Review Article

The Effects of Yoga on Cardiovascular Risk Factors among Patients with Type 2 Diabetes Mellitus: Systematic Review and Meta-Analysis

Anuradha, Niharika Singh Rojaria, Jaspreet Kaur, Minaxi Saini[1]

Department of Physiotherapy, Guru Jambheshwar University of Science and Technology, Hisar, [1]Mother Teresa Saket College of Physiotherapy, Panchkula, Haryana, India

Abstract

Type 2 diabetes mellitus (T2DM) is a fastest evolving metabolic disorder and India houses second highest number of patients with diabetes after China. Cardiovascular diseases are the major cause of mortality among patients with T2DM. Yoga is an ancient Indian practice that proves to be effective for patients with diabetes. The present systematic review and meta-analysis has been conducted to see the benefits of yoga on blood pressure, lipid profile, and anthropometric measures among patients with T2DM. The articles were extracted from three databases - PubMed, The Cochrane library, and Google scholar. Only English language articles, with PEDro score≥6, were included in the current study. The duplicates were removed using Mendeley. Fourteen randomized controlled trials (RCTs) and three 3 non-RCTs were included in the analysis. The meta-analysis was done using Review Manager 5.3. The results reveal that yoga is effect in improving blood pressure (P<0.01), lipid profile (P<0.01) except HDL (P=0.06), and anthropometric measures (P<0.01) except waist-hip ratio (P=0.79). Heterogeneity was also high for most of the variables. It may be concluded from the results that the yoga is effective in improving of blood pressure, lipid profile, and anthropometric measures. However, high heterogeneity sought the need of more high quality RCTs to affirm these findings.

Keywords: *Hypertension, lipid profile, type 2 diabetes mellitus, yoga*

Introduction

Type 2 diabetes mellitus (T2DM) is a metabolic disease which is increasing at alarming rate. It is characterized by increase in the blood glucose level. This increase in blood glucose leads to multisystem complications in the human body.[1] T2DM mostly exist in deadly quartet which include glucose intolerance, hypertension (HTN), obesity, and hypertriglyceridemia.[2] A recent cohort study stated that DM at baseline is a significant predictor of HTN incidence with odds ratio, 3.14 and 95% confidence interval, 2.17–4.54.[3] Obesity and DM goes hands-on-hands. Recent study has revealed that nearly 90% patients of T2DM are either obese or overweight.[4] Hypertriglyceridemia is common among patients with diabetes. This quadrant is the major risk factor for the development of cardiovascular disease. Therefore, the control of this quadrant among the patient with T2DM is the major concern as cardiovascular disease is the leading cause of mortality among Indians.[5]

Yoga is the ancient Indian practice which gains universal recognition after the celebration of World yoga day in 2015. Extensive literature support the benefit of Yoga on blood glucose,[6] HTN,[7,8] obesity,[9] and lipid profile[10,11] among patients with T2DM. This literature mostly includes small trials, with poor quality, and with inconclusive results. This lack their capability to generate the quality evidence to support the practice of yoga among these patients. Available systematic reviews and meta-analysis have included data up to 2015.[12-14] However, most of the quality research are of after 2015 after the introduction of world yoga day. Therefore, this systematic review and meta-analysis are conducted to see the benefit of yoga therapy on major cardiovascular risk factors such as HTN, lipid profile, and anthropometric measures among patients with T2DM so that strong evidence can be generated through the pooled analysis of quality trials.

How to cite this article: Anuradha, Rojaria NS, Kaur J, Saini M. The effects of yoga on cardiovascular risk factors among patients with type 2 diabetes mellitus: Systematic review and meta-analysis. Int J Yoga 2022;15:3-11.

Submitted: 17-Sep-2021 **Revised:** 04-Jan-2022
Accepted: 21-Jan-2022 **Published:** 21-Mar-2022

Address for correspondence:
Dr. Minaxi Saini,
Mother Teresa Saket College of Physiotherapy, Chandi Mandir, Panchkula - 134 107, Haryana, India.
E-mail: xs4minaxi@gmail.com

Access this article online

Website: www.ijoy.org.in

DOI: 10.4103/ijoy.ijoy_151_21

Quick Response Code:

Methods

This meta-analysis and systematic review was performed as per the Preferred Reporting Items for Systematic reviews and Meta-analysis (PRISMA) guidelines.

Search strategy

The search strategy was drafted by two authors (MS and A) by doing extensive search of the articles related to the topic. Mesh terms were also taken into consideration while drafting the search strategy. Any query was discussed with another two authors (JK and NS). Three databases (PubMed, The Cochrane Library, and Google scholar) were searched systematically from inception to till August, 31 2021 by the two authors independently (MS and A) Only human trial and English language were taken as filter. The search strategy for one database is available in Table 1.

Study selection process

The study selection process was done independently by the two authors (MS and A). MS and A consulted JK and NS, respectively, for any doubt in selection of articles. Final decision of inclusion and exclusion was taken by the mutual consent by all the four authors (MS, A, JK, NS). The duplicates were removed through Mendeley database. After the removal of duplicates, the remaining articles were screened on the basis of eligibility criteria. Then, the full-text of all the eligible articles was printed out. The full-text articles were also screened again on the basis of same eligibility criteria. The rejected full text articles were also screened again to recover any potential neglect.

Eligibility criteria

The eligibility criteria were decided as per Participants, Intervention, Control, Outcome, and study design (PICOS).

1. The study must be conducted on patients with T2DM (P)
2. The study examining and comparing the yoga intervention (asana or pranayama or meditation) with other usual care or control or placebo group (I and C)
3. The study evaluating and comparing at least one of the outcome measure (O)
4. The randomized control trial (RCT), randomized cross-over studies, cluster-randomized control trial, or quasi-experimental trials were included (S).

Exclusion criteria

1. The study participants having other comorbid state such as diabetic nephropathy and retinopathy.
2. Unavailability of data in mean ± standard deviation (SD) will be excluded (only for meta-analysis)
3. PEDro score <6.

Data extraction and management

The above mentioned data were extracted from the included studies by the two authors independently (MS and A) and any query was discussed with the another two authors (JK and NS). Data were extracted on the excel sheet prepared as per PRISMA guidelines. The following categories were decided: (1) Bibliometric data (Author's name, year of publication, continent/country, and study duration), (2) study design, (3) study participants data (age/gender, sample size, and sampling

Table 1: Search strategy for PubMed database

Search	Query	Items found
1	Search ((((Yoga[Title/Abstract] OR Yogasan[Title/Abstract] OR Pranayam[Title/Abstract] OR Yog[Title/Abstract] OR Dhyana[Title/Abstract] OR asana[Title/Abstract])))) AND ((Diabetes[Title/Abstract] OR Diabetes mellitus[Title/Abstract] OR Adult onset diabetes mellitus[Title/Abstract] OR Non-insulin dependent diabetes mellitus[Title/Abstract] OR Type 2 Diabetes mellitus[Title/Abstract] OR Type 2 Diabetes[Title/Abstract] OR T2DM[Title/Abstract]))) AND ((Body composition[Title/Abstract] OR Body weight[Title/Abstract] OR Waist circumference[Title/Abstract] OR waist hip ratio[Title/Abstract] OR Body mass index[Title/Abstract]))	39
2	Search ((((Blood pressure[Title/Abstract] OR Arterial pressure[Title/Abstract] OR hypertension[Title/Abstract] OR systolic blood pressure[Title/Abstract] OR diastolic blood pressure[Title/Abstract]))) AND ((Yoga[Title/Abstract] OR Yogasan[Title/Abstract] OR Pranayam[Title/Abstract] OR Yog[Title/Abstract] OR Dhyana[Title/Abstract] OR asana[Title/Abstract])))) AND ((Diabetes[Title/Abstract] OR Diabetes mellitus[Title/Abstract] OR Adult onset diabetes mellitus[Title/Abstract] OR non-insulin dependent diabetes mellitus[Title/Abstract] OR Type 2 Diabets mellitus[Title/Abstract] OR Type 2 Diabets[Title/Abstract] OR T2DM[Title/Abstract] OR Diabetes mellitus Type 2[Title/Abstract] OR Diabetes Type 2[Title/Abstract]))	72
3	Search (((((Diabetes[Title/Abstract] OR Diabetes mellitus[Title/Abstract] OR adult onset diabetes mellitus[Title/Abstract] OR non-insulin dependent diabetes mellitus[Title/Abstract] OR type 2 Diabetes mellitus[Title/Abstract] OR type 2 diabetes[Title/Abstract] OR T2DM[Title/Abstract]))) AND ((Yoga[Title/Abstract] OR Yogasan[Title/Abstract] OR Pranayam[Title/Abstract] OR Yog[Title/Abstract] OR Dhyana[Title/Abstract] OR asana[Title/Abstract]))))) AND ((Lipid profile[Title/Abstract] OR cholesterol[Title/Abstract] OR High density lipoprotein cholesterol[Title/Abstract] OR High density lipoprotein cholesterol[Title/Abstract] OR Triglyceride[Title/Abstract]))	33

method), (4) Intervention detail (Type, frequency, and duration of yoga), (5) Control group detail (Type-usual care/placebo etc., frequency, and duration), and (6) Outcome measures (blood pressure-systolic blood pressure and diastolic blood pressure (SBP and DBP); Anthropometric measures-body weight (BW), body mass index (BMI), waist-hip ratio (WHR), and waist circumference (WC); lipid profile-total cholesterol (TC), triglycerides (TG), high-density lipoprotein (HDL), and low-density lipoprotein (LDL).

The corresponding author of the full-text eligible studies was contacted to retrieve any missing data through E-mail. Wherever the data were missing for SD then it was imputed as per Cochrane Handbook for Systematic Reviews of Intervention. The data for TC and triglyceride were converted using the software to bring homogeneity in the units.

Data items

The primary outcomes for the study were blood pressure, i.e., SBP and DBP and total lipid profile i.e., TC, TG, HDL, and LDL. The secondary outcome measure was anthropometric i.e., BW, BMI, WHR, and WC.

Assessment of quality of individual study

The methodological quality of individual study was assessed through the PEDro rating scale. It is a reliable[15] and valid[16] score for the measurement of methodological quality of RCTs. It is an 11-items score having maximum score of 11. A score of 6 or more is considered as high quality; while a score <5 is considered a fair and a score below 3 is considered poor.

Study risk of bias assessment

Assessment of risk of bias of individual study as well as across the studies was evaluated using Review Manager 5.3 (RevMan version 5.3; The Nordic Cochrane Centre, Copenhagen, Denmark). Risk of bias of the individual study was evaluated through Cochrane Collaboration's modified tool. It consists of seven items: "random sequence generation, allocation concealment, selective reporting, blinding of participants and personnel, blinding of outcome assessment, incomplete outcome data, and other sources of bias." On the basis of these items, the study can be classified as high risk, low risk, or unclear risk. Assessment of risk of bias across the studies was evaluated through the heterogeneity analysis. Funnel plot was also plotted and analysed for publication bias.

Statistical analysis

It was also done using Review Manager 5.3 (RevMan 5.3) which is a Cochrane Collaboration's software for systemic reviews and meta-analysis. Weighted mean difference (WMD), 95% CI and overall effect was computed by feeding data for mean, SD and total number subjects for both control and diabetic group. Forest plots for each outcome measure were also produced. Significance level was set at 0.05. Random model was used for the analysis. Heterogeneity was tested using I^2 statistics. Heterogeneity of "0%–25% was considered as low heterogeneity, 26%–75% as moderate heterogeneity and 76%–100% as substantial heterogeneity" in I^2 test. If the I^2 value is >50% then sensitivity analysis was performed. Additional analysis such as sensitivity and subgroup analysis was also performed as per the availability of the data.

Results

Search results

Total 32568 studies were found after the advance search in three databases: PubMed, Cochrane Library, and Google scholar by two authors (MS and A) independently. 848 were removed due to duplication using Mendeley software. Title and abstract of remaining 31720 studies were evaluated on the basis of eligibility criteria. After initial scanning, 31704 records were excluded as not meeting inclusion criteria. Remaining 46 full text articles were scanned independently by two authors for eligibility. From these articles, 29 were excluded due to reasons as mentioned in Figure 1. Excluded studies were also scanned by another two authors (JK and NS) to retrieve any potential neglect. Figure 1 showed the flow diagram of the study. Total 17 studies were included qualitative analysis (systematic review)[11, 17-32] and 15 were considered for quantitative analysis (meta-analysis) as data for mean ± SD was not available for two studies.[17,20]

Study characteristics and study quality

The characteristics of included studies is represented in Supplementary Table 1. As shown in table, 13 were RCT, 1 was randomized cross-over study, 3 were nonRCT. 13 studies were from India, 1 each from England, USA, Australia, and Cuba. Six studies were having PEDro 6 and 7 was scored by another 6 studies. 8 and 9 scoring on PEDro was obtained by 1 study each. In 17 studies, total 1725 patients with T2DM were included. 804 were in experimental group and 807 were in the control group. The total duration of the yoga protocol was immediate, 2 months, 40 days, and 45 days in 1 study each. One study has not mentioned about the duration of the protocol. In 8 studies, the yoga protocol was given for 3 months. 6 months and 9 months of yoga protocol were given in one study each.

The duration of one session of yoga was very variable among the studies. It was from immediate to 2 h, as shown in Supplementary Table 1. Yogic intervention is also variable. Pranayama, asana, suryanamaskara, hath yoga, prayer, deep breathing, Debts Recovery Appellate Tribunals, quick reaction team etc., were given as yogic intervention. Control group has given the nonyogic intervention. Two studies[28,30] have given sham yoga to the

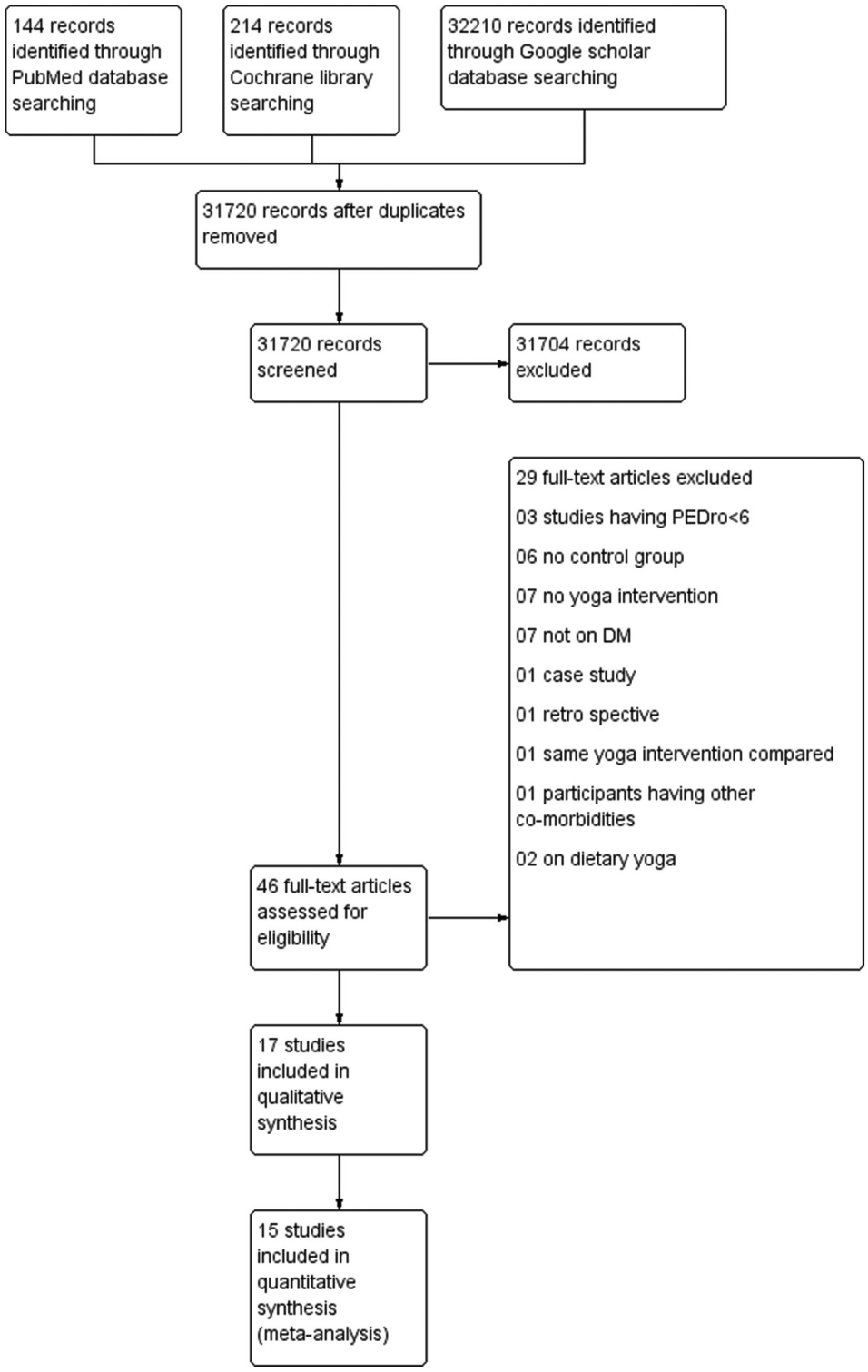

Figure 1: Flow diagram of study as per PRISMA guidelines

control group. Only two studies[11,20] have taken follow-up of the participants. Two studies have not provided the mean ± SD.[17,20] The insignificant improvement was found only in two studies.[20,30] Rest of the studies has shown significant improvement in at least one of the outcome measure.

Results for primary outcome

Blood pressure

Total eight studies have taken blood pressure as outcome measure. Among these two studies have not reported about the mean ± SD. Therefore, the forest plot was produced

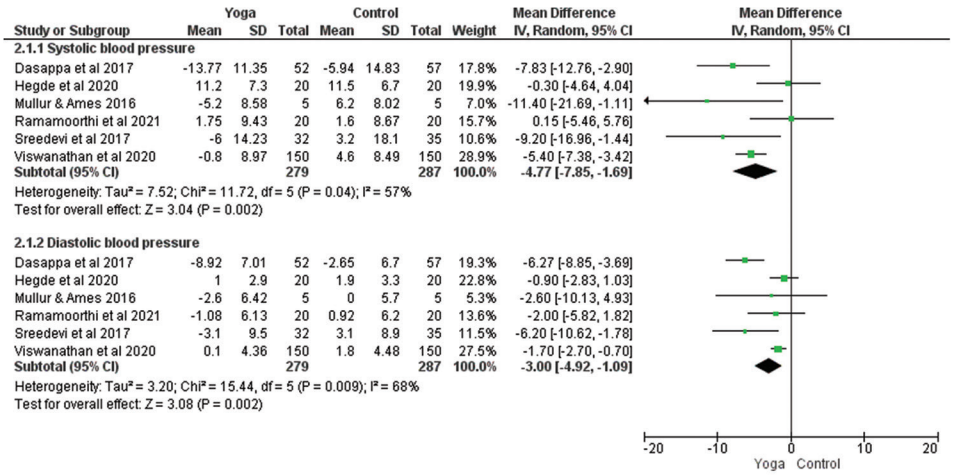

Figure 2: Forest plot for blood pressure

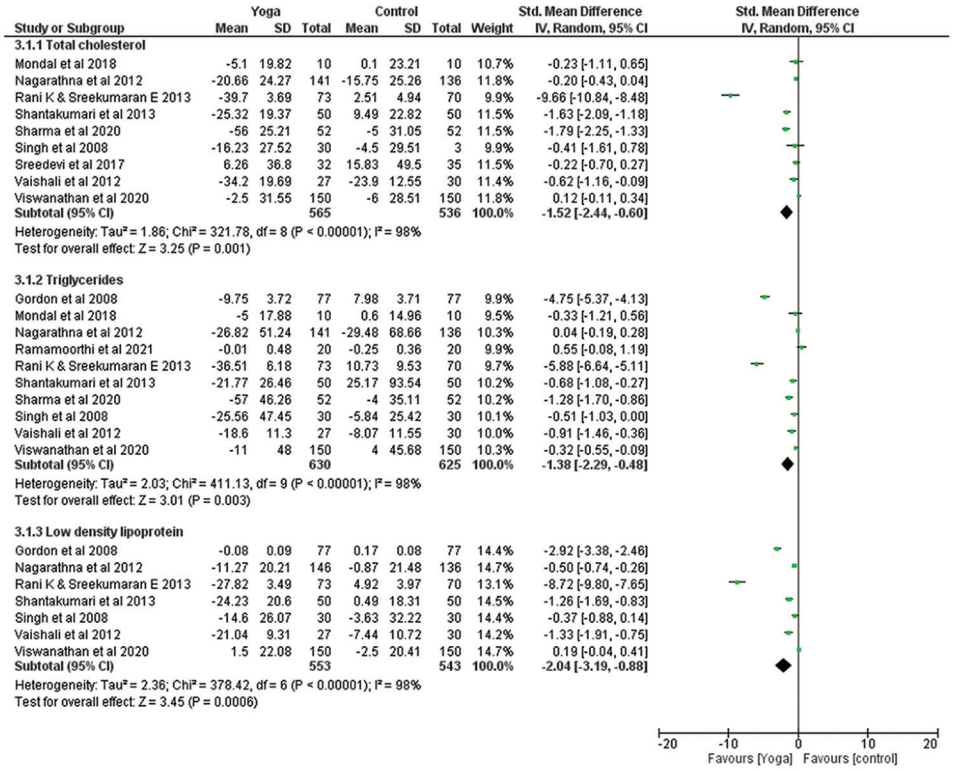

Figure 3: Forest plot for lipid profile

using six studies [Figure 2]. The results show the significant reduction of SBP and DBP in yoga group in comparison to the control group ($P = 0.002$) with WMD = −4.77 and −3.00, respectively. However, the heterogeneity was moderate i.e.,

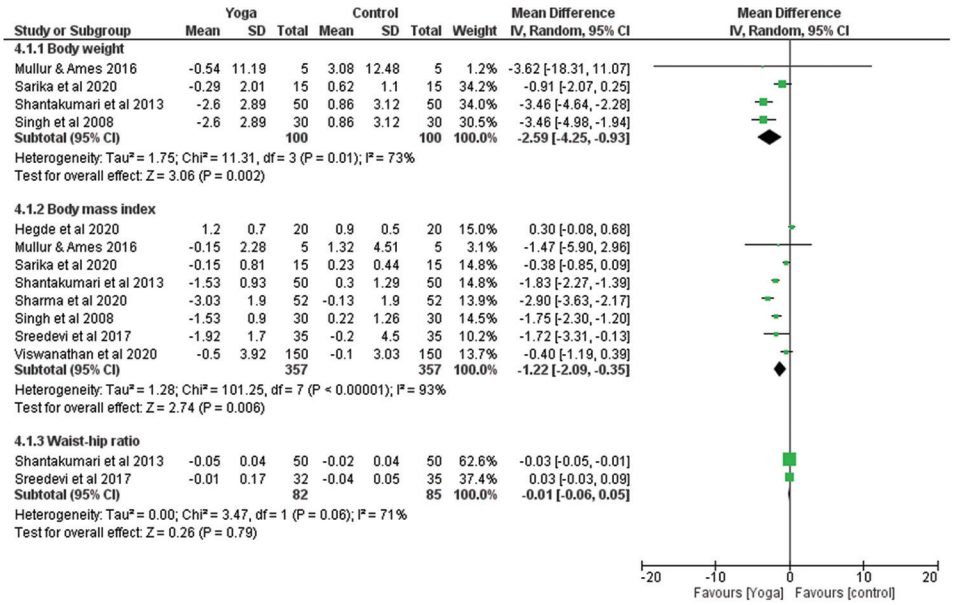

Figure 4: Forest plot for anthropometric measures

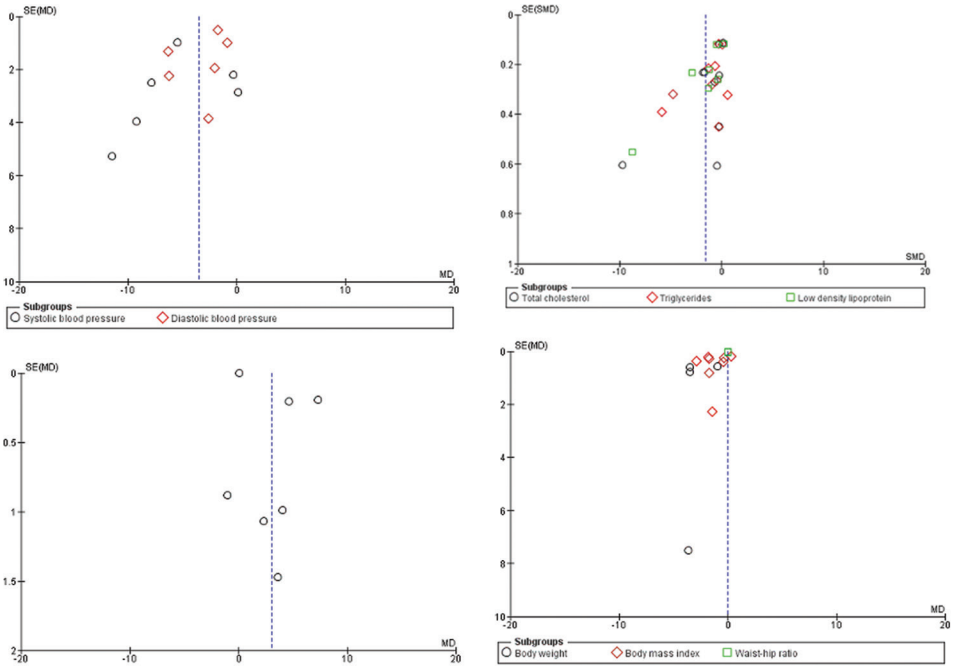

Figure 5: Funnel Plots

57% and 68% respectively for SBP and DBP. Sensitivity analysis by removing two studies[17,20,25,28] has decreased the heterogeneity, as shown in Supplementary Figure 1.

Lipid profile

Total cholesterol

Total nine and ten studies for TC and TG, respectively, and eight studies each for HDL and LDL were included for meta-analysis [Figure 3]. The analysis reveals the significant improvement in TC, TG, and LDL with P = 0.001, 0.003, and 0.001; WMD = −1.52, −1.38, and −2.04 respectively. However, the heterogeneity was substantial i.e., 98% for TC, TG, and LDL. The results for HDL were also in favor of Yoga therapy. However, the difference was not significant (P = 0.06). Removal of single or many studies has not changed the heterogeneity to the significant level.

Anthropometric measures

Total four, eight, and two studies were found for BW, BMI, and WHR, respectively [Figure 4]. The results were

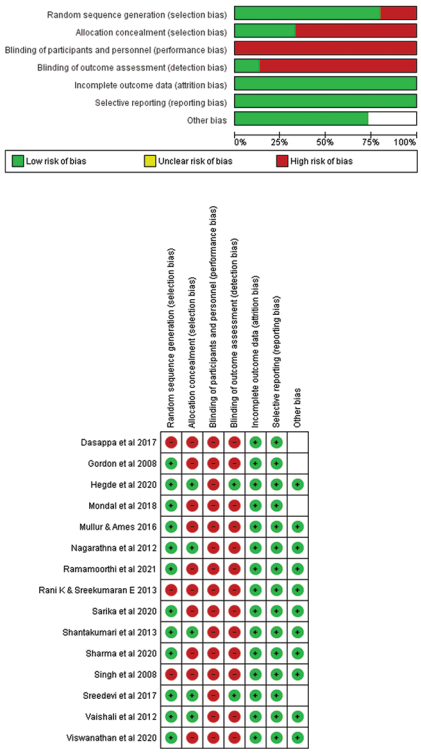

Figure 6: Risk of bias assessment

in favor of Yoga therapy. However, it was not significant for WHR (P = 0.79). The WMD was −2.59, −1.22, −0.01 for BW, BMI, and WHR, respectively [Figure 4]. The heterogeneity was moderate to substantial (>70%). The sensitivity analysis revealed that the heterogeneity reduces to the significant level by keeping the studies with 3 months duration only. This has reduced the heterogeneity to significant level [Supplementary Figure 2].

Publication bias and risk of bias

The publication bias is represented through funnel plot [Figure 5]. No publication bias was found for BP, TC, and TG. However, funnel plot analysis showed the publication bias for LDL, HDL, BW, BMI, and WHR. The risk of bias graph and summary is represented in Figure 6.

Discussion

This systematic review and meta-analysis was performed to explore the effect of yoga on cardiovascular risk factors among patients with T2DM. The primary outcomes measures were SBP, DBP, TC, TG, HDL, and LDL. The secondary outcome measures were BW, BMI, WHR, and WC. The findings of the meta-analysis reveal that the yoga is beneficial in improving all the outcome measures. However, the results are not significant for WHR and HDL. Heterogeneity was also high for these variables. The sensitivity analysis does not affect the results in term of heterogeneity and significance level for these variables. Various reviews[31] have also discussed the benefit of yoga intervention among patients with T2DM. Many systematic reviews and meta-analysis has also evaluated the benefit of yoga for the patients with T2DM.[12-14,33,34] Our results are in agreement with this literature. However, our study is superior to the existing literature as their database search is bound up to 2015 and we have searched up to August, 2021. Therefore, we are able to get more recent and quality articles as most of the quality research in yoga therapy is after the introduction of world yoga day in 2015. Our meta-analysis results are based upon the 15 trial and among these 13 were RCTs. This is the biggest strength of this yoga based meta-analysis. Second, we have included studies which have PEDro score ≥6 which strengthen the evidence generated by this systematic review and meta-analysis.

There are a few limitations of this systematic review and meta-analysis. First, high heterogeneity for study variables. This is the biggest limitation. This may be because of the methodological variations among the studies. Secondly, the maximum studies which we are able to get are from India. This is because yoga is an ancient Indian practice and Indian are more aware about its true concept and benefits. However, Yoga gains universal recognition after the celebration of world yoga day. Now the good quality trials are coming from around the world. Finally, we get few studies for each subgroup analysis this could be the limitation of the study.

Future scope

These results of this study could be taken as ground for future RCT. The study also sought the need of more trial on anthropometric measures as we get a few studies on BW, WC, and WHR, and these studies are also having publication bias as revealed through the funnel plots. The anthropometric measures are important risk factor for cardiovascular diseases; therefore, more high quality studies are required for the effect of yoga on anthropometric measures among patients with T2DM. Further, the inclusion of more homogenous studies in future meta-analysis may reduce the heterogeneity.

Clinical significance

This meta-analysis generates the evidence for the effectiveness of yoga intervention in the reduction of blood pressure, lipid profile, and anthropometric measures. These three are important risk factors for the cardiovascular disease. This may help the yoga instructors for evidence-based practice for the benefit of patients with T2DM.

Conclusions

It may be concluded from the results that the yoga is effective in reduction of blood pressure, lipid profile, and anthropometric measure for patients with T2DM. However, higher heterogeneity in forest plot analysis sought the requirement of large scale good quality RCT. The good quality trial of long duration is also warranted as maximum trial which we get is of short duration (≤3 months).

Ethical clearance

No ethical clearance is required.

Acknowledgments

This work has been submitted at Guru Jambheshwar University of Science and Technology, Hisar for the partial fulfilment for the degree of Maters of Science (Yoga therapy and Science) by the first author.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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Supplementary Table 1: Characteristics of included studies

Author/year	Country	Study design	PEDro score	Total	Yoga intervention/one session/total duration	Experiment (*n*)	Age (years)	Control intervention
Skoro-Kondza *et al.*/2009	England	Exploratorty RCT	6	59	Pranayama + asanas/90 min/3 months	29	NA	Life style advice
McDermott *et al.*/2014	India	RCT	8	41	19 asanas + 4 BE + relaxation + meditation/75 min/2 months	21	47±9.7	Walking
Mullur and Ames/2016	USA	RCT	7	10	5 postures + DB/10 min/3 months	5	68.8±5.97	Information + handouts of yoga class
Hegde *et al.*/2020	India	RCT	9	40	15 asanas + 3 pranayama/ 75-90 min/3 months	20	57.1	Nonaerobic ex + walking
Ramamoorthi *et al.*/2021	Austrila	Randomized cross-over study	7	20	Asanas + relaxation/ immediated	20	44.95±9.80	Sham yoga
Dasappa *et al.*/2017	India	Non RCT	6	109	10 asana + 3 pranayams + sudarshan kriya/40 min/40 days	52	>35	NA
Rani K and Sreekumaran E/2013	India	Non RCT	6	143	Pranayama + asanas + savasana/90 min/3 months	73	64	Walking + nonspecific exercises
Shantakumari *et al.*/2013	India	RCT	6	100	13 asana + 4 pranayam + meditation/1 h/2 weeks	50	44.46	Standard treatment
Vaishali *et al.*/2012	India	RCT	7	57	12 asana + 2 pranayama/45-60 min/3 months	27	64.4±3.8	Life style education
Ngarathna *et al.*/2012	India	RCT	6	277	Asana + yoga kriya/1 h/9 months	141	53.46±8.86	Nonyogic BE + walking
Singh *et al.*/2008	India	Non RCT	6	60	5 asana + 5 pranayama + suryanamaskara + conventional medication/45 min/45 days	30	NA	Conventional medication
Viswanathan *et al.*/2020	India	RCT	6	300	10 asana + 5 prayanama + QRT/50 min/3 months	150	50.8±8.3	Simple physical exercise
Sharma *et al.*/2020	India	RCT	6	104	3 prayer + 8 asana + 3 pranayama + meditation/40 min/6 months	52	NA	Standard treatment
Mondal *et al.*/2018	India	RCT	7	20	Suryanamaskara + asana + pranayama + meditation/35-55 min/3 months	10	64.70±4.03	NA
Sarika *et al.*/2020	India	RCT	7	30	Yoga + pranayama + meditation/23 min/6 months	15	54.87±10.27	Life style modification instructions
Gordon *et al.*/2008	Cuba	RCT	6	231	Hath yoga/2 h/6 months	77	64.25	NA
Sreedevi *et al.*/2017	India	RCT	7	124	Asana + suryanamaskar + DRT + pranayama/60 min	32	51.97±7.40	Satandard care

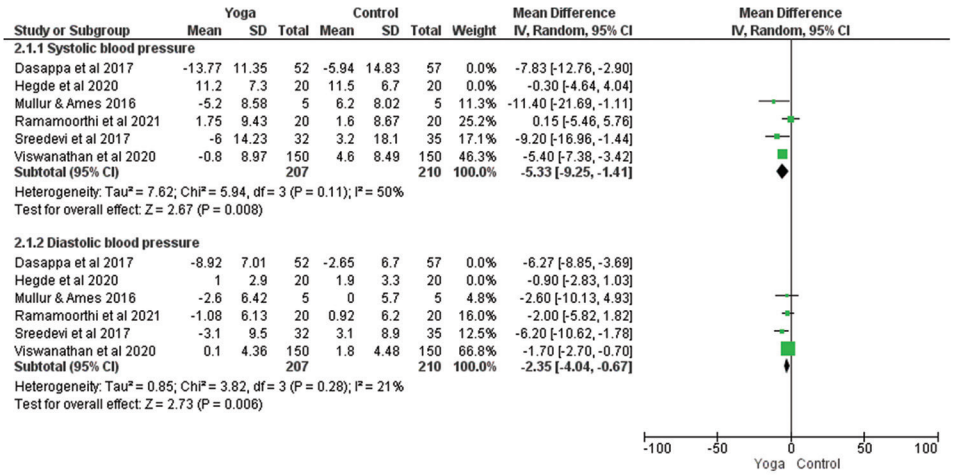
Author/year	Control (*n*)	Age (years)	Follow-up period	Outcome measures	Result	Droupouts (%)
Skoro-Kondza *et al.*/2009	30	NA	6 month	Lipid profile, blood pressure etc.	No significant improvement	NA
McDermott *et al.*/2014	20	47.2±9.1	NA	BMI, weight, WC, TC, TG, SBP, DBP	Significant improvement in both the groups	7.32
Mullur and Ames/2016	5	60±10.34	NA	BMI, weight, SBP, DBP etc.	Significant improvement in only DBP	Nil
Hegde *et al.*/2020	20	57.55	NA	SBP, DBP, BMI, WC etc.	Significant improvement in oxydative stress	Nil
Ramamoorthi *et al.*/2021	20	44.95±9.80	NA	TG, SBP, DBP etc.	NA	Nil
Dasappa *et al.*/2017	57	>35	NA	SBP, DBP etc.	Significant improvement in outcome variables	52.3

Contd...

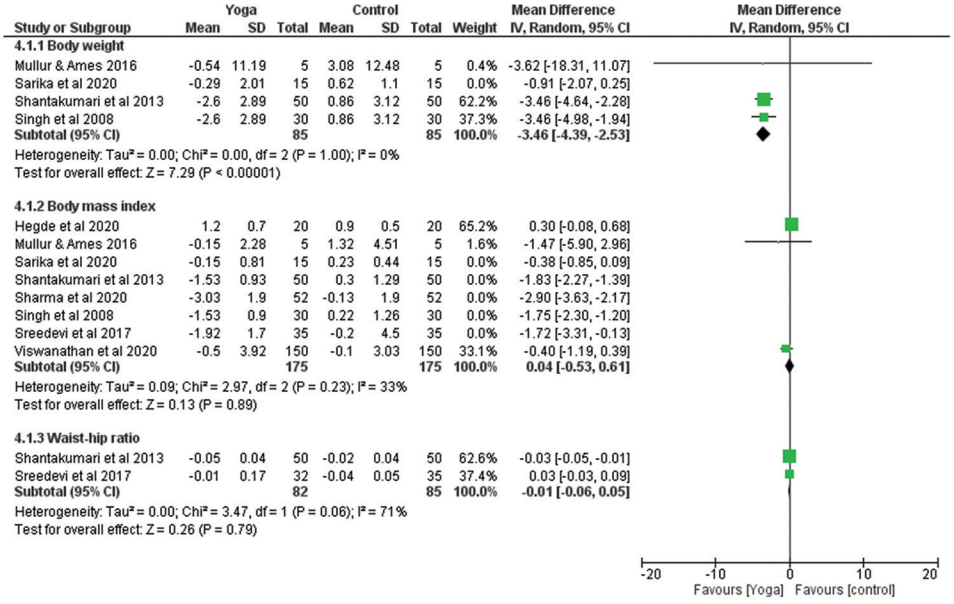
Supplementary Table 1: Contd...

Author/year	Control (*n*)	Age (years)	Follow-up period	Outcome measures	Result	Droupouts (%)
Rani K and Sreekumaran E/2013	70	62	NA	TC, TG, HDL, LDL etc.	Significant within group reduction in outcome measures. No significant reduction in DBP and no between group significant reduction in all outcome measures	Nil
Shantakumari *et al*./2013	50	45.51	3 months every month upto 3 months	BMI, weight, WHR, TC, TG, HDL, LDL etc.	No significant between and within group improvement	Nil
Vaishali *et al*./2012	30	65.8 + 3.8	NA	TG, TC, HDL, LDL etc.	Significant reduction in SBP and DBP in intervention group	5.26
Ngarathna *et al*./2012	136	51.38 + 8.39		HDL, LDL, TG, TC *et al*.	Significant reduction in lipid profile	34.47
Singh *et al*./2008	30	NA	NA	Weight, BMI, TC, TG, HDL, LDL etc.	Non-significant decrease in BMI, significant decrease in weight, , TC, TG, and LDL, non-significant elevation in HDL in experimental group	Nil
Viswanathan *et al*./2020	150	52.8 + 7.0	NA	BMI, SBP, DBP, TC, TG, HDL, LDL etc.	Significant improvement in lipid profile	25
Sharma *et al*./2020	52	NA	NA	BMI, WHR, TC, TG, HDL, LDL etc.	Significant reduction in LDL, TG, and TC and significant increase in HDL	Nil
Mondal *et al*./2018	10	64.40 + 4.79	NA	TC, TG, LDL, HDL etc.	Significant reduction in weight, BMI, and lipid profile in experimental group	Nil
Sarika *et al*./2020	15	48.53 + 8.95	NA	Weight, BMI, FBG etc.	Significant improvement in BMI, lipid profile	Nil
Gordon *et al*./2008	77	63.15	NA	TG, LDL, HDL etc.	Significant improvement in BMI, WHR, and lipid profile	55
Sreedevi *et al*./2017	35	51.92 + 6.57	NA	SBP, DBP, BMI, WHR, TC etc.	Significant improvement in lipid rofile	12.1

RCT=Randomized controlled trials, NA=Not available, BMI=Body mass index, WC=Waist circumference, SBP=Systolic blood pressure, DBP=Diastolic blood pressure, TG=Triglycerides, FBG=Fasting blood glucose, LDL=Low-density lipoprotein, HDL=High-density lipoprotein, WHR=Waist-hip ratio, BE=Breathing exercise, DB=Deep breathing



Supplementary Figure 1: Sensitivity analysis for blood pressure



Supplementary Figure 2: Sensitivity analysis for anthropometric measures