

### **3.0 REVIEW OF SCIENTIFIC LITERATURE ON T2D, OXIDATIVE STRESS AND DNA DAMAGE & YOGA**

Sustained hyperglycaemic condition, a hallmark of T2D is also associated with lower antioxidant capacity, high OS, and increased DNA damage (Hinokio et al., 1999; Lodovici et al., 2008). Oxidative stress and DNA damage can in turn have a deleterious effect on cells and tissues, including pancreatic- cells, affecting insulin production (Kawahito et al., 2009; Song et al., 2007). If unchecked, this gets into a vicious cycle and heightens the hyperglycaemic condition, and may even lead to various complications, including macro and micro-vascular pathologies generally associated with poorly controlled T2D condition.

Besides non-modifiable factors, an unhealthy lifestyle is considered to be a major contributing factor in the development of T2D and its complications (Gong et al., 2019). Hence, apart from the medical management, diet and physical activity-based health behavior modifications are also strongly recommended by experts and governing bodies for T2D management (Johansen et al., 2017; Lascar et al., 2018; van Sloten et al., 2020). Yoga, a mind-body practice that originated in India and being practiced worldwide, is considered one of the effective therapeutic approaches based on health behavior modifications for the prevention and management of T2D (Innes & Vincent, 2007; Thind et al., 2017).

Research evidence indicates that yoga practices helped T2D patients in improving blood sugar, lipid levels, body composition, pulmonary and autonomic functions, mood, sleep, quality of life, and reduced medications (Gordon et al., 2008; Johansen et al., 2017). A randomized pilot study involving yoga found benefits like weight reduction, reduction in waist circumference, and improvement in psychological well-being though no significant improvement was observed in blood glucose (McDermott et al., 2014). While an RCT with yoga intervention observed improvement in blood glucose, lipid profile, and reduction in

medication (Nagarathna et al., 2012), another study observed yoga practices can bestow better control on blood glucose, lipid, and insulin levels in T2D subjects (Singh et al., 2008). Also, few systematic reviews and meta-analyses on the efficacy of yoga on T2D show better glycemic control compared to the exercise group (Jayawardena et al., 2018), improved glycemic and lipid profile (Vizcaino & Stover, 2016), reduction in waist-hip ratio, blood pressure control and better glycemic, lipid profile outcomes (Thind et al., 2017). Studies have also found yoga interventions safe, feasible with high acceptability (Bock et al., 2019; McDermott et al., 2014), and highly cost-effective compared to the conventional treatment (Hartfiel et al., 2017).

Yoga intervention was found to reduce oxidative stress (Bisht et al., 2017) and increase antioxidant capacity (Gordon et al., 2008). While a blood glucose-lowering intervention showed a significant decrease in DNA damage (Xavier et al., 2014), another reported yoga practices reduced OS (Gordon et al., 2008; Hegde et al., 2019) in T2D patients and DNA damage in sperm cells (Bisht et al., 2017). Though few other studies reported a beneficial effect of exercise on genomic stability in T2D patients (Dimauro et al., 2017) and reduced DNA damage in normal healthy individuals (Soares et al., 2015), hitherto, no study has looked into the mechanism of yoga at the molecular level in T2D-associated DNA damage and repair.

### 3.1 SUMMARY TABLE OF SCIENTIFIC RESEARCH ON T2D, OXIDATIVE STRESS, DNA DAMAGE & YOGA

Citation	Study Design	Intervention	Variables	Findings
Gordon et al., 2008	Prospective randomized study	Hatha yoga for 24 weeks	FBG, TC, triglycerides, LDL, VLDL, HDL, MDA, protein oxidation, PLA2 activity, SOD and catalase activities	Hatha yoga may have therapeutic preventative and protective effects on diabetes mellitus by decreasing oxidative stress and improving antioxidant status.
McDermott et al., 2014	Randomized controlled pilot study	Yoga for 8 weeks	BMI, waist circumference, fasting blood glucose, postprandial blood glucose, insulin, insulin resistance, blood pressure, and cholesterol	Yoga can be a useful lifestyle intervention for decreasing weight-related type 2 diabetes risk factors and improving psychological well-being.
Nagarathna et al., 2012	Randomized control study	Yoga-based life style modification program	Medication score, blood glucose, HbA1c and lipid profile	Yoga is better than exercise in decreasing oral hypoglycaemic medication requirement and LDL; and increasing HDL in T2D
Singh et al., 2008	Non-randomized control study	Pranayama and yoga-asanas for 45 days	Fasting and post prandial blood glucose levels, lipid profile and serum insulin levels	Diabetes can be better controlled if yoga can also be simultaneously administered along with the conventional medicines
Jayawardena et al., 2018	Systematic Review and Meta-Analysis	Yoga	FBG, PPBG and HbA1c, BMI, waist circumference WHR, blood pressure, lipid profile	Yoga has beneficial effects on glycaemic control.

Thind et al., 2017	Systematic review and meta-analysis	Yoga	HbA1c, FBG, or PPBG, lipid profile, systolic and diastolic blood pressure, body composition	Yoga improves glycaemic outcomes, lipid profile, blood pressure, and waist/hip ratio in adults with T2D.
Bisht et al., 2017	Review	NA	Oxidative stress in spermatozoa	Oxidative stress is central to the aetiology of male infertility. lifestyle-related interventions like meditation and yoga, might help to reduce the risk of oxidative DNA damage and improve spermfunction
Hegde et al., 2019	Single-Blinded Randomized Pilot Study	Yoga - 3months	Fasting plasma glucose, HbA1c, BMI Waist circumference, Blood pressure, Malondialdehyde Glutathione, Vitamin C, Superoxide dismutase	Yoga and sham yoga had identical effects on oxidative stress, glycaemic status, and anthropometry in T2DM. Levels of reduced glutathione improved only in the yoga group.
Soares et al., 2015	Non-randomized control study	Combined physical exercise for 16 weeks	DNA damage, MDA, Total Antioxidant Capacity, OGG1,	Combined physical exercise training increased physical fitness and reduced DNA damage in lymphocytes and MDA levels, with an increase in total antioxidant capacity.

**Table 1. Summary table of scientific research on T2D, oxidative stress, DNA damage & yoga**