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Review Article

The effects of yoga among adults with type 2 diabetes: A systematic review and meta-analysis

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ABSTRACT

The purpose of this meta-analysis was to examine the effects of yoga for glycemic control among adults with type 2 diabetes (T2DM). Comprehensive electronic databases searches located 2559 unique studies with relevant key terms. Studies were included if they (1) evaluated a yoga intervention to promote T2DM management, (2) used a comparison group, (3) reported an objective measure of glycemic control at post-intervention, and (4) had follow-up length or post-test of at least 8 weeks from baseline. Independent raters coded participant, design and methodological characteristics and intervention content. Summary effect sizes and 95% confidence intervals (CI) were calculated. Twenty-three studies with 2473 participants (mean age = 53 years; 43% women) met eligibility criteria. Compared with controls, yoga participants were successful in improving their HbA1c (d + = 0.36, 95% CI = 0.16, 0.56; k = 16), FBG (d+ = 0.58, 95% CI = 0.40, 0.76; k = 20), and PPBG (d + = 0.40, 95% CI = 0.23, 0.56; k = 14). Yoga was also associated with significant improvements in lipid profile, blood pressure, body mass index, waist/hip ratio and cortisol levels. Overall, studies satisfied an average of 41% of the methodological quality (MQ) criteria; MQ score was not associated with any outcome (Ps > 0.05). Yoga improved glycemic outcomes and other risk factors for complications in adults with T2DM relative to a control condition. Additional studies with longer follow-ups are needed to determine the long-term efficacy of yoga for adults with T2DM.

1. Introduction

About one out of every eleven adults in the United States currently has diabetes (Center for Disease Control and Prevention, 2016). Type 2 diabetes (T2DM) accounts for 90–95% of all diabetes cases in adults. Diabetes is a major risk factor for heart disease and stroke and is the seventh leading cause of death in the United States (Center for Disease Control and Prevention, 2011). In 2012, the total estimated economic cost of diagnosed diabetes was $245 billion, a 41% increase from 2007 (American Diabetes Association, 2013a).

Controlling blood glucose level is fundamental to the management of T2DM (American Diabetes Association, 2013b). Improved glycemic control is associated with a significant decrease in long-term complications (Skyler et al., 2009; Stettler et al., 2006; UKPDS, 1998). Often pharmacological treatment alone is insufficient to achieve glycemic control; adherence to dietary and physical activity recommendations is advised (Dyson et al., 2011; Knutson et al., 2006; Surwit et al., 2002). However, these lifestyle changes are difficult to achieve and maintain (Kim et al., 2013). One-third of diabetic patients use some type of complementary or alternative medicine (CAM) therapy, and about 3–20% use CAM specifically to treat their diabetes (Bell et al., 2006; Nahin et al., 2012). Yoga, an ancient Indian practice with over 20 million users, is one of the most common CAM therapies used among adults in the United States (Clarke et al., 2015).

Recent studies have demonstrated that yoga improves a variety of symptoms along with physical functioning, depression, neurocognitive functions, and quality of life (D'Silva et al., 2012; Froeliger et al., 2012; Patel et al., 2012; Shapiro et al., 2007). Yoga has received considerable attention in cancer research as an approach for improving quality of life (Levine and Balk, 2012). Studies in cardiac patients have found similar positive effects including reduced blood pressure, cholesterol and body weight (Mamtani and Mamtani, 2005; Okonta, 2012). The benefit of

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yoga for diabetes management has also been found in recent reviews. Innes and Selfe (2016) showed that yoga may improve glycemic control, lipid levels, and body composition (weight, body mass index) among adults with T2DM. Similarly, Cui et al.' (2016) meta-analysis reported a pooled weighted mean difference of −23.72 mg/dL (95% CI = −37.78, −9.65) for fasting blood glucose (FBG) and −0.47% (95% CI = −0.87, −0.07) for HbA1c. In another meta-analysis, Kumar et al. (2016) reported beneficial effects of yoga in comparison to standard treatment alone for FBG [Standardized Mean Difference (SMD) −1.40, 95%CI = −1.90, −0.90] and for HbA1c [SMD −0.64, 95%CI = −0.97, −0.30]. However, this meta-analysis included studies with short follow-up duration (i.e., 40 days). Since HbA1c reflects the average glycemia over the preceding 8–12 weeks (American Diabetes Association, 2016; Nathan et al., 2007), short follow-up duration is insufficient to estimate changes among intervention participants. Furthermore, the authors only examined glycemic parameters. The authors did perform subgroup analysis based on difference in intervention (i.e. breathing practice alone or combination of asanas, breathing and meditation), but no other intervention or sample characteristics were examined as moderators of intervention effect. Finally, a recently published meta-analysis by Vizcaino and Stover (2016) examined lipid profile and blood pressure in addition to the glycemic parameters. The authors found significant decreases in FBG for participants in the yoga condition compared controls (mean difference = −25.72 mg/dL, 95% CI = −40.67, −10.76), but no significant differences for HbA1c and postprandial blood glucose (PPBG). This meta-analysis did not control for the baseline values in their analyses which may have biased the findings.

The purpose of this systematic review and meta-analysis is to examine current evidence on the effect of yoga for diabetes management. Our review updates and extends the scope of the prior meta-analytic reviews in several ways. First, we expand the literature covered and included in this meta-analysis by searching comprehensive list of databases and using an extensive list of search terms. Second, we assess a broad range of outcomes related to glycemic control and other markers of diabetes management including lipid profile, blood pressure, body composition and fasting cortisol. Finally, we examine study (i.e. geographical location, recruitment method), and sample characteristics (e.g. gender) and intervention features (e.g. intervention duration and components) as potential moderators of the intervention effect.

2. Methods

The current systematic review and meta-analysis is reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Moher et al., 2009). The PRISMA checklist can be found in the Supplemental Materials 1.

2.1. Eligibility criteria

Studies were included if the study (1) examined a yoga intervention to promote T2DM management, (2) used a randomized control trial or quasi-experimental design that included a control or comparison group, (3) included adults ≥ 18 years of age, (4) reported an objective measure of glycemic control (HbA1c, FBG), (5) provided relevant statistics to calculate between-group effect size, and (6) had follow-up length or post-test of at least 8 weeks from baseline. Studies were excluded if (1) participants did not have T2DM at baseline, (2) participants had type 1 or gestational diabetes, and (3) yoga was not the primary intervention but a part of multimodal intervention (e.g. mindfulness-based stress reduction).

2.2. Information sources and search

Several information sources were used to identify relevant studies: (1) Electronic bibliographic databases (PubMed, PsycInfo, The Cochrane Library, CINAHL, EMBASE, Global Health, Academic Search Premier, PsycARTICLES, Proquest Dissertations and Theses) were searched using a Boolean search strategy: ((yoga) OR (yogasan*) OR (yogi*) OR (yog*) OR (pranayam*) OR (asana*) OR (dhyana) or (vinyasa) or (viniyog*)) NOT ((YOGURT) OR (YOGHURT)) AND ((diabetes) OR (diabetic) OR (NIDDM) OR ("noninsulin-dependent diabetes mellitus") OR ("noninsulin dependent diabetes mellitus") OR ("diabetes mellitus") OR (glycem*) OR (glycaem*) OR (hyperglycem*) OR (hyperglycaem*) OR (glucose*) OR (glycosylated Hb) OR (haemoglobin A) OR (hemoglobin A) OR ("glycated hemoglobin") OR (HbA1c) OR (A1C) OR (T2DM) OR ("type II diabetes") OR ("type 2 diabetes") OR ("diabetes mellitus type 2") OR ("diabetes mellitus type II") OR ("type II diabetes mellitus") OR ("type 2 diabetes mellitus") OR (T2D) OR (DM2) OR (SUGAR) OR (INSULIN) or (FBS) OR ("fasting blood sugar") OR (PPBS) OR ("postprandial glucose test") OR (FPG) OR ("fasting plasma glucose") OR (PPG) OR ("postprandial blood glucose") OR ("oral glucose tolerance") or (metabolic syndrome) OR ("diabetes control")). The search fields were modified based on the search parameters imposed on each electronic database. No language restrictions were applied. The electronic reference databases were searched in February 2015 and updated in February 2016. We searched the database two months following the end of the calendar year due to the delay in the indexing process of electronic bibliographic databases. This was done to ensure that we retrieved all studies published and/or available through December 31, 2015. (2) Reference lists of manuscripts (including published reviews and included studies) were also reviewed. (3) Finally, we searched the tables of contents of relevant journals (e.g., *International Journal of Yoga*) for additional studies.

2.3. Study selection

Initial screening involved review of study titles and abstracts for possible inclusion. Full-text manuscripts of potentially relevant records and references from relevant manuscripts were reviewed for final inclusion. When study details or additional information (e.g., results from a pilot study) were published across multiple manuscripts, those manuscripts were linked in the database and represented as a single unit and the manuscript reporting the most complete data was selected as the primary manuscript. Authors were contacted for additional information and/or clarifications when the study details were not reported in full.

2.4. Data collection process and reliability

Two independent coders (HT and RL) extracted study information (e.g., publication year), sample characteristics (e.g., age, gender), design specifics (e.g., recruitment method), intervention procedures (e.g., yoga style, number of classes), and yoga components (e.g., postures, breathing) from each study. The methodological quality of each study was assessed using 15 items (total possible score of 21) adapted from validated measures (Downs and Black, 1998; Jadad et al., 1996; Miller et al., 1995; Miller et al., 2003).

Inter-rater reliability was assessed for all study, sample, design, and intervention characteristics. For categorical variables, raters agreed on 98% of the judgments (mean Cohen's $\kappa = 0.94$; range = 0.55 to 1.00). Reliability for the continuous variables yielded an average intra-class correlation coefficient (ρ) of 0.96 across categories (median = 1.00). Disagreements between the coders were resolved with the help of the third investigator (LAJSS).

2.5. Study outcomes

The primary study outcomes included an objective measure of glycemic control (i.e. HbA1c, FBG, or PPBG). Secondary outcomes included other markers of diabetes management such as lipid profile, systolic and diastolic blood pressure, body composition, and fasting