

Physical Exercise and Yoga are Must in a Standard Protocol for Integrated Management of Diabetes Mellitus

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INTRODUCTION

Physical activity encompasses all forms of movement that increase energy expenditure, whereas physical exercise refers to planned and structured physical activity.^[1] Physical exercise improves blood glucose control in individuals with type 2 diabetes, reduces cardiovascular risk factors, supports weight management, and enhances overall well-being. Regular physical activity may also prevent or delay the onset of type 2 diabetes. However, the challenges of managing blood glucose during physical exercise vary depending on diabetes type, type of activity, and the presence of diabetes-related complications. Therefore, exercise recommendations should be tailored to the specific needs of each individual.

Currently, India is the diabetic capital of the world. The World Health Organization (WHO) predicts that by 2030, diabetes will rank as the seventh leading cause of death globally. Type 2 Diabetes Mellitus (T2DM) is a metabolic disorder characterized by chronic hyperglycemia. Its pathogenesis involves insulin resistance and impaired insulin secretion, though genetic and environmental factors do also contribute to disease risk.^[2] More than half of T2DM patients exhibit poor glycemic control and are often diagnosed with diabetic complications or ischemic cardiovascular disease at the same time. Additionally, 30-40% of elderly patients present with combined glucose metabolism disorders, hypertension, abdominal obesity, and hypertriglyceridemia due to lipoprotein lipase gene mutations. A central goal in managing T2DM is reducing blood glucose levels, which lowers the risk of microvascular and other complications. However, while glycemic control remains a priority, recent perspectives emphasize the importance of multifactorial management to address the complex interplay of factors underlying T2DM and its complication. Reducing Cardiovascular Disease (CVD) risk factors is particularly crucial. Additional objectives include alleviating diabetes-related distress, reducing depression,

and improving emotional well-being and quality of life, all of which are significant predictors of glycemic control, complication rates, and treatment adherence.

Treatment approaches for diabetes generally fall into two categories: pharmacological and non-pharmacological. Pharmacological treatments effectively lower glucose levels but may cause side effects and adverse reactions. Non-pharmaceutical interventions, owing to their simplicity, safety, and potential efficacy, are gaining increasing attention in the healthcare community.^[2] In integrated diabetes management, blood glucose control remains the primary strategy, while lipid control is a critical measure for preventing and treating cardiovascular complications in T2DM. Numerous international studies have explored the effects of exercise on diabetic patients. A consistent finding is that physical inactivity is a significant risk factor for diabetes, while exercise interventions serve as an essential component of diabetes management.^[3] Physical exercises for diabetes management include Aerobic exercise, Resistance (strength) training exercise, combined aerobic and resistance exercise, High-intensity interval training regimen, and other categories of exercise such as balance exercises, tai chi, yoga etc.^[4]

Aerobic Exercise

Aerobic exercise involves continuous, rhythmic movement of large muscle groups. Activities such as walking, cycling, jogging, and swimming primarily rely on aerobic energy systems. Regular aerobic training enhances insulin sensitivity and mitochondrial function in adults with Type 2 Diabetes Mellitus (T2DM). It also improves glycated Hemoglobin (HbA_{1c}) control and increases cardiorespiratory fitness.

Resistance Exercise

Resistance (or strength) training includes activities using free weights, machines, body weight, or elastic resistance bands. This type of exercise improves muscular strength, bone mineral density, blood pressure, lipid profile, skeletal muscle mass, and insulin sensitivity in adults with T2DM. According to the American College of Sports Medicine and the American Diabetes Association, resistance training helps reduce cardiovascular risk and minimize injuries. It has also been shown to improve blood glucose and HbA_{1c} control.



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Combined Exercise Training

Combining aerobic and resistance exercises may produce greater benefits than either modality alone. Such combined training improves inflammatory, metabolic, and lipid markers in middle-aged and older adults with T2DM. Studies show that combined training leads to a greater reduction in HbA_{1c} levels compared to performing only aerobic or resistance exercise.

High-Intensity Interval Training (HIIT)

It consists of short bouts of aerobic exercise performed at 65-90% of VO₂ peak or 75-95% of maximum heart rate, lasting from 10 sec to 4 min, interspersed with 12 sec to 5 min of active or passive recovery. HIIT is a time-efficient method that induces significant physiological and metabolic adaptations. In adults with T2DM, even a single HIIT session (e.g., 10 × 60 sec of cycling at ~90% HRmax) can reduce postprandial hyperglycemia and improve cardiorespiratory fitness, HbA_{1c}, and Body Mass Index (BMI). HIIT also lowers cardiovascular risk factors, enhances diastolic function, increases left ventricular wall mass and end-diastolic volume, and improves endothelial function.

Other Types of Exercise Training

Flexibility exercises enhance joint range of motion, while balance exercises improve gait stability and help prevent falls. Activities such as yoga and tai chi integrate flexibility, balance, and resistance components.

- Yoga has been shown to improve glycemic control, lipid levels, and BMI in adults with T2DM. Limited evidence also suggests benefits for oxidative stress, blood pressure, pulmonary and autonomic function, mood, sleep, quality of life, and medication use.
- Tai chi may enhance glycemic control, balance, and neuropathic symptoms, as well as certain aspects of quality of life.
- Additionally, Method Training (MT), a form of physical and mental exercise rooted in traditional Chinese medicine, has gained recognition for its overall health-promoting effects.

Exercise directly aids blood glucose regulation by expending energy and improving metabolic function. In the body, glucose is mainly utilized by the skeletal muscle. Therefore, more the muscle mass of the individual, more is the capacity to utilize and metabolize glucose. Practice of regular physical exercise, especially the resistance exercises, increases the skeletal muscle mass. Exercise, apart from increasing the muscle mass, regulates cortical activity, influences the hypothalamic-pituitary-target gland axis, and enhances pancreatic islet β -cell function, thereby promoting insulin secretion. Furthermore, exercise promotes skeletal muscle glucose uptake, improves insulin sensitivity, and enhances glucose transport. These physiological effects help stabilize blood

glucose levels while improving lipid profiles, blood pressure, cardiovascular health, and overall well-being in individuals with T2DM.^[5] Further, Aerobic Exercise Training (AET) increases tone and activity of vagus nerve. Cholinergic vagal stimulation increases insulin secretion from β -cell of pancreas. Thus, physical exercise is an important stimulator of insulin secretion and sensitivity.^[6] There is broad agreement that regular aerobic exercise training improves glycemic control, lipid levels, blood pressure, and general health in adults with T2DM.^[2] Recent advances in exercise metabolism research have also emphasized the benefits of Resistance Training (RT), particularly when combined with aerobic exercise. Studies indicate that Combined Training (CBT) more effectively improves blood glucose and lipid levels than either AET or RT alone, especially in middle-aged and older patients. However, while Moderate-Intensity Continuous Training (MICT) can be effective, it often requires substantial time and may lead to poor adherence. High-Intensity Interval Training (HIIT), on the other hand, is time-efficient and tends to have higher compliance rates. Some studies show that HIIT is as effective as other forms of exercise in improving glycemic and lipid outcomes in T2DM. As a low-to-moderate intensity activity, MT has been shown in recent studies to improve blood lipid and glucose levels in patients with T2DM. Taichi, a traditional Chinese exercise emphasizing slow, controlled movements centered on the waist, is another low-to-moderate intensity activity. Meta-analyses indicate that Yoga and Taichi improve glycemic control, reduce body weight, regulate blood lipids, and enhance quality of life in T2DM patients.

Yoga, originally a traditional system of India, has gained widespread global popularity in recent decades, with yoga therapy emerging as a growing field in medical practice. The primary goal of yoga is not merely to achieve physical fitness but the harmonization of mind, body, and spirit, promoting balance, awareness, and inner peace. Given these complexities of diabetes management as discussed above, sustainable lifestyle interventions that target multiple aspects of T2DM are essential. Mind-body practices such as yoga, which integrate physical and mental well-being, are especially well-suited for such multifactorial management. Though there are several branches and practices of yoga, *Raja* (classical or royal) yoga and *Hatha* yoga are the most widely practiced. *Hatha* yoga, which is more prevalent in Western countries, emphasizes postures (*asanas*), breath control (*pranayama*), concentration (*dharana*), and meditation (*dhyana*), along with cleansing techniques, chants (*mantras*), and hand gestures (*mudras*). Originally developed to prepare the body for flexibility, balance and meditation, *Hatha* yoga has evolved into many systems of yoga including *Iyengar* yoga and *Ashtanga* yoga.^[7]

A growing body of research evidence indicates that yoga can reduce cardiovascular risk and enhance physical health and well-being across various populations including those with T2DM. Controlled trials suggest that yoga-based programs may significantly improve glycemic control, lipid levels, and body composition in individuals with T2DM.^[8] Preliminary data also indicate potential benefits for

blood pressure, oxidative stress, pulmonary and nervous system function, mood, sleep, and overall quality of life. However, due to methodological limitations and variability among studies, these findings should be interpreted with caution. High-quality, standardized trials are needed to validate and expand upon these promising results. However, report of nationwide multicentric randomized controlled trial demonstrated that comprehensive lifestyle modification through a yoga-based lifestyle protocol incorporating ethical precepts, postures (*asanas*), breath regulation (*pranayama*), meditation, and dietary adjustments, is an effective strategy for preventing or delaying diabetes in individuals with prediabetes.^[9] A recently conducted RCT from our laboratory has revealed that 12 weeks practice of structured yoga schedule that includes asanas and pranayama is very much helpful in reducing disease severity, reducing the allopathic medications and CV disease risks, improving the heart rate variability and quality of life in T2DM patients.^[10] These findings suggest that Yoga Lifestyle Protocols (YLPs) may offer a practical, low-to-moderate intensity intervention for reducing diabetes risks, disease severity and improving overall health. However, large-scale studies and long-term follow-ups are needed to confirm and sustain these effects.

Apart from doing physical exercises, which are scheduled for a particular time and duration of the day, one should also be engaged in the regular and usual daily physical activities such as cleaning rooms, washing clothes, climbing stairs in the house and office instead of using lift, practicing yoga-break at workplace, and so on. Intermittent and unscheduled physical activity burn calories, prevent deposition of fat, decreases musculo-skeletal stiffness, maintains blood glucose level.

Physical activity, physical exercise and yoga should be recommended and prescribed to all individuals with diabetes as part of management of glycemic control and overall health. Specific recommendations and precautions will vary by the type of diabetes, age, activity done, and presence of diabetes-related health complications. Recommendations should be tailored to meet the specific needs of each individual. In addition to engaging in regular physical activity, all adults should be encouraged to decrease the

total amount of daily sedentary time and to break up sitting time with frequent bouts of activity. Finally, behavior-change strategies can be used to promote the adoption and maintenance of lifetime physical activity. Support and encouragement from family members of a patient suffering from diabetes plays a vital role in regularly practicing exercise and yoga.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

ABBREVIATIONS

WHO: World Health Organization; **CVD:** Cardiovascular Disease; **T2DM:** Type 2 Diabetes Mellitus; **HIIT:** High Intensity Interval Training; **BMI:** Body Mass Index; **MT:** Method Training; **AET:** Aerobic Exercise Training; **RT:** Resistance Training; **MICT:** Moderate Intensity Combined Training.

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