U-test = 50.0, 0.02). Further, participants who did not start medications had significantly lesser FBS (mean [SD]: 142.29 [35.01]) and HbA1c (Mean [SD]: 7.69 [1.42]) as compared to those who maintained their same medicines (FBS - mean [SD]: 171.26 [42.56]; and HbA1c - Mean [SD]: 9.18 [1.42]), who in turn had lesser FBS (mean [SD]: 234.7 [86.59]) and HbA1c (Mean [SD]: 11.07 [2.48]) than participants who changed their medicines in between the study (Kruskal–Wallis Chi-square: FBS = 6.36; $P = 0.04$; HbA1c = 9.32; $P = 0.01$). As none of the participants stopped taking sweets during the study period, there were no group differences in the outcome parameters between those who “Occasionally took sweets” as compared to those who “Regularly took sweets.”

Logistic Regression to predict the binary outcome variable (adherence) based on the covariates (FBS, HbA1c, stress, diet, and medication intake) after adjusting for stress, medication intake, and diet pattern was conducted. Results depicted that levels of FBS or HbA1c could not predict the adherence. However, there was a trend toward

Table 4: Correlation between adherence to yoga (total adherence over 6 months) and demographic outcome variables at baseline/end of study (n=52)

Variable	Pearson 'r'	P
Age ^	0.23	0.10
Education status ^	-0.10	0.48
Monthly income ^	-0.10	0.47
Duration of Type 2 diabetes ^	0.11	0.45
Duration of physical activity/day ^	0.26	0.07
Frequency of physical activity ^	0.36	0.01*
BMI ^	-0.19	0.18
Fasting blood sugar#	-0.38	0.02*
Postprandial blood sugar#	-0.16	0.35
HbA1c#	-0.14	0.42

^At baseline; #End of study. BMI = Body mass index, HbA1c = Glycated hemoglobin. *P<0.05

Table 5: Logistic regression for adherence

Variable	β	Significant	OR	95% CI for OR
FBS	0.026	0.07	1.027	0.998-1.056
HbA1c	-0.417	0.31	0.659	0.297-1.464

OR=Odds ratio, CI=Confidence interval, FBS=Fasting blood sugar, HbA1c=Glycated hemoglobin

those who dropped out having higher FBS, controlling for medication intake, stress levels, and diet pattern (odds ratio [OR] = 1.027, P = 0.07) [Table 5].

The qualitative data analysis revealed that most of the participants joined the yoga program to help cure their diabetes – this was the main factor that motivated them to complete the program. After doing the practice, positive changes observed by them were feeling of lightness in the body and mental relaxation. However, majority of them reported that they would be unable to practice yoga in their home due to lack of time, not feeling motivated to practice alone at home, noise and disturbance at home, and inability to follow all steps with concentration while practicing at home. Participants who dropped out from the yoga program gave reasons of travel, ill-health, and increased workload at office.

The intermediate nonparticipant observation by the researcher noted that the participants found the overall yoga module feasible and were sincere, disciplined, and cooperative toward the practices. They were able to learn the practices quickly and were good in their performance. Also, the overall performance of the trainer in delivery of the module was found to be very good. The trainer was also satisfied with the participants' performance in the yoga program.

DISCUSSION

In this study, the researchers have aimed at understanding the adherence to yoga in patients with Type 2 diabetes over a period of 6 months. With respect to the

sociodemographic data, the results are in keeping with that of other studies conducted in developing countries, which have reported that the age range of people with Type 2 diabetes is 45–64 years, more males are affected with the disease than females,^[18-21] and the prevalence of Type 2 diabetes is less among highly educated people as compared to lesser educated individuals.^[22,23] The average (SD) duration of Type 2 illness in this study was seen to be 77.13 (73.07) months, i.e., around 6 years of illness. A look at the data shows that a majority of the participants were on medications (n = 43; 82.69%) and qualitative responses clearly depict that as they were unable to control their blood glucose levels through medication, they had opted for this yoga program. Further, a subgroup analysis based on HbA1c values showed that more number of participants were of severe diabetes (8.0% and above; n = 38) category as compared to mild-moderate diabetes (≤7.9%; n = 14)^[24] indicating that diabetes was not controlled in most participants at baseline in spite of taking medications.

In the current study, the participants were indulging in some form of physical activity (apart from yoga) at least once a day (Mean [SD]: 0.73 [0.52]) for 38.6 (31.0) minutes. Based on these data and earlier data on severity of diabetes, it can be observed that in spite of indulging in physical activity, most participants continued to have severe diabetes (HbA1c = 8.0% and above). The possible reasons for this could be (1) the physical activity duration and frequency was not sufficient to bring about a change in their blood glucose levels, (2) the type of physical activity indulged in was not able to bring about a change in their blood glucose levels as possibly the activities tackled only the physical level of fitness ignoring the mental level – which could be managed with yoga, and (3) the severity of the cases (with diabetes) leads to poor prognosis irrespective of the type of physical activity. In this context, the importance of using yoga as an intervention (mind-body intervention) for Type 2 diabetes assumes significance.

With respect to adherence to yoga, as observed in Skoro-Kondza *et al.* study,^[15] the researchers observed that in this study too, the average attendance of the participants over the 6 months was 48.83% and this adherence rate is low, possibly as the researchers allowed for naturalistic attrition and the setting was in the community (outpatient). The adherence rates could also be understood from the perspective of behavior change paradigm where psychological theories cite environmental, personal, and behavioral characteristics as the major factors in behavioral determination. From the perspective of “Self-efficacy theory,” an individual's impression of their own ability to perform a demanding or challenging task such as yoga could be a determinant

of adherence.^[25] Learning theory state that individuals learn by duplicating behaviors they observe in others and that rewards are essential ensuring the repetition of desirable behavior.^[26] The results of this study too depict this aspect that completers had significantly lower HbA1c at the end of 3rd month as compared to baseline whereas no significant difference over time was observed in dropout group, i.e., some individuals who did not observe any change in the blood glucose levels post 3 months of yoga were more likely to drop out from the program as compared to those who did observe some changes (rewards).

However, it is important to note that social behavior change is dependent on three factors such as environment, personal and behavior elements. Hence, apart from self-efficacy factors, personal reasons (other commitments, family, etc.,) and environmental reasons (distance of yoga center from home, etc.) are important aspects for behavior change/adherence as brought out in the results of this study. The ideal participant would be one who follows “The Health Action Process Approach”^[27] where he/she subjects himself/herself to two continuous self-regulatory processes, a goal-setting phase (motivation) and a goal-pursuit phase (volition).

The adherence rates could be higher if researchers consciously intervened to maintain adherence and/or in an in-patient residential setting. However, the results of this study are extremely important as majority of the people in India stay in rural and semi-urban areas (in the community) and very few people can access yoga residential services in the urban cities. In this context, as yoga needs to be propagated and provided in the community to expand its reach, this adherence rate in a community setting is significant in designing future community-based yoga studies.

In this study, three analyses were observed to be clinically significant: (1) Participants who completed the yoga program had significantly lower HbA1c (end of 3rd month), (2) at the end of the study, yoga adherence was significantly negatively correlated with FBS and stress, and (3) trend toward those who dropped out having higher FBS, controlling for medication intake, stress levels, and diet pattern (OR = 1.027, $P = 0.07$) on logistic regression, clearly indicating that adherence to yoga has an effect on outcome parameters as observed in other studies.^[13-15] This result throws up three important points of discussion:

1. Adherence to yoga has an important effect on the blood glucose parameters in diabetes
2. Fifty percent adherence to yoga may not be enough to bring about a significant change in all the blood glucose parameters over a period
3. There could be other factors such as medication intake,

stress, and diet which could be acting as extraneous variables affecting the blood glucose parameters, apart from adherence to yoga, due to which results were not sustained over a period of 6 months.

There could be multiple reasons for the above results as discussed below:

Yoga as alternative or adjunct treatment

The pharmaceutical treatment in treating diabetes is proven to have a large and immediate effect and in these circumstances, yoga can be considered as add-on intervention; in such case, effects are small and can be observed only over a long-term period. In this context, it is difficult to predict if the effect or no-effect is due to the pharmaceutical treatment or the adjunct yoga treatment. Also, it is difficult to predict if the effect or no-effect is due to the pharmaceutical treatment or the adjunct yoga treatment. In our study, it was observed that people who were not on medications improved the best on blood glucose parameters as compared to those who were on stable medications and the group that changes its medications fared the worst. In this context, to observe these small adjunct effects in adjunct/add-on treatments, larger sample sizes need to be taken or yoga needs to be provided as an alternative treatment to pharmaceutical treatment to those participants with diabetes who clinically can undergo nondrug treatment (who have no complications of diabetes or drug-naïve patients/freshly diagnosed diabetics). Only in this scenario, we can clearly state that pharmaceutical treatment or yoga treatment had an effect or no-effect on the blood glucose levels.

Tools of data collection

FBS and PPBS may not be the ideal outcome parameters to test the effect of yoga on blood glucose levels as both these parameters are highly sensitive to pharmaceutical intake and stabilize with medications. Further, with variations in blood glucose between laboratories and within individuals over a period, HbA1c or diabetes complications (such as neuropathy, nephropathy) may be more reliable outcome parameters of blood glucose levels. This could be one of the reasons for no significant results in our study. Possibly, we can make a statement that yoga is effective if the participants do not develop any complications over the period of yoga sessions, irrespective of variations in FBS and PPBS.

Community versus residential setting

Adherence to yoga, although one of the important factors of blood glucose, the medication intake, diet, and stress levels also affect the blood glucose levels. Controlling for all these variables may be feasible only in a residential

setting and not in a community setting – another reason for the nil significant results in our study.

Statistical versus clinical significance

As observed in our study, we have obtained statistically significant results (trends) on some variables at 3rd month/6th month. However, this statistical significance is very small (trend) as the sample size is small due to nonadherence/attrition. An increase in sample size may have improved the statistical significance. However, the statistical tests do not provide information about clinical significance which may be more important indicator of whether yoga had an overall effect for patients. Qualitative results in our study depict that majority of the participants felt subjectively better/healthier after undergoing the yoga program. Although there were variations in the FBS and PPBS parameters over the period of 6 months, HbA1c has reduced (clinically significant, statistically not significant) in participants who were considered as “Completers” in the study as compared to those who were “Dropout” from the study. This result could be used to state that yoga is useful in reducing blood glucose levels in participants with diabetes.

The strengths of this study are that it corroborated both quantitative as well as qualitative methodology to arrive at the current results of the study. It also brought out the importance of extraneous outcome variables such as stress, diet, and medication in blood glucose outcomes in Type 2 diabetes, which had a bearing on the overall results of the study and brought out the relation between these variables and yoga adherence. The limitation of the study is its sample size in spite of using G power calculation for calculating the sample size, and significant results on all outcome variables could have been obtained if the sample size was larger, especially as the grouping was not equal. Further, the sample was a mixed group of participants, mild and severe cases of diabetes based on HbA1c values. If a sample of participants with only mild diabetes had been taken, the results could have been more conclusive. Further, the researchers did not follow-up the participants postcompletion of the study to assess their continued adherence.

In spite of its limitations, the results of the study depict that adherence to yoga is an important factor in testing the efficacy of outcome parameters in participants with Type 2 diabetes. Further, the importance of adherence to yoga, along with other parameters such as regularity in taking prescribed medications, appropriate diet, and management of excessive stress for improvement in blood glucose levels, has been amply demonstrated in this study for implementation. The present study could be utilized

to motivate diabetic as well as patients suffering from other comorbidities to undergo “lifestyle modification practices” to help improve their overall diabetes status. Future studies can be follow-up participants who have completed a yoga program so that aspects of adherence postcompletion of formal supervised yoga classes could be assessed.

CONCLUSION

Adherence to yoga has an important effect on the blood glucose parameters in diabetes, apart from factors such as medication intake, stress, and diet. Adherence to yoga in the community in Bangalore is only around 50% over a period of 6 months. In this context, strategies to motivate participants with Type 2 diabetes to undergo “lifestyle modification practices” including maximizing adherence to yoga should be the focus to experience any beneficial effects of yoga.

Acknowledgments

The researchers of this paper would like to thank the team of VASK Hesaraghatta, Bengaluru, for helping in the conduction of the camp and providing the necessary support in implementation of the intervention during the period of the study.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Kumar P, Clark ML. Kumar and Clark’s Clinical Medicine (Google eBook). London, UK: Elsevier Health Sciences; 2012.
2. Sharma RK. Dash, Caraka Samhita, 1st Edition. Varanasi India: Chowkhamba sanskrit series office. 1988.
3. Nagendra HR, Tripathi S, Nagarathna R. Validation of an integrated ayurveda-yoga module for residential treatment of patients with type 2 diabetes mellitus – A compilation from traditional literature. *Int J Ayurvedic Herb Med* 2012;25:921-34.
4. Tripathi BB. Rssdi: Textbook of Diabetes Mellitus. Hyderabad, India: JP Medical Ltd.; 2012.
5. Pandey A, Tripathi P, Pandey R, Srivatava R, Goswami S. Alternative therapies useful in the management of diabetes: A systematic review. *J Pharm Bioallied Sci* 2011;3:504-12.
6. Posadzki P, Lee MS, Ernst E. Complementary and alternative medicine for diabetes mellitus: An overview of systematic reviews. *Focus Altern Complement Ther* 2012;17:142-8.
7. Anderson JG, Taylor AG. The metabolic syndrome and mind-body therapies: A systematic review. *J Nutr Metab* 2011;2011:276419.
8. Lui E, Upadhyay AK, Balkrishna A, Upadhyay RT. Effect of pranayama [Voluntary Regulated Yoga Breathing] and yogasana [Yoga Postures] in

- diabetes mellitus (DM): A scientific review. *J Complement Integr Med* 2008;1:1-2.
9. Cheema BS, Houridis A, Busch L, Raschke-Cheema V, Melville GW, Marshall PW, *et al.* Effect of an office worksite-based yoga program on heart rate variability: Outcomes of a randomized controlled trial. *BMC Complement Altern Med* 2013;13:82.
 10. Speed-Andrews AE, Stevinson C, Belanger LJ, Mirus JJ, Courneya KS. Predictors of adherence to an Iyengar yoga program in breast cancer survivors. *Int J Yoga* 2012;5:3-9.
 11. Moadel AB, Shah C, Wylie-Rosett J, Harris MS, Patel SR, Hall CB, *et al.* Randomized controlled trial of yoga among a multiethnic sample of breast cancer patients: Effects on quality of life. *J Clin Oncol* 2007;25:4387-95.
 12. Waelde LC, Thompson L, Gallagher-Thompson D. A pilot study of a yoga and meditation intervention for dementia caregiver stress. *J Clin Psychol* 2004;60:677-87.
 13. Flegal KE, Kishiyama S, Zajdel D, Haas M, Oken BS. Adherence to yoga and exercise interventions in a 6-month clinical trial. *BMC Complement Altern Med* 2007;7:37.
 14. Yang K. A review of yoga programs for four leading risk factors of chronic diseases. *Evid Based Complement Alternat Med* 2007;4:487-91.
 15. Skoro-Kondza L, Tai SS, Gadelrab R, Drincevic D, Greenhalgh T. Community based yoga classes for type 2 diabetes: An exploratory randomised controlled trial. *BMC Health Serv Res* 2009;9:33.
 16. Holmes – Rahe Stress Inventory | The American Institute of Stress. Available from: <http://www.stress.org/holmes-rahe-stress-inventory/>. [Last accessed on 2014 Sep 20].
 17. Kumar V. Development and Validation of Yoga Module for Patients with Type 2 Diabetes Mellitus. Submitted as MD Degree Thesis in Yoga and Rehabilitation to SVYASA University; 2013.
 18. Mohan V, Sandeep S, Deepa R, Shah B, Varghese C. Epidemiology of type 2 diabetes: Indian scenario. *Indian J Med Res* 2007;125:217-30.
 19. Wild S, Roglic G, Green A, Sicree R, King H. Global prevalence of diabetes: Estimates for the year 2000 and projections for 2030. *Diabetes Care* 2004;27:1047-53.
 20. King H, Aubert RE, Herman WH. Global burden of diabetes, 1995-2025: Prevalence, numerical estimates, and projections. *Diabetes Care* 1998;21:1414-31.
 21. Dunstan DW, Zimmet PZ, Welborn TA, De Courten MP, Cameron AJ, Sicree RA, *et al.* The rising prevalence of diabetes and impaired glucose tolerance: The Australian diabetes, obesity and lifestyle study. *Diabetes Care* 2002;25:829-34.
 22. Beckles GL, Engelgau MM, Narayan KM, Herman WH, Aubert RE, Williamson DF. Population-based assessment of the level of care among adults with diabetes in the U.S. *Diabetes Care* 1998;21:1432-8.
 23. Malerbi DA, Franco LJ. Multicenter study of the prevalence of diabetes mellitus and impaired glucose tolerance in the urban Brazilian population aged 30-69 yr. The Brazilian Cooperative Group on the Study of Diabetes Prevalence. *Diabetes Care* 1992;15:1509-16.
 24. American Diabetes Association. Standards of medical care in diabetes – 2010. *Diabetes Care* 2010;33 Suppl 1:S11-61.
 25. Bandura A. *Self-Efficacy: The Exercise of Control*. New York: Worth Publishers; 1997.
 26. Schwarzer R. Social-cognitive factors in changing health-related behaviors. *Curr Dir Psychol Sci* 2001;10:47-51.
 27. Gross R. *Psychology: The Science of Mind and Behaviour*. 7th ed. London, UK: Hodder Education, an Hachette UK Company; 2015.

Author Help: Reference checking facility

The manuscript system (www.journalonweb.com) allows the authors to check and verify the accuracy and style of references. The tool checks the references with PubMed as per a predefined style. Authors are encouraged to use this facility, before submitting articles to the journal.

- The style as well as bibliographic elements should be 100% accurate, to help get the references verified from the system. Even a single spelling error or addition of issue number/month of publication will lead to an error when verifying the reference.
- Example of a correct style
Sheahan P, O'leary G, Lee G, Fitzgibbon J. Cystic cervical metastases: Incidence and diagnosis using fine needle aspiration biopsy. *Otolaryngol Head Neck Surg* 2002;127:294-8.
- Only the references from journals indexed in PubMed will be checked.
- Enter each reference in new line, without a serial number.
- Add up to a maximum of 15 references at a time.
- If the reference is correct for its bibliographic elements and punctuations, it will be shown as CORRECT and a link to the correct article in PubMed will be given.
- If any of the bibliographic elements are missing, incorrect or extra (such as issue number), it will be shown as INCORRECT and link to possible articles in PubMed will be given.