Hatha Yoga Practice for Type 2 Diabetes Mellitus Patients: A Pilot Study

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Abstract

Objective: This study was conducted to examine the impact of Hatha yoga on glycemic control, psychological and physiological stress, and self-care for individuals with type 2 diabetes mellitus (T2DM). **Methods:** Ten sedentary individuals with T2DM who were non–insulin dependent, free of diabetes-related complications, and had no previous yoga experience completed therapeutic yoga classes for 6 weeks, 3 times per week. Glycemic control measures included fasting blood glucose, glycated hemoglobin, and fasting insulin. The State-Trait Anxiety Inventory, Perceived Stress Scale, and salivary cortisol were used to assess levels of stress, and the Summary of Diabetes Self-care Activities questionnaire was used to assess regimen adherence. **Results:** No significant changes in glucose control or physiological stress were found; however, significant changes in perceived stress, state anxiety, and self-care behaviors were detected. **Conclusions:** Preliminary findings support further investigation of the benefits of Hatha yoga as a complementary therapy for those with T2DM.

Key Words: yoga, diabetes, glycemic control, stress, anxiety, cortisol

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Diabetes mellitus is a chronic disease with the potential for serious complications. In the United States it is estimated that 25.8 million people, or 8.3% of the population, suffer from diabetes (CDC, 2011). Worldwide, 346 million people have diabetes and approximately 3.4 million have died in past years from consequences of high blood glucose (WHO, 2011). In the United States approximately 60% to 70% of those with diabetes suffer mild to severe nervous system damage, or neuropathy. Of those age 40 or older, 28.5% suffer damage to the blood vessels of the retina of the eye, or retinopathy, which can lead to severe vision loss or even blindness (ADA, 2011). Clinical evidence indicates that heart disease rates are 2 to 4 times higher in adults with diabetes than in healthy adults (ADA, 2011). Globally, cardiovascular disease is the major cause of death from diabetes, producing about 50% of all diabetes fatalities and a large percentage of disability (IDF, 2011).

Depression is more prevalent in those with diabetes than in the general population (ADA, 2011). Patients who suffer from both diabetes mellitus and mental illness may struggle with treatment regimen, self-care, and potential drug interactions (Warren, Crews, & Schulte, 2001). Depression can affect sleep and quality of life (Skomro, 2008) and is associated with disability and work absence in individuals who are challenged by this chronic disease (Stein, Cox, Afifi, Belik, & Sareen, 2006). As such, the psychological costs of the disease can be considerable. The purpose of this study was to examine whether participation in a Hatha yoga program would be associated with changes in glycemic control, psychological and physiological stress, and self-care for individuals with type 2 diabetes mellitus (T2DM).

Potential Benefits of Yoga for T2DM

Yoga has been investigated as a complementary therapy for diabetes patients. Some study results have associated yoga practice with beneficial effects on glycemic control, including fasting blood glucose (FBG), glycated hemoglobin (HbA1c), and postprandial blood glucose (Aljasir, Bryson, & Al-shehri, 2010; Innes & Vincent, 2007). However, the lack of empirical rigor of these studies requires findings to be interpreted as preliminary and speculative.

Results of several investigations suggest that for individuals with T2DM, yoga may be a therapy to improve range of motion (Vizcaino, 2012) and to reduce anxiety (Gupta, Khera, Vempati, Sharma, & Biljani, 2006) and total cholesterol (Agte & Tarwadi, 2004). Again, given the paucity of empirical reports, continued scientific inquiry is needed.

The potential benefits of yoga for healthy adults of all ages have been widely studied. Yoga is known to reduce psychological stress (Cowen & Adams, 2005; Granath, Ingvarsson, von Thiele, & Lumberg, 2006; Smith, Hancock, Blake-Mortimer, & Eckert, 2007; West, Otte, Geher, Johnson, & Mohr, 2004; Wheeler & Wilkin, 2007), anxiety (Agte & Chiplonkar, 2008; Javnbakht, Kenari, & Ghasemi, 2009; Smith et al., 2007), and depression (Campbell & Moore, 2004; Javnbakht et al., 2009) and to contribute to improved quality of life (Oken et al., 2006).

Yoga practice is also associated with improvements in flexibility, strength, and balance (Cowen & Adams, 2005; Schure, Christopher, & Christopher, 2008; Tran, Holly, Lashbrook, & Amsterdam, 2001). It has also been linked with improved sleep patterns, balance, and range of motion in 60- to 86-year-old women (Chen & Tseng, 2008). Yoga has been reported to be more effective than physical therapy and a self-care book alone for the treatment of chronic low back pain in that it improves spinal flexibility and functionality in adults (Sherman, Cherkin, Erro, Miglioretti, & Deyo, 2005; Sherman et al., 2011; Tekur, Singphow, Nagendra, & Raghuram, 2008).

Preliminary studies suggest that yoga practice may help improve glucose control and ameliorate lesser-known complications and comorbid conditions for individuals with T2DM (Aljasir et al., 2010; Innes & Vincent, 2007). It may also help reduce symptoms of psychological stress and increase overall quality of life.

Yoga for T2DM

The effect of yoga practice on glycemic control for individuals with T2DM were examined under controlled conditions in this pilot study. Changes in physiological and psychological markers of stress and measures of self-care were also explored.

Participation in a yoga program was hypothesized to affect two individual pathways. First, yoga practice was anticipated to decrease psychological anxiety and stress and the stress hormone cortisol, which can increase gluconeogenesis and insulin resistance and diminish the insulin response from the pancreas. Lower levels of circulating cortisol were anticipated to enhance insulin response and insulin sensitivity and decrease glucose levels. Second, stress relief related to yoga practice was predicted to improve measures of regimen adherence and subsequently improve glycemic status.

Methods

Participants

The Institutional Review Board of the University of Texas at El Paso approved the study protocol. Seventeen participants (8 female) were recruited from and around the university community. Participants had been previously diagnosed with T2DM according to the guidelines of the ADA (American Diabetes Association, 2010) by their personal physician. Participants were sedentary, overweight or obese, greater than age 50 years, non–insulin dependent, and had no previous experience with yoga or meditation. The majority of participants were diagnosed with hypertension, though none suffered from cardiovascular disease or diabetes-related complications. Participants did not have medical conditions that alter the 120-day lifespan of red blood cells. All women were postmenopausal and were not on hormone replacement therapy. No major musculoskeletal disorders or injuries were reported, and individuals were required to be able to stand unassisted for at least 30 minutes. A written statement from a physician authorizing participation in an exercise program was required from each participant prior to intervention onset. All participants signed an informed consent form prior to the initiation of data collection.

Of the 17 individuals who completed initial baseline testing, 4 withdrew prior to the intervention because of schedule conflicts or lack of physician approval to participate. Two individuals withdrew after the first week because of scheduling conflicts or health complications unrelated to the yoga program. Data from one participant were excluded because of reported use of insulin therapy, leaving a final study sample of 10 individuals (8 female).

Characteristics of the final sample are shown in Table 1. According to the American College of Sports Medicine (ACSM) and the World Health Organization (WHO), body mass index (BMI), a measure of weight relative to height, is a useful and practical approach to estimate body composition. A BMI between 18 and 24.5 indicates normal body weight, 25 and 29.9 indicates overweight, and greater than 30 indicates obesity. Several studies have found that those who are obese experience greater insulin resistance than do those of normal weight (see paragraph 3 in the Discussion section). Risk for coronary heart disease, ischemic stroke, and T2DM also increases as BMI increases. Similarly, a large waist circumference, more than 40 inches (102 cm) for men and more than 35 inches (88 cm) for women, is associated with increased risk for heart disease and T2DM.

Table 1.
Characteristics of Participants (N = 10) with T2DM

Measure	Mean	SD
Age (yrs)	61.40	±6.68
Body mass index (kg/m^2)	36.26	±7.55
Waist circumference (cm)	108.50	±16.29
Length of disease (yrs)	6.10	±6.33
Systolic blood pressure (mmHg)	140.60	±20.64
Diastolic blood pressure (mmHg)	77.30	±15.16

Measures

Each participant completed a battery of assessments at baseline and at the end of the 6-week yoga intervention. Anthropometric characteristics, such as height, body mass, and waist circumference, were measured, as was blood pressure. Glucose control was assessed using fasting venous blood samples, which included FBG, a short-term measure of glycemic control, and HbA_{1c}, a long-term measure of glycemic control. Fasting insulin was also assessed from blood samples.

Physiological stress. Physiological stress (salivary cortisol) was assessed based on salivary samples collected at home at midnight by the participants. Research has indicated that night-time salivary cortisol is as valid a measure of cortisol levels as 24-hour urinary free cortisol excretion (Viardot et al., 2005). For the convenience of the participants, salivary samples were collected using materials provided by the investigator, who had previously explained in detail the data collection procedure. Participants delivered the frozen samples the following day at the laboratory. Samples were collected and analyzed according to protocol specified by the manufacturer (Salimetrics, LLC, State College, PA).

Psychological distress. The 14-item version of the *Perceived Stress Scale* (PSS; Cohen & Williamson, 1988) was used to measure stress. Seven positive and seven negative assessment items were used to appraise participants' experience during the previous month, including the extent to which the respondent has perceived life situations to be stressful, unpredictable, and uncontrollable. Items were answered using a Likert scale ranging from 0 (*never*) to 4 (*very often*). A total score was obtained by reversing the scores on the positive items and then summing across all items. The higher the score, the greater the individual's perceived stress. The scale has shown adequate internal reliability, as indicated by a Cronbach's alpha coefficient of .75 (Cohen & Williamson, 1988).

The *State-Trait Anxiety Inventory* (STAI; Spielberger, Gorsuch, & Lushene, 1970) was used to measure levels of anxiety. The STAI consists of two subscales, the State scale (S-scale) and the Trait scale (T-scale); each contains 20 items rated on a 4-point Likert scale. Higher scores represent higher levels of anxiety. State anxiety is defined as a temporary emotional state, and trait anxiety is defined as a relatively stable personal characteristic of anxiety proneness. Previous research has indicated that test–retest reliability tends to be high for trait anxiety and low for state anxiety, with alpha coefficients between .73 and .95, respectively (Spielberger et al., 1970).

Self-care. Self-care was assessed with the *Summary of Diabetes Self-Care Activities* questionnaire developed by Toobert & Glasgow (1994). The questionnaire is used to assess dimensions of diabetes self-care, including blood glucose testing and medication adherence. Questions record the number of days during the previous week the individual engaged in a specific health behavior. The total score is obtained by summing number of days across dimensions, minus the smoking status and number of cigarettes smoked. Hence, the higher the score, the greater the adherence to self-care behaviors. The validity and reliability of the questionnaire have been previously examined with participants with T2DM (Toobert, Hampson, & Glasgow, 2000).

Physical activity. Physical activity was documented pre- and postintervention by using the long version of the International *Physical Activity Questionnaire* (IPAQ; Craig et al., 2003). The respondent is asked a series of questions regarding various types of physical activity, including job-related, transportation, and leisure. Each item is rated in number of days per week and time expended each day on a particular activity. The validity and reliability of the IPAQ has been previously demonstrated in several studies (Craig et al., 2003).

Diet log. Diet was documented using dietary software (The Food Processor 2004, ESHA Research, Salem, OR) before and after the intervention through diet recalls assessed for caloric intake and macronutrient composition. Participants were asked to describe every meal for a regular day in detail. Information was entered into the program, which computed calculated caloric intake and macronutrient composition.

Medication log. A medication log documenting all prescribed medication was completed at the beginning and at the end of the intervention.

Yoga Intervention

Six weeks of Hatha yoga classes consisting of physical postures (*asana*), breathing exercises (*pranayama*), and meditation were led by the author, a qualified registered yoga teacher (RYT). Each class lasted approximately 50–60 minutes. Classes were held 3 days per week, with 1 day of rest in between each session.

Most postures were modified to accommodate participants' limited flexibility, balance, and strength. Props, including chairs, belts, or blankets, were used to achieve appropriate alignment, technique, and balance and to provide participants the opportunity to obtain full benefit of the practices. Participants were instructed to center their attention on their breathing and to become aware of their body position in each posture. Some of the classes focused on a particular topic such as "yoga for the neck and shoulders," "yoga for the back," "yoga for insomnia," and "yoga as a meditative practice." These special sessions were designed based on the feedback provided by the participants during the 6-week intervention.

Yoga mats and chairs were provided to all participants. Participants supplied props such as belts, towels, or blankets. Handouts describing yoga poses and meditation exercises were provided approximately every 2 weeks so that participants could continue practice at home during and after the intervention. All participants were encouraged to closely monitor their glucose levels before and after practice as a precautionary measure. A detailed description of the components of the classes is provided in Table 2.

Table 2.
Sample Yoga Class for Participants with T2DM

Element	Approximate time
Short meditation	5 min
Warm-up	6–8 min
Neck rolls	
Shoulder rolls	
Mirror stretch*	
Open wing stretch*	
Seated asanas	6–8 min
Spinal twist	
Head-to-knee forward bend	
Wide-angle seated forward bend	
Standing asanas	15 min
Warrior II	
Triangle pose	
Warrior I	
Intense side stretch	
Tree pose	
Dancer's pose	
Restorative asanas	6–8 min
Puppy pose	
Child's pose	
Lying arm raise with bent leg*	
Savasana	
Closing meditation	10 min

Note. *These exercises are described in detail in Payne, L., & Usatine, R. (2002). *Yoga Rx*. New York, NY: Broadway Books.

Statistical Analysis

Data were analyzed using the Statistical Package for the Social Sciences (version 20.0, Chicago, IL). Because data on glucose control, cortisol, insulin, and physical activity were not normally distributed and because of the limited sample size, the Wilcoxon Signed Rank Test was used to assess changes between pre- and postintervention values in these variables. Paired-samples *t*-test analysis was conducted to assess changes in measures of perceived stress, anxiety, and self-care. Similarly, a paired-samples *t*-test analysis was conducted to assess changes in dietary intake. Significance was set at alpha level .05. Effect sizes for normally distributed data were estimated with the formula, $d = {}_{group1} - {}_{group2} / SD_{pooled}$. Effect sizes for nonnormally distributed data were estimated with the formula, $r = Z / \sqrt{N}$.

Results

Data regarding 10 participants were included in the final analysis. The average attendance rate of the yoga classes was 81.6%. Type of medication used by participants included metformin (n = 9), sulfonylureas (n = 1), alpha-glucosidase inhibitors (n = 1), meglitinide (n = 1), incretin (n = 1), and glitazone (n = 1).

Results are reported in Table 3. There was a trend toward improved glucose control (FBG and HbA_{1c}) and increases in plasma insulin, but the changes were not statistically significant (FBG, $Z = -1.36$, $p = .17$; HbA_{1c}, $Z = -.9$, $p = .37$; $Z = -1.27$, $p = .20$, respectively). Paired-samples t-tests revealed statistically significant pre- to posttest improvements in perceived stress, $t(9) = 2.59$, $p = .03$; state anxiety, $t(9) = 3.20$, $p = .01$; and self-care, $t(9) = -3.19$, $p = .01$. Nonsignificant decreases in cortisol, $Z = -1.68$, $p = .09$, and trait anxiety, $t(9) = 1.87$, $p = .09$, were also found.

Table 3.
Glycemic Control Measures of Participants with T2DM at Baseline and Following the 6-week Yoga Intervention

	Preintervention		Postintervention		Effect sizes
FBG (mg/dL)	130.59	±81.83	119.81	±65.57	−0.30
HbA_{1c} (%)	8.35	±2.79	8.28	±2.44	−0.20
Insulin (pmol/l)	97.85	±73.55	112.86	±80.63	−0.28

Note. FBG = fasting blood glucose; HbA_{1c} = glycated hemoglobin. No significant differences between pre- and postintervention values ($p > 0.05$).

Medication log reports indicated no changes in medication. Similarly, results from the physical activity questionnaire indicated no significant change in physical activity patterns, $Z = -.36$, $p = 0.72$. The dietary analysis revealed a decrease in protein consumption, $t(9) = 2.39$, $p = .04$. However, changes in total calorie consumption, $t(9) = 1.71$, $p = .12$; calories from fat, $t(9) = 1.43$, $p = .19$; saturated fat, $t(9) = 1.39$, $p = .20$; and total fat consumption, $t(9) = 1.43$, $p = .19$; were not significant.

Participants did not report any injuries or adverse health events as a result of the yoga intervention. Similarly, no hypoglycemic events occurred during any of the yoga classes.

Discussion

The primary purpose of this pilot study was to investigate the impact of a therapeutic yoga practice on glycemic control for participants with T2DM. A trend toward improved glycemic control was found following the 6-week intervention. These results differ from those of previous studies conducted in India that found significant decreases in glycemic control parameters, such as FBG, HbA_{1c}, and postprandial glucose (Amita, Prabhakar, Manoj, Harminder, & Pavan, 2009; Malhotra, Singh, Tandon, & Sharma, 2005; Singh, Kyizom, Singh, Tandon, & Madhu, 2008; Singh, Malhotra, Singh, Madhu, & Tandon, 2004; Singh et al., 2001) following yoga practice. The length of the intervention in these studies was approximately 40 to 45 days, similar to the 42-day intervention of this investigation, with the exception of the Amita et al. (2009) study, which included a 3-month yoga-nidra intervention.

Table 4.
Physiological and Psychological Measures of Stress and Self-care Measure of Participants with T2DM at Baseline and Following the 6-week Yoga Intervention

	Preintervention		Postintervention		Effect sizes
Cortisol (mg/dL)	0.25	±0.28	0.10	±0.25	−0.38
PSS	22.80	±7.96	17.50	±7.12*	0.70
State anxiety	39.80	±13.27	29.20	±8.56*	0.95
Trait anxiety	36.80	±11.22	31.10	±8.13	0.58
SDSC	42.96	±12.88	56.04	±15.26*	−0.93

Note. PSS = Perceived Stress Scale; state and trait anxiety determined from State and Trait Anxiety Inventory; SDSC = Summary of Diabetes Self-Care questionnaire.
*$p < 0.05$.

The dramatic difference in anthropometric characteristics between the participants in this investigation and those in previous studies may account for the discrepancy. BMI classifications (ACSM, 2010) of subjects in the Amita et al. (2009) study were in the normal range, that is, 22.64 kg/m^2 (no standard deviation provided), and participants in the Malhotra et al. (2005) and Singh et al. (2008) studies were marginally overweight, 26.81 ± 0.90 kg/m^2 and 26.12 ± 1.54 kg/m^2, respectively. Two participants in our study were in the obesity Class II category, 37.67 ± 2.82 kg/m^2, and four were in the obesity Class III category, 43.73 ± 1.18 kg/m^2. It is possible that these marked differences were associated with our discrepant findings.

Insulin resistance has been shown to be more prevalent among individuals with obesity and abdominal adiposity (Vanhala, Pitkajarvi, Kumpusalo, & Takala, 1998). Fasting insulin and insulin responses to an oral glucose challenge are observed to be significantly higher for obese patients with diabetes than for diabetes patients of normal weight (Turkoglu et al., 2003). Increases in insulin secretion may not fully compensate the degree of insulin resistance in obese patients (Bonadonna et al., 1990). It is likely that participants in this study possessed a higher degree of insulin resistance as a function of their obesity status. It may be more difficult for them to experience significant changes in glycemic control than for normal-weight and marginally overweight participants.

Previous studies investigating the effect of exercise training on insulin sensitivity and responsiveness in obese T2DM patients have found significant improvements in peripheral insulin sensitivity and better glucose control following 7 days of training (O'Gorman et al., 2006; Winnick et al., 2008), even in the absence of weight reduction (Kirwan, Solomon, Wojta, Staten, & Holloswy, 2009). These studies used moderate exercise intensity, or approximately 70% of maximal aerobic capacity. Clay, Lloyd, Walker, Sharp, and Pankey (2005) found that Hatha yoga practice requires low aerobic intensity, corresponding to 14.5% of maximal oxygen uptake reserve. The intensity of yoga may not be sufficient enough to elicit significant changes in glucose control in a 6-week intervention.

Michishita, Shono, Kasahara, & Tsuruta (2008) found significant improvements in fasting glucose, glucose tolerance, and insulin secretion in overweight diabetes patients following 12 weeks of low-intensity exercise therapy. They reported a decreasing trend in fasting glucose in a 2-hour glucose tolerance test after 7 days of exercise. These decreases were not statistically significant (Michishita et al., 2008). Perhaps overweight individuals with diabetes require practices that involve longer periods of time at low cardiovascular intensities, such as yoga, to experience significant changes in glucose control. It is likely that the obese participants in this study needed more time to become insulin responsive and may have benefited from a longer yoga intervention. Further studies are needed to test this proposition.

The frequency of yoga practice may be of vital importance to changes in glycemic control. Studies that reported a significant decrease for FBG, postprandial glucose, or HbA_{1C} involved daily yoga practice (Amita et al., 2009; Malhotra et al., 2005; Singh et al., 2004; Singh et al., 2001; Singh et al., 2008). In contrast, Skoro-Kondza, Tai, Gadelrab, Drincevic, and Greenhalgh's (2009) 2 times per week, 3-month yoga therapy intervention for individuals with T2DM led to no significant changes in HbA_{1c}. Although participants in this study were encouraged to practice daily, the intervention provided structured yoga sessions only 3 days per week. Because home practice sessions were not recorded during this study, the extent of participants' independent practice is not known.

Because of its small sample, this pilot study was considerably statistically underpowered, which seriously limited the ability to detect statistically significant effects for any of the study variables. Previous studies used much larger samples. Gokal and colleagues (2007) implemented a 7-day yoga intervention to 258 participants with a variety of medical conditions, including T2DM, and found a modest but significant decrease in FBG ($\Delta \approx 5.4$ mg/dL) following the intervention, approximately one half of that observed in this study ($\Delta \approx 10.8$ mg/dL). A posthoc, two-tailed power analysis conducted with G*Power (Faul, Erdfelder, Lang, & Buchner, 2007) indicated that our study possessed a power of 0.29 based on a sample of 10 participants, which represents a medium effect size of .50 (± = .05). It is possible that significant changes may have been detected if the study had included a larger sample size.

This study also examined the extent to which a therapeutic yoga intervention would affect psychological stress. Significant decreases were observed in perceived stress and state anxiety, both of which showed strong effect sizes ($d = 0.70$ and $d = 0.95$, respectively). Trait anxiety did not change, but this outcome had been anticipated because trait anxiety reflects a relatively stable personality characteristic.

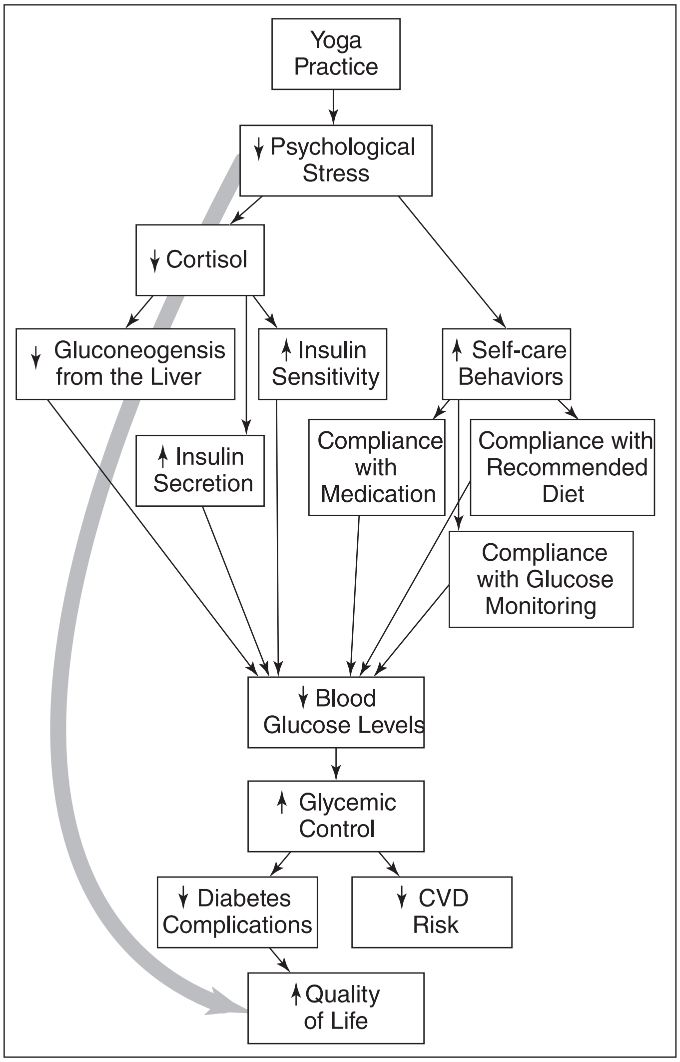
The reduction in psychological stress may have accounted for the decreased circulation of the hormone cortisol. Reductions in cortisol, may in turn, be related to the decreasing trend in FBG and HbA_{1c} vis-à-vis diminished glucose output from the liver and enhanced peripheral insulin sensitivity. Lower levels of circulating cortisol may also account for the increased trend in insulin production, in that insulin secretion from the pancreas increased, which can contribute to an improved glycemic status. Because changes in cortisol, FBG, HbA_{1c}, and insulin were not statistically significant, these ideas are speculative. Further studies are needed to assess the relationship between yoga-related stress relief and cortisol, and glucose control in those with T2DM.

Stress relief may have contributed to improvements in measures of self-care. Cohen and Kanter (2004) found that adherence to self-care behaviors, such as regular clinic attendance, blood tests, medication, diet, and physical activity, was negatively associated with psychological distress. Yoga practices, including meditation, may reduce chronic disease and improve adherence to a diabetes regimen. Effective self-care behaviors are likely to decrease glucose levels and contribute to improvements in glycemic status. A reduction in psychological stress may account for decreases in cortisol levels and enhancement of self-care behaviors, which alone or in combination may contribute substantially to the improvement of glycemic status. Improved glycemic status decreases the risk for cardiovascular disease and diabetes complications, which may significantly contribute to overall quality of life. Hypothesized pathways for these potential beneficial effects of yoga on glucose control are shown in Figure 1 (page 64).

Conclusion

Hatha yoga practice may be a complementary therapeutic option for individuals with T2DM. Potential benefits include improvements in glycemic control through decreases in psychological stress, which in turn may decrease levels of the stress hormone cortisol and enable greater compliance with self-care behaviors. This study provided support for the beneficial impact of yoga on perceived stress and state anxiety and on measures of self-care. Future longitudinal investigations that use longer interventions; refined experimental designs, such as randomized, controlled trials and repeated measurement over time; and advanced statistical techniques, such as structural equation modeling, are needed. These investigations will lend greater insight into the long-term impact of yoga practice on the glycemic control and psychological well-being of individuals with T2DM.

Figure 1.
Hypothesized pathways for the potential beneficial effect of yoga practice on glycemic control of T2DM patients.



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