Yoga for Management of Type 2 Diabetes: A Review for Clinicians

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ABSTRACT

Background: Empirical evidence indicates that yogic practices may be beneficial for the management of type 2 diabetes. The purpose of this review is to analyze and synthesize recent experimental trials examining the effect of yoga asana-based interventions on blood glucose, HbA1C, and anthropometric measures among individuals with type 2 diabetes. This review focuses on clinically relevant findings that support the prescription of yogic asana practices to this population.

Methods: Electronic searches of several databases were performed for experimental studies through December 2015. Studies were included if they were in English, peer reviewed, included asana-based yoga interventions among adults with type 2 diabetes, and reported relevant outcomes.

Results: The search identified 19 experimental studies. A majority of the studies found improvements in blood glucose measures, hemoglobin A1c, and/or anthropometric measures. Style of yoga, duration of yogic interventions, and type of control group varied across studies.

Conclusion: These studies suggest that regular yoga practice may lead to improvements in blood glucose measures, hemoglobin A1c, body weight, and body mass index. Further research is warranted to confirm these preliminary findings and better understand how yoga interventions can be implemented into clinical settings. *Journal of Clinical Exercise Psychology*. 2017;6(3):50–58.

Keywords: exercise, asana, weight, fasting blood glucose, postprandial blood glucose, hemoglobin A1c

INTRODUCTION

Worldwide diabetes prevalence quadrupled from 108 million in 1980 to 422 million in 2014 (11). In the United States, it is estimated that 29.1 million people have diabetes (28% of these individuals are undiagnosed), and another 86 million have prediabetes (it is estimated that 9 out of 10 are undiagnosed), and 51% of these individuals are 65 years and older (11). Global diabetes rates are projected to surpass 470 million by 2030, exemplifying a significant public health concern and burden (26). Additionally, diabetes is associated with multiple and significant comorbidities and health complications contributing to a decline in quality of life, increased economic burden, and a 50% higher risk of death than adults without diabetes (11,62). Diabetes is the seventh leading cause of death in the United States and is projected to become the seventh leading cause of death globally by 2030 (11,36). Individuals with diabetes are at an increased risk for heart disease, stroke, vision loss, kidney failure, neuropathies, amputations, and are 2 times more likely to be depressed than individuals without type 2 diabetes (11,44,20).

Type 2 diabetes is an endocrine disorder resulting from elevated blood glucose levels, insulin, and/or decreased insulin sensitivity (60). Treatment and management of type 2 diabetes

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focuses on lifestyle changes such as nutrition, increasing physical activity, and properly self-managing symptoms and prescribed treatments (3). Physical activity and lifestyle interventions, including smoking cessation, have been effective for reducing diabetes-related health concerns such as weight, hemoglobin A1c (HbA1c), and cost burden (7,18,54).

An expanding body of evidence suggests that yoga can be employed to prevent, manage, and treat many chronic conditions, including depression (15,32), anxiety (10,57), arthritis (49), high blood pressure (23), other cardiovascular disease risk factors (14), low back pain (8), osteoporosis (37), and neuropathy (35). Additionally, research indicates that yoga is a promising therapeutic option for the prevention and management of type 2 diabetes and its associated comorbidities, as discussed in recent reviews and meta-analyses (2,12,24,27,28,48). Mind-body therapies that reduce weight-bearing and high-impact activity (which may include walking) is gaining research interest for both relatively "healthy" adults with type 2 diabetes and those with peripheral neuropathy and retinopathy related to type 2 diabetes (an important cause of blindness) (29).

Recent reviews have proposed several potential pathways and underlying mechanisms related to how yoga may influence type 2 diabetes outcomes (9,27,45). For example, evidence suggests that physical activity may improve both metabolic and psychological risk profiles in individuals with type 2 diabetes. Therefore, the exercise effect (i.e., the physical component of yoga postures) has been postulated as a potential mechanism of how yoga may positively impact diabetes-related health outcomes. Additionally, reviews suggest that yoga may change the biochemical and hormonal profiles of individuals with type 2 diabetes via reduced reactivity and activation of the hypothalamic-pituitary-adrenal axis and sympathoadrenal system. A recent systematic review of controlled trials of yoga for adults with type 2 diabetes suggested that yoga may also indirectly improve health-related outcomes in individuals with type 2 diabetes by instilling a personal sense of discipline and awareness that impacts larger lifestyle modifications (27).

Yoga may be an optimal prevention and treatment option, given it has demonstrated to be a safe, cost-effective, and easily accessible exercise modality for adults who are healthy or have physical limitations. Additionally, yoga offers multiple ancillary benefits and no reported significant negative side effects (1,28). Despite the encouraging evidence and attractive qualities of yoga as a prevention and treatment option, the need for reliable and discriminative research remains.

The purpose of this review was to analyze and synthesize recent experimental trials examining the effect of asana-based (i.e., postures) yoga interventions on blood glucose, HbA1C, and anthropometrics among individuals with type 2 diabetes. This review focuses on clinically relevant findings that support the prescription of yogic asana practices to this population.

This review will expand upon previous reviews by solely focusing on the clinical application of asana-based yoga as it relates to exercise prescription guidelines for individuals with type 2 diabetes. Unlike previous reviews that included a wide variety of styles and methods of yoga, the intention of this review was to focus on making exercise-specific recommendations for clinicians. Yoga encompasses many different styles and methods of practice. Asana-based yoga relies primarily on postures or the physical activity component of the yoga practice. Therefore, this review will focus on asana-based yoga interventions, given it most closely resembles other forms of physical activity. Thus, asana-based yoga is the most relevant type of yoga when attempting to make clinical exercise recommendations.

Methods

Electronic searches of MEDLINE, PubMed, Google Scholar, CINAHL, Academic Search Premier, Health Source: Academic edition, SportDiscus, and AltHealth Watch were performed for experimental studies through December 2015. Figure 1 details the data extraction process. Intervention trials targeting the treatment or control of type 2 diabetes mellitus using primarily yoga asana (postures) were included in this review. Studies that focused only on breathing (pranayama) or meditation as the yoga intervention were not included. Additionally, studies that included nonexperimental study designs, no quantitative data, were written in a non-English language, and included individuals less than 18 years old were excluded. Studies that included individuals without a designated type 2 diabetes diagnosis (i.e., metabolic syndrome, prediabetes, gestational diabetes, cardiovascular disease) were not included in this review. Articles that did not include biochemical, physiological, anthropometric, or clinical outcomes were also excluded.

Outcomes measured in the studies reviewed included fasting blood glucose (FBG), postprandial blood glucose (PPBG), HbA1c, and anthropometric measures.

Summary of Findings

Among the 19 identified studies (see Table 1), 6 used a randomized controlled design (40,41,46,47,51,58), 9 used a quasi-experimental design (5,6,16,25,31,34,42,43,52), and 4 used a pre-post design (19,33,55,59). The majority of studies did not specifically state a style of yoga or specifically which postures were chosen, making it difficult to indicate if any specific style of yoga or yoga postures were more effective than others. The studies selected for this review (Table 1) used asana as the primary intervention technique.

The duration of yoga interventions ranged from 7 d (55) to multiple sessions over a 9-month intervention (40). There was a notable absence of long-term intervention designs. For the majority of interventions, outcome assessments were conducted between 3 to 6 months. To accurately assess the long-term effect of yoga interventions on type 2 diabetes symptoms, extended follow-up assessments should be measured.

Fasting Blood Glucose/Postprandial Blood Glucose

The studies reviewed reported significant decreases in FBG following the yoga interventions (5,16,19,25,31,33,34,35,40,

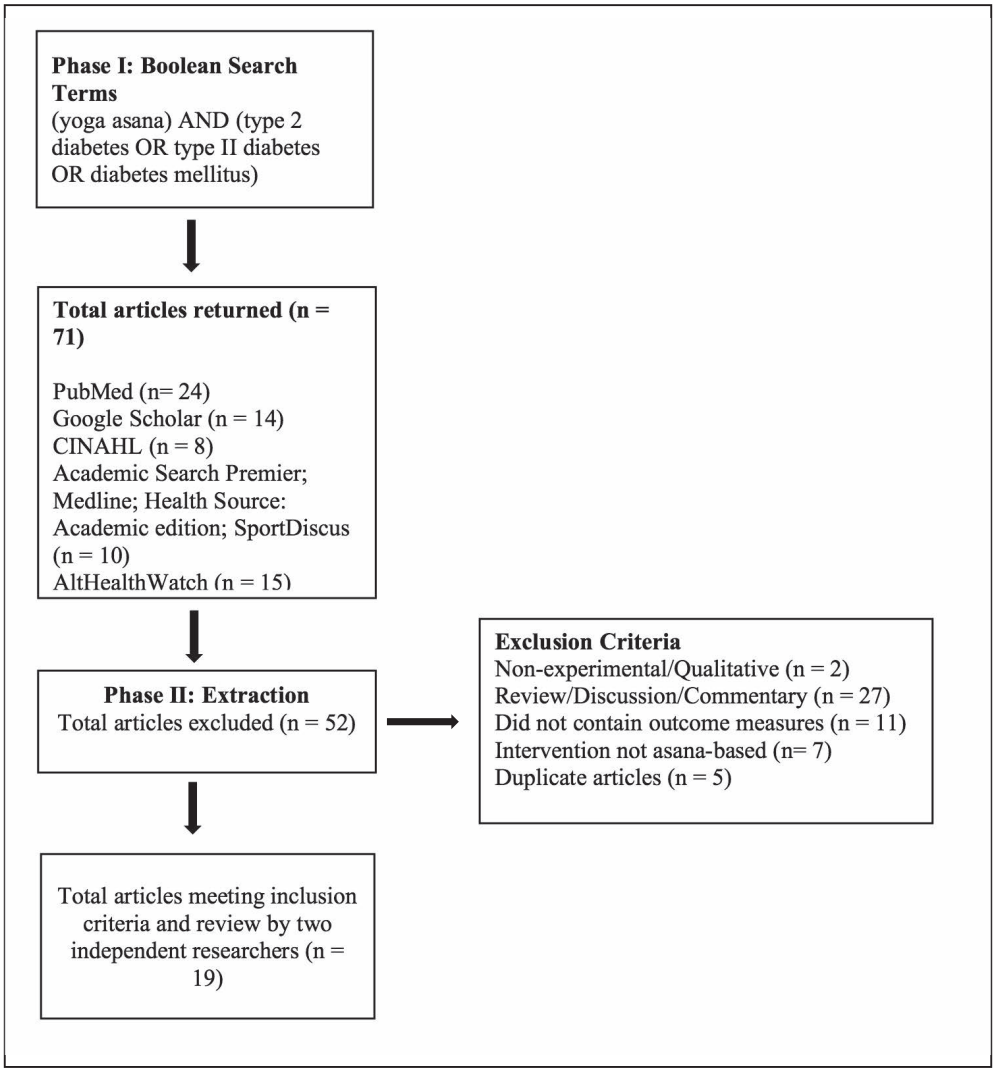

FIGURE 1. Flow chart illustrating data extraction process.

41,42,47,52,58,59). Participants were prescribed oral antihyperglycemic agents and/or insulin in some of the studies (5,6,16,34,35). Postprandial blood glucose (PPBG) was significantly reduced in numerous studies (5,16,19,25,33,41,42). Significant reductions in FBG and PPBG were achieved when the yoga intervention included at least 3 sessions per week, at least 30 min per session (up to 90 min), and lasted at least 2 weeks. These design qualities resulted in FBG reductions of 10 to 50+ $mg \cdot dL^{-1}$ (5,16,19,25,31,33,40,41,42,47,52,58,59). One study reported significant, progressive reductions in FBG each month over 6 months in patients not yet prescribed oral medications (1 h, daily practice) (42). In a larger trial (n = 231) with participants randomized to yoga, conventional exercise, or control, FBG was reduced by 30% after 6 months of yoga practice and 27% after conventional exercise, compared to a 7% reduction in the control group receiving standard care (22). This preliminary pilot data demonstrates reductions in FBG equivalent and potentially greater to that of oral medications and conventional exercise (42).

Reductions in PPBG ranged from 17 to 110 $mg \cdot dL^{-1}$ across the previous studies. When yoga was performed daily, the greatest reductions in FBG and PPBG were observed. A minimum of 30 min per day was an effective duration to reduce FBG and PPBG on at least 5 d of the week. Daily sessions appear to result in the greatest reduction in FBG and PPBG. Although long-term outcomes, adherence, and sustainability have not been studied, these preliminary findings demonstrate reductions in FBG and PPBG in the short term. The current literature could support the recommendation for participation in regular yoga-asana practice soon following diagnosis to help control glucose, prevent the need for oral medications or insulin, improve glucose control in conjunction with oral medications and insulin, and possibly prevent the conversion to overt diabetes in those with prediabetes. The lack of adverse events related to yoga participation provides additional confidence when recommending yoga as a therapeutic modality.

These findings are consistent with known physiological responses of glucose to activity as exercise enhances glucose uptake even when insulin resistance is present (17). The effect of exercise on glucose uptake lasts up to 48 h. Therefore, asana-based yoga should be recommended daily, or at

TABLE 1. Summary of Study Characteristics and Findings.

Year	Authors	Design and Sample	Intervention	Duration and Frequency	Findings
2008	Mahapure	Nonrandomized, controlled (n = 40) adults ages 40–55 years with type 2 diabetes on regular diet and medications.	Yoga (n = 30) or control (n = 10; standard care).	Asana and pranayama 6 times/week for 6 weeks plus standard care.	Significant improvements in HbA1c and FBG compared to control group.
2009	Skoro-Kondza et al.	Randomized, controlled study; 59 adults (n = 13 male; n = 36 female) with diagnosed type 2 diabetes >30 ± 5 years not taking insulin; 60 ±5 years old.	Yoga (n = 29) or wait-list control (n = 30).	Asana and pranayama 2 times/week for 12 weeks; each session for 90 min; lifestyle leaflet. Total 24 sessions.	HbA1c nonsignificant reduction at 12 weeks in yoga group.
2010	Pardanasay	Randomized, controlled study; 45 adults (n = 28 male; n = 17 female) with type 2 diabetes on hypoglycemic medication.	Yoga (n = 15) or tai chi (n = 15) or usual care (hypoglycemic medication only; n = 15).	Hatha yoga 3 times/ week for 12 weeks.	Significant decrease in FBG (173.67 ± 28.45 to 150.67 ± 23.22; P < 0.001), PPBG (234.67 ± 63.95 to 190.33 ± 44.15; P = 0.014), HbA1c (9.07 ± 0.41% to 8.83 ± 0.4%; P = 0.001), LDL (102.4 ± 13.6 to 93.87 ± 7.98; P = 0.003), and TC (178.6 ± 17.16 to 166.93 ± 15.28; P = 0.002) for yoga group. Significant decrease for tai chi group in FBG, PPBG, HbA1c, LDL, TC. No significant changes for control.
2010	Kyozim et al.	Age and sex matched quasi-experimental study; 35–60 years (n = 60) adults with type 2 diabetes on oral hypoglycemic medication.	Yoga (n = 30) or control (conventional care; n = 30).	Asana and pranayama daily for 5 d (supervised) and daily (unsupervised) for total of 45 d.	Significant decrease in FBG (172.87 ± 45.55 mg/dL to 133.77 ± 38.77 mg/dL; P < 0.0001). Significant improvement in the latency and amplitude of N200 and P300 as compared to control group (P < 0.05).
2011	Hegde et al	Nonrandomized controlled study; n = 123 participants aged 40–75 years with diabetes diagnosis.	Yoga (n = 60) or control (n = 63; general oral and written information on diet and exercise).	Asana and pranayama; 3 d/week; 3 months; supervised.	Yoga group significant improvements in BMI, FBG, PPBG, HbA1c, MDA, glutathione, vitamin C (P < 0.05) compared to control.
2011	Duraiswamy et al.	Nonrandomized; no control group; n = 20 aged 40–64 years (n = 12 male; n = 8 female) with type 2 diabetes >6 months.	Yoga treatment (asana and pranayama).	Asana and pranayama; daily for 5 weeks.	Significant improvements in FBG (166.5 ± 271.2 to 131.5 ± 39.0; P = 0.0007), PPBG (270.5 ± 119.2 to 182.0 ± 60.5; P < 0.0001), and biomarkers for oxidative stress (serum cortisol, MDA, super oxide dismutase; P < 0.0001).
2011	Balaji	Nonrandomized controlled study; n = 44 participants aged 40–55 years with diabetes diagnosis 1–10 years.	Yoga (n = 22): subgroup T1 (n = 16) + oral drugs; subgroup T2 (n = 6) + oral drugs and insulin. Control (usual care; n = 22).	Asana and pranayama daily for 3 months; each session for 60 min.	Yoga T1 and T2: Significant decrease in FBG: (T1 182.87 ± 45.55 to 135.77 ± 38.88, T2 160.64 ± 41.22 to 130.82 ± 36.11; P < 0.001), PPBG: (T1 270.64 ± 76.6 to 196.90 ± 64.47; P < 0.001), HbA1c (T1 9.77 ± 0.5% to 7.68 ± 0.4%, T2 8.46 ± 0.3% to 7.23 ± 0.3%; P < 0.001). Significant decrease in weight, BMI, WHR for yoga group. No significant changes for control.

TABLE 1. Continued.

Year	Authors	Design and Sample	Intervention	Duration and Frequency	Findings
2012	Madanmohan	Nonrandomized; no control group; n = 15 females aged 36–63 years (50.40 ± 2.47) with type 2 diabetes diagnosis.	Yoga treatment (asana and pranayama).	60 min 3 d/week yoga (supervised class) for 6 weeks.	Significant improvement in FBG (160.07 ± 15.65 to 127.07 ± 10.24 mg/dL; P < 0.005), PPBG (244.20 ± 17.12 to 208.73 ± 16.07 mg/dL; P < 0.001), TC (161.24 ± 9.10 to 152.95 ± 7.17 mg/dL; P < 0.01), TG (110.53 ± 10.56 to 99.60 ± 8.37 mg/dL; P < 0.02), LDL (96.53 ± 9.46 to 86.27 ± 7.78 mg/dL; P < 0.001), VLDL (22.11 ± 2.11 to 19.95 ± 1.67 mg/dL; P < 0.02), HDL (42.60 ± 5.16 to 47.07 ± 5.08 mg/dL; P < 0.02).
2012	Nagarathna	Prospective, randomized controlled study; n = 277 over 25 years with type 2 diabetes >1 year and oral hypoglycemic medication >3 weeks.	Yoga (n = 141) included asana, pranayama, meditation, lecture; or active control (n = 136) included physical training exercises and walking and rest.	Both groups trained 60 min 5 d/week (supervised) for 12 weeks followed by weekly classes for 120 min for 9 months.	Significant reduction in oral hypoglycemic drug requirement (P < 0.001) and improvement in HDL (P = 0.007), LDL (P < 0.0015), FBG (P = 0.016) in yoga versus control group. Nonsignificant improvements for both groups in TG, TC, VLDL, PPBG, HbA1c.
2012	Subramaniyan	Randomized comparison study; 20 males.	Yoga (asana) or active control (brisk walking) group.	60 min of yoga or walking daily; 15 consecutive days (supervised).	Significant decrease in FBG in both groups (P < 0.0001).
2012	Vaishali et al.	Randomized controlled study; 57 (n = 36 male; n = 21 female) participants on antidiabetic drugs >15 years; 65.8 ± 2.6 years old.	Yoga or control (educational) group.	45–60 min daily; 6 d/week; 12 weeks; supervised.	HbA1c significantly reduced in yoga group (10.28 ± 0.86% to 9.12 ± 0.55%; P < 0.05). Yoga group significantly reduced FBG, TC, TG, LDL, and significantly increased HDL (P < 0.05). No significant changes in control group.
2012	Shantakumari et al.	Randomized parallel study; 100 (n = 52 male; n = 48 female) participants; 33–55 years old; taking sulfonylurea medications.	Yoga treatment (asanas, pranayama, and meditation) or control group.	1-hr daily yoga (supervised for 2 weeks, then home based); 3 months. Control group reported monthly for follow up.	Nonsignificant increases in SBP and DBP in the control group. Significant reductions in SBP (141.71 ± 71 to 132.23 ± 7.89; P < 0.01), DBP (90.57 ± 4.07 to 85.49 ± 5.03; P < 0.01), and FBG (155.86 ± 60.53 to 126.63 ± 40.59; P < 0.05) in the experimental group.
2013	Bindra et al.	Nonrandomized controlled study; 100 (n = 50 yoga; n = 50 control) participants with diagnosed type 2 diabetes for <10 years, not taking insulin.	Yoga treatment (not described) with conventional medicine or control (conventional medicine).	90 d; no further description on frequency or duration.	At 90 d, statistically significant reductions in HbA1c (P < 0.05), FBG, TC, LDL, HDL (P < 0.01).

TABLE 1. Continued.

Year	Authors	Design and Sample	Intervention	Duration and Frequency	Findings
2013	Rani et al.	Nonrandomized; 73 elderly patients, 60–70 years old.	Yoga sessions (pranayamas, warm-up exercises, asanas, savasana).	90 min daily (supervised); 3 months.	Statistically significant reductions in glucose, HbA1c (P = 0.000), lipids (P = 0.000), cortisol (P = 0.000), ferritin (P = 0.000), MDA (P = 0.000), and a significant increase in catalase activity (P = 0.000) in the yoga group.
2013	Vizcaino	Nonrandomized, no control group, experimental study; 10 participants (n = 8 females); 61.4 ± 6.68 years old; on diabetic medications; no insulin.	Hatha yoga classes (asanas, pranayama, and meditation).	50–60 min/class; 6 weeks, 3 times per week.	Nonsignificant reductions in FBG, HbA1c, and cortisol. Significant improvements in perceived stress (P = 0.03), state anxiety (P = 0.01), and diabetes self-care (P = 0.01).
2013	Shantakumari et al.	Randomized parallel study; 100 male and female participants; 33–55 years old; sulfonylurea medications.	Yoga + oral hypoglycemic drug. Control group received hypoglycemic drug only.	1-hr daily yoga; 3 months.	Intervention group significantly reduced weight 62.2 ± 4.45 to 59.6 ± 4.65 kg; WHR 0.94 + 0.07 to 0.89 + 0.07; TC 244.86 ± 28.09 mg/dL to 219.56 ± 32.02 mg/dL; TG 151.88 ± 43.08 mg/dL to 130.11 ± 28.82 mg/dL; LDL 144.74 ± 28.45 mg/dL to 120.51 ± 34.31 mg/dL.
2014	Dash et al.	Nonrandomized controlled study; 60 participants aged 40–60 years with type 2 diabetes 0–10 years.	Yoga (n = 30; yoga plus prescribed diet and oral antidiabetic medicines) or control (n = 30; prescribed diet plus standard medical therapy including oral medications).	Yoga 30–40 min daily for 40 d; plus prescribed diet, oral medication.	Significant reduction in FBG (P < 0.05), PPBG (P < 0.05), and HbA1c (P = 0.019) in yoga group compared to control group. Significant reduction in CHOL, TG, LDL (P < 0.05) and significant increase in HDL (P < 0.05).
2014	Popli et al.	Nonrandomized controlled study; 130 participants aged 30–60 years with type 2 diabetes not on oral hypoglycemic drugs or insulin.	Yoga (n = 80) or control (n = 50; standard care).	1-hr yoga 5 d/week for first month, continued practice at home for 5 months.	Significant reductions in FBG, PPBG, and HbA1c in the intervention group (P < 0.001). No adverse events.
2015	Tikhe et al.	Single group pre-post study; 24 (n = 6 females) participants; 43–68 years old.	Integrated approach of yoga therapy = sukma vyayama, yogasanas, pranayama, dhyana, kriyas, devotional sessions, sattvic diet, yogic games, and lectures from experts. Conducted in a residential setup.	5:00 am to 10:00 pm; 7 d	Significant reductions in all body composition measures (P < 0.001; weight, fat, visceral fat, resting metabolism, BMI, body age, subcutaneous whole body, subcutaneous trunk, subcutaneous arms, and subcutaneous legs).

FBG = fasting blood glucose; PPBG = post prandial blood glucose, TC = total cholesterol; TG = triglycerides; LDL = low density lipoprotein; HDL = high density lipoprotien; WHR = waist-to-hip ratio; BMI = body mass index; HbA1c = hemoglobin A1c; MDA = malondialdehyde; VLDL = very low density lipoprotein; SBP = systolic blood pressure; DBP = diastolic blood pressure; Chol = cholesterol

least every other day, to achieve the desired effect on blood glucose (17,39,61).

Hemoglobin A1c

Multiple studies have demonstrated reductions in HbA1c following a yoga-asana intervention (5,25,41,42,43,51,58, 59). Current recommendations are to achieve glucose control represented by a HbA1c of 7% or lower, as this has been shown to result in reduced risk of developing chronic complications associated with diabetes such as kidney disease, retinopathy, microalbuminuria, stroke, and heart disease (30). Yoga interventions have produced significant

reductions in HbA1c (approximately 1% on average), in many of the studies, reducing measures below the recommended control value of 7% (6,27). Studies that reported significant reductions in HbA1c were those with supervised sessions lasting 45–90 min in duration, 3 to 6 d per week, or daily for at least 45 d and up to 12 weeks (5,25,41,43,51, 58,59).

Anthropometric Measures

A weight loss threshold of >5% has been previously reported to achieve beneficial metabolic outcomes, such as improved HbA1c, beneficial lipid changes, and reduced blood pressure, in patients with type 2 diabetes (21). A recent review reported body weight reductions following asana-based interventions in the range of 3–7% (5,50). In a group of adults with type 2 diabetes (n = 24), Tikhe et al. (55) reported a 1.06% decrease in weight (72.3 ± 13.3 kg to 71.5 ± 12.7 kg, $p < 0.001$) following a 7-d yoga intervention. Similarly, following a daily 60-min yoga class for 3 months, Shantakumari et al. (47) observed a reduction of approximately 2 kg ($p < 0.001$) in participants that combined yoga with an oral hypoglycemic drug in comparison to a control group receiving only medication. Weight was significantly reduced following a 45-d yoga-asana intervention, performed daily for 45 min, among middle-aged adults (50). The yoga-asanas were combined with standard oral hypoglycemic medications, which led to a significant reduction in weight and a nonsignificant reduction in body mass index (BMI), while the control group (medications only) had a significant increase in weight and a nonsignificant increase in BMI (3 kg weight loss, $p < 0.05$; 1 kg weight gain, $p < 0.05$) (50).

Similarly, significant reductions in weight were reported following a 3-month daily yoga-asana intervention compared to a control group (yoga and oral meds 66 ± 5 to 62 ± 5, $p < 0.001$; yoga, oral meds, and insulin 64 ± 5 to 62 ± 4.4, $p < 0.001$; control, 69 ± 4 to 65 ± 5) (5). Additionally, 1 study reported a significant reduction in waist-to-hip ratio ($p < 0.05$) (46) following a 3-month daily yoga intervention. Despite the short duration and small sample size of many studies, incorporating yoga-asanas has been shown to produce significant reductions in body weight independently and in conjunction with hypoglycemic medication use (6,47,50,54).

These reductions provide preliminary evidence-based suggestions for duration and frequency of yoga for reducing blood glucose measures, HbA1c, and anthropometric measures. The reductions reported are similar to those seen in traditional moderate-intensity exercise programs (13). Design varied greatly across studies, which reduces the ability to develop specific recommendations for this population. Importantly no adverse events were reported in any of the studies. Control of blood glucose is important for preventing and reducing diabetes-related complications such as eye, kidney, nerve, and cardiovascular diseases (30,53). Intensity of the yoga exercise was not measured; however, other studies among healthy individuals indicate that the intensity of asana-based yoga varies significantly across studies (10 to 27% of VO_2max) (56). Direct measurement of metabolic equivalent of task (MET) levels of asanas/postures were >2 METs depending on the style of yoga, which is considered low-intensity activity (56). Despite the low intensity of yoga-asanas, the previously mentioned studies still demonstrated positive and significant reductions in FBG, PPBG, and HbA1c. Although intensity was not directly measured in the majority of the current literature, significant reductions in FBG and PPBG were observed, suggesting that the low level of exercise intensity generated sufficient muscular contraction to promote increased glucose uptake and clearance. Further examination of the mechanisms underlying the metabolic changes associated with low-intensity yogic exercise is needed.

CLINICAL RECOMMENDATIONS

This review indicates that regular yoga practice may lead to reductions in numerous diabetes-related outcomes. Yoga shows promise for additional diabetes care-related benefits such as medication compliance, self-care compliance, and stress reduction (5). Based on these observations, there are several recommendations that can be made based on the existing literature. First, it appears safe to include yoga as an adjunctive treatment to traditional exercise recommendations and in addition to medications for individuals with type 2 diabetes. Preferably, type 2 diabetes patients should attend a yoga session at least 3 d per week. Yoga practice should be maintained for at least 12 weeks to elicit the benefits presented in this review, and individual sessions should range between 30 to 90 min. Yoga should be recommended in addition to standard cardiorespiratory training regimens, not as a replacement. The studies included in this review support yoga practice as a promising means for reducing FBG, PPBG, HbA1c, and would appear to produce a similar insulin-like effect of enhancing glucose uptake when compared to other exercise modalities. For these recommendations to be most effective, it is essential that practitioners be trained in the safety and benefits of both exercise and yoga practices as it pertains to working with individuals with type 2 diabetes.

Future Research and Conclusions

Although the number of studies in this area has increased in recent years, there is a significant need for more systematic, methodologically robust interventions examining the efficacy of yoga as a viable treatment option for type 2 diabetes. Common limitations identified in the previous reviews included small sample size, nontheoretical frameworks, lack of program fidelity evaluation, significant variability in research design, and inconsistency in the populations studied (i.e., broad range of disease profiles and co-occurring illnesses). Furthermore, variation in style of yoga, dosage, and intensity; lack of definitions for yoga; and limited details related to the intervention protocol made comparison across studies challenging. Future studies must address these limitations and focus on the reliable quantification of benefits needed to guide clinical practice and policy.

Given the global burden of type 2 diabetes mellitus and the evidence of ethnic disparities associated with type 2 diabetes mellitus in Western countries (26,38), it may be beneficial for future research to test intervention protocols designed to manage symptoms associated with type 2 diabetes in other countries. There is also a need for adequately powered randomized trials examining the metabolic outcomes of habitual yoga practice. Future research of yoga interventions and adults with type 2 diabetes should include anthropometric measures to evaluate the effect of the intervention on weight loss and type 2 diabetes-related metabolic outcomes, including measures of insulin resistance. Finally, because type 2 diabetes is a lifelong disease, more interventions are needed that include a long-term intervention design. This would provide more accurate yoga recommendations for sustainable lifestyle, long-term behavioral changes, and the feasibility of maintaining long-term adherence to a yoga program.

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