Chapter – 3

REVIEW OF SCIENTIFIC LITERATURE

3 REVIEW OF SCIENTIFIC LITERATURE

3.1 YOGA AND DIABETES

Many older texts have been mentioned the usefulness of yoga in the prevention and treatment of many diseases, and in preservation of health (Sahay, 2007). To better manage diabetes, It is necessary to involve in lifestyle modification programs such as yoga-based lifestyle for long duration of time on regular basis (Jagannathan et al., 2015). Many studies have shown the effectiveness of yoga on metabolic disorders including diabetes mellitus. A study concluded that yoga-based program is a possible risk reduction option for the adults with high risk for T2DM (Yang et al., 2011). An 8-week yoga intervention showed a positive effect on behavioural health outcomes in patients with T2DM (Alexander et al., 2012). In a recent meta-analysis conducted with a total of 12 yoga studies on T2DM, the pooled weighted mean reduction was 0.47 for HbA1c (Cui et al., 2017). The results of a recent study demonstrated that the yoga is effective in reducing the blood glucose levels in patients with T2DM (Chimkode, Kumaran, Kanhere, & Shivanna, 2015). One another study has demonstrated that the HbA1c levels reduced significantly by 14.17% in yoga group with no significant difference between yoga and exercise group after nine months of interventions (the HbA1c reduced 0.50 % in exercise group). The study also concluded that yoga is better than exercise in decreasing oral hypoglycaemic medication requirement in type 2 diabetics (Nagarathna et al., 2012). In above mentioned study, FBS level reduced significantly by 9.64 mg/dl (7.20%) in yoga group and it reduced insignificantly by 5.11 mg/dl (3.92%) in exercise group but the study did not demonstrate the significant difference between the groups. Similarly, the PPBS reduced significantly in yoga group by 14.6% in yoga group and by 8.9% in exercise group after 9 months of intervention with insignificant difference between the groups (Nagarathna et al., 2012). One another study conducted in Cuba demonstrated that mean FBS reduced by 29.48% in yoga group and 27.43% in exercise group after six months of intervention (Gordon et al.,

2008b). Further, an 8-week yoga intervention showed to be a effective lifestyle intervention to reduce weight-related T2DM risk factors and to improve psychological well-being (McDermott et al., 2014).

Yoga practice affords multiple short-term benefits for individuals with or at risk for T2DM (Alexander, 2010). As we discussed, yoga intervention was found to be effective in improving the blood glucose levels in patients with T2DM (Subhash et al., 2015). A 40 days yoga intervention resulted in reduced BMI, improved well-being and reduced anxiety in patients suffering from T2DM (Kosuri & Sridhar, 2009). Yoga practices can also be used as an effective therapy in reducing oxidative stress along with BMI in T2DM (Hegde et al., 2011a). Yoga-based lifestyle including exercise and stress management training can also reduce elevated lipid levels in patients with T2DM (Shantakumari et al., 2013). Yoga postures can be practiced with proper diet and drugs in the management of T2DM (Malhotra et al., 2005). Yoga intervention not only improved glycaemic control but also improved nerve function in patients suffering from mild to moderate T2DM with sub-clinical neuropathy (Malhotra et al., 2002). *Table 1* provides the details of controlled studies on yoga for Type 2 Diabetes Mellitus.

3.2 YOGA AND ELECTRO-PHOTONIC IMAGING

Several studies have shown the positive effects of yogic practices on EPI variables. A seven day yoga camp on diabetes management showed changes which could be seen through EPI in a large number of parameters for both general and organ specific (Bhat et al., 2017). Electro-photonic imaging cam be used to investigate the functional physiological and psycho-physiological state of meditators (Deo, Itagi, et al., 2015). One recent study with the intervention of Cyclic Meditation practice showed reduction on stress and improvement on psycho-physiological health compared to Supine Rest in managers (Kushwah, Srinivasan, Nagendra, & Ilavarasu, 2016). Integrated Yoga Practices (IYP) reduced stress levels and

improved the health indices at the psycho-physiological level shown by electro photonic Imaging technique (Kushwah, Nagendra, & Srinivasan, 2015). One study aimed to observe effect of *Anapanasati* meditation on the electro-photonic imaging parameters in long-term meditators and naive meditators (practicing meditation for first time for seven days). The results of the study showed larger health related advantages in long-term meditators (LTM) and naive meditators (NM) group at the physiological and psychophysiological level. (Deo, Kumar, et al., 2015). One another study tried to see the effect of *Anapanasati* meditation on the electro-photonic imaging (EPI) parameters in long-term meditators (LTM) and short-term meditators (STM) using electro-photonic imaging (EPI). Both groups showed health-related improvement. Woman meditators exhibited more positive improvement in EPI parameters than men (Deo et al., 2016). *Table 2* provides the details of yoga studies on Electro-photonic Imaging.

3.3 DIABETES AND ELECTRO-PHOTONIC IMAGING

Diabetes is a chronic illness that requires continuing medical assistance to prevent complications (American Diabetes Association, 2013). The complexity of diabetes demands management beyond mere glycaemic control, as it influences the functioning of the major viscera. This calls for the application of early screening methods like EPI to understand early changes in the various regions of the body due to hyperglycaemia. A study comparing 115 subjects with diabetes and 84 healthy subjects using EPI technique showed the organ values were significantly more in patients with diabetes for hypothalamus, and thyroid gland. While, lesser organ values in eyes, cerebral cortex, cardiovascular system, and kidneys were recorded (Shiva Kumar et al., 2016). Another study was conducted with 29 healthy subjects, 13 pre-diabetics, and 60 patients with diabetes. A significant correlation was found between FBS (Fasting Blood Sugar) and right kidney in the pre-diabetic group (Bhat et al., 2016). EPI parameters were compared across the groups with differing chronicity of Diabetes in a study

examining 138 patients with T2DM and 84 healthy subjects. Three subgroups were formed within T2DM group according to duration of the pathology; Dia1 (T2DM for less than 5 years), Dia2 (T2DM for 5 to10 years) and Dia3 (T2DM for more than10 years). Results showed significant differences between the groups. The Healthy group differed significantly from Dia2 in cardiovascular, endocrine, urogenital and immune systems and from Dia3 in all variables except cardiovascular system. Dia1 did not differ significantly from the healthy group, but differed from Dia2 for the immune system and from Dia3 for endocrine, locomotive, digestive, urogenital and immune systems. Dia2 differed significantly from Dia3 in locomotive and digestive system parameters (Sharma & Hankey, 2014).

3.4 DIABETES AND THERMAL IMAGING

The peripheral body temperature of patients with diabetics mellitus is lower due to reduced metabolic rate and significant endothelial dysfunction (Kenny et al., 2016). The other co-morbidity like dyslipidaemia, obesity and hypertension lead to peripheral vascular resistance and lesser perfusion to the extremities (Kenny et al., 2016; Yardley et al., 2013). The main causes of foot complications are ischemia and loss of sensation. Liquid thermography and infrared thermography have become popular in early detection of tissue damage helping to identify at-risk diabetes patients prone to develop foot ulceration. It is recommended that 5-year use of these techniques for regular self-examination can significantly reduce diabetic foot complications in high-risk patients with diabetes (Lavery et al., 2007). A study demonstrated abnormal temperatures patterns in feet and hands, notably on toes, metatarsal regions, fingers of persons with diabetes (Brånemark et al., 1967).

One study suggested that sweating disorder indicates early sympathetic damages in diabetics (Sun et al., 2006). Another differentiated asymptomatic neuropathy, symptomatic neuropathy and Charcot's arthropathy using contralateral normal limb. The neuropathic and Charcot's

arthropathic limbs demonstrated significant temperature changes and was very minimal in asymptomatic neuropathy (Armstrong et al., 1997). Bhagavathiappan et al. (2009) studied diabetics mellitus with vascular disorders and noticed that the temperatures in the affected limb are higher than the normal limb due to the sluggish circulation and stasis (Bagavathiappan et al., 2009). A recent study demonstrated IRT as an alternative to invasive blood extracting methods to screen and diagnose diabetic patients and drew correlations to HbA1c, lipid profile and blood pressure (Sivanandam et al., 2017). They found significant reduction in temperatures at inner canthi of the eyes, knees, tibial regions and forehead. The HbA1C levels negatively correlated with skin temperatures of forehead, inner canthi of eyes, neck region, tympanic region of the ear, carotid region, palms, knee, tibial region and positively correlated with age and blood pressure (Sivanandam et al., 2013). This study showed 90% sensitivity and 56% specificity in determining the undiagnosed diabetes mellitus with positive predictive value of 65%, negative predictive value of 85%, and accuracy of 73% (Sivanandam et al., 2012, 2013).

Bharara et all (2006) studied cold stress test in diabetics mellitus with neuropathy and demonstrated significant temperature differences in patients with diabetes mellitus with neuropathy when measured independently at all 3 sites tested (first metatarsal head (MTH), second MTH and heel. This clinical trial first time showed the evidence of poor rewarming times of the diabetic neuropathy foot (Bharara et al., 2006). The temperature deficit suggests potential degeneration of thermoreceptors leading to diminished hypothalamus mediated activity in the diabetic neuropathic group (Bharara et al., 2006).

Table 1: Controlled studies on yoga for Type 2 Diabetes Mellitus

SN	Author	Year	Sample	Design	Assessment	Intervention	Control	Results
1	Nagarathna et al.	2012	277 patients type 2 diabetics of both genders aged above 28 years	Prospective randomized controlled study	Fasting plasma glucose (FPG), post prandial plasma glucose (PPPG), HbA1c, blood pressure (BP), waist circumference, waist-hip ratio and BMI	Yoga based Life Style modification Program for 9 months (one hour/day 5 days /week)	Exercise based Life Style modification Program (one hour/day 5 days /week)	There was better reduction oral hypoglycaemic medication and increase in HDL in Yoga as compared to the control group. There was significant reduction within groups in FBG, PPBG, HbA1c, Triglycerides, VLDL and total cholesterol (Nagarathna et al., 2012)
2	McDermott et al.	2014	41 patients with type 2 diabetes mellitus	Randomized controlled pilot study	Weight, waist circumference, BMI, fasting blood glucose, postprandial blood glucose, insulin resistance	75-minute yoga intervention, six days a week for eight weeks	Monitored walking, 6 days per week for the same duration	Significant reduction in weight, waist circumference and BMI among yoga group compared to the control group (McDermott et al., 2014)..
3	Gordon et al.	2008	231 patients with T2DM without severe complications of the disease (Hatha Yoga group; 77, PT group; 77 and	Prospective randomized controlled trial	Fasting blood glucose, Serum total cholesterol, Triglycerides, LDL, VLDL, HDL, Oxidative stress indicators and oxidative status	Hatha yoga for 2 hours, once a week for 24 weeks	Physical training exercises (for PT group) for the same duration	FBG decreased significantly by 29.48% and 27.43% respectively in yoga group and conventional PT exercise group compared to a reduction of 7.48% in the control group Significant improvement on lipid profile, oxidative stress markers and

			control group; 77)					antioxidant status in yoga group (Gordon,et al. 2008).
4	Khatri et al.	2007	101 patients with T2DM (usual care; 46 and yoga intervention in addition to usual care; 55)	Randomized case control study	BMI, Waist circumference, Blood pressure, Fasting blood sugar, HbA1c, Serum triglyceride & HDL cholesterol	Three months of yoga intervention in addition to usual care	Usual care for three months	Waist circumference, Systolic blood pressure, Diastolic blood pressure, Fasting blood sugar, HbA1c and serum triglyceride decreased significantly, and serum HDL increased significantly in study group after 3 months (Khatri et al., 2007).
5	Skoro-Kondza et al.	2009	59 people with Type 2 diabetes not taking insulin (mean age; 60±10)	Randomized controlled trial	HbA1c, body mass index, waist-hip ratio, systolic and diastolic blood pressure, lipid levels, risk score, and scores on the psychometric instruments	90-minute yoga class, twice a week for 12 weeks	Encouragement for healthy lifestyle with exercise or the same duration	In the intervention group, HbA1c reduced slightly from 7.06 to 6.86 immediately after the intervention. HbA1c reduced from 7.03 to 6.95 in control group. None of these differences were statistically significant (Skoro-Kondza et al., 2009).
6	Amita et al.	2014	41 middle aged patients with type 2 diabetes mellitus	Randomized controlled trial	Fasting blood glucose and postprandial blood glucose	30-minute yoga-nidra daily for 90 days along with oral hypoglycaemic agents	Only oral hypoglycaemic agents or the same duration	significant reduction of fasting blood glucose and postprandial blood glucose levels the experimental group after 90 days of intervention (Amita et al., 2014).
7	Jyotsna et al.	2012	49 Patients having HbA1c between 6% and 9% for at least 3 months	Prospective randomized controlled trial	FBS, PPBS, HbA1c, electrocardiogram, ocular tension measurement, blood urea and serum creatinine	Sudarshan Kriya Yoga (SKY) for three months (1 hour every week at hospital visit,	Standard treatment for the same duration	There was a trend of improvement in glycaemic control in the yogic breathing group compared with standard treatment group. There was significant improvement in

			with lifestyle modification and oral antidiabetic medication			25-35 minutes every day at home)		physical, psychological variables in yogic breathing program as compared with the control (Jyotsna et al., 2012).
8	Shantakumari et al.	2012	100 patients with Type 2 diabetes and hypertension in the age group of 35 to 55 years	Randomized parallel trial	Fasting blood sugar (FBS), post prandial blood sugar (PPBS) and blood pressure levels	1 hour yoga intervention daily with oral hypoglycaemic drugs for 3 months	Only oral hypoglycaemic drugs for 3 months	Significant reduction in systolic blood pressure, diastolic blood pressure and fasting blood pressure in yoga group. Control group did not show any significant changes
9	Vaishali et al.	2012	60 elderly with more than 15 years of type 2 diabetes mellitus	Randomized controlled Trial	HbA1c, fasting glucose level, and serum lipid profile	Yogasana and pranayama, 6 days a week for 12 weeks.	Health education on maintaining a general healthy lifestyle	Significant improvement in HbA1c, Fasting glucose level, and serum lipid profile in Yoga group compared to Educational group (Vaishali et al., 2012).
10	Kerr et al.	2002	37 patients with poorly controlled diabetes (14 with type 1 diabetes)	Randomized control trial	HbA1c, Total cholesterol, Triglycerides, HDL, LDL, Cholesterol ratio, Blood Pressure, Weight, QOL, Pulse rate, daily insulin requirement & Quality of life.	90 minutes bi-weekly hatha yoga for 16 weeks (32 sessions)	simple exercises for the same duration	Insulin requirement in the yoga group remained same where as it got increased in the exercise group. Yoga could not improve the quality of life in subjects but it improved mood and well-being with greater effect compared to exercises (Kerr et al., 2002).
	Singh et al.	2008	60 patients with T2DM in the age range	Non-randomized	Weight, BMI, Fasting blood glucose, post	Yoga postures and pranayama for 45 minutes	Conventional medicines for	Yoga group showed significant decrease in weight, blood glucose, serum insulin

			of 35 to 60 years (30 in yoga group & 30 in group Yoga)	controlled study	prandial blood glucose, Lipid profile and Serum insulin levels	for 45 days along with conventional hypoglycaemic medicines	the same duration	and improvement in lipid profile. Control group showed increase in weight and non-significant improvement in other parameters (Singh et al., 2008).
11	Gordon Lorenzo et al.	2008	231 patients with T2DM without severe complications of the disease (Hatha Yoga group; 77, PT group; 77 and control group; 77)	Prospective randomized controlled trial	Weekly systolic and diastolic blood pressures, Body mass index (BMI), Weekly blood glucose, Serum creatinine, micro albuminuria and HbA1c (at baseline & every 3 months)	Hatha yoga for 2 hours, once a week for 24 weeks	Physical training exercises (for PT group) for the same duration	There was a significant reduction in the weekly blood glucose, systolic and diastolic blood pressures, HbA1c, and micro albuminuria in Hatha yoga and PT group compared to control group. PT group showed more clinical features of hypoglycaemia and hyperglycaemia when compare to the yoga group (Gordon et al., 2008).
12	Mahapure et al.	2008	40 patients with type 2 diabetes mellitus aged 40–55 years	Non-randomized controlled study	superoxide dismutase (SOD), HbA1c and fasting blood glucose levels	Yogic practices for an hour every day for 6 days a week for six weeks	Regular diet and anti-diabetic drug or the same duration	Significant changes were found between the groups and within groups. SOD levels improved, HbA1c and glucose levels decreased in yoga group compared to control group (Mahapure et al., 2008).
13	Kyizom et al.	2010	60 patients diagnosed as type 2 diabetes mellitus	Matched controlled study	Basal recordings of P300, Fasting blood glucose and postprandial blood glucose	yoga (asana and pranayama) intervention for 45 days	only conventional medical therapy	Significant improvement in the latency and the amplitude of N200, P300 in the yoga group as compared to the control group (Kyizom et al., 2010).

			(age range; 35-65 years)					
14	Hegde et al.	2011	123 type 2 diabetics aged between 40 and 75 years (60 for yoga and 63 for control)	Non-randomized controlled study	Malondialdehyde, reduced glutathione, superoxide dismutase, vitamin C & E, Oxidative stress, antioxidant status, BMI, waist-hip ratio, blood pressure, FBS, PPBS and HbA1c	Yoga intervention, 3 days per week for 3 months	General oral and written information about diet and exercise	Yoga group showed significant improvements in BMI, FBS, PPBS, HbA1c, malondialdehyde, glutathione, and vitamin C at 3 months compared with the controlled group (Hegde et al., 2011b).
15	Hegde et al.	2012	123 participants with type 2 diabetes, aged between 40 and 75 year	Non-randomized controlled study	Malondialdehyde, reduced glutathione, superoxide dismutase, vitamin C & E, oxidative stress, antioxidant status, FBS, PPBS, HbA1c, BP, waist-hip ratio and BMI	15 to 20 minutes Diaphragmatic breathing with standard care, twice a day, for 3 months	Only standard care for the same duration	Significant reduction in body mass index, waist-hip ratio, BMI, FBS, PPBS, HbA1c, malondialdehyde, superoxide dismutase and improvement in glutathione and vitamin C compared to standard care group (Hegde et al., 2012).
16	Beena & Sreekumaran	2013	143 elderly patients with type 2 diabetes mellitus in the age group of 60 to 70 years	Non-randomized controlled study	A1C, FBS, lipid profile, cortisol, ferritin, malondialdehyde (MDA) and catalase activity	Yoga intervention, 90 minutes every day for 3 months.	Daily activities such as walking and other non-specific exercises	There was significant decrease in FBS, HbA1c, lipids, cortisol, ferritin, MDA and significant increase in catalase activity after yogic practice (Beena & Sreekumaran, 2013)

Table 2: Yoga studies on Electro-photonic Imaging

S. N.	Author	Year	Design	Sample	Assessment	Intervention	Control	Results	Model of GDV
1	Kushwah et al.	2016	Randomized controlled trial	66 male managers, age ranges from 35 to 60 years (mean ± SD 53.97 ± 5.96) (Cyclic Meditation; 33, and Supine Rest; 33)	Electro-photonic imaging (EPI)	35 min of Cyclic Meditation (CM) session	35 min of Supine Rest (SR) session	IE Left was higher in SR group than CM group (1.79) after the intervention. CM group showed highly significant reduction in stress. IA Left and Right values increased in CM group. IE Right reduced in CM group. IA right and IE Left increased in SR group (Kushwah et al., 2016)	GDV Camera Pro
2	Kushwah et al.	2015	One group pre Post study	152 healthy volunteers, age ranging 18 to 60 years, both male and female, having Integral area value between –0.6 to +1	Electro-photonic imaging (EPI)	Residential Integrated Yoga Program (IYP) for four weeks. The program started daily at 4.30 am till 10.00 pm.	_____	There was significant reduction in AC after the intervention. Both Integral IALN and IARN Increased significantly after the intervention. Male had higher values than Female in following GDV parameters; IALN, IARN, IALW, and IARW (Kushwah et al., 2015).	GDV Camera Pro
3	Bhat, Mavathur & Srinivasan	2017	Pre Post design	37 patients suffering from diabetes mellitus	Electro-photonic imaging (EPI), FBS	Yoga based life style program for 7 days.	_____	Significant changes were found on Area, Form Coefficient, Entropy, liver, Pancreas, Coronary vessels,	GDV Camera Pro

				(mean age: 54.46 ± 7.21)				Cerebral vessels, Left kidney and Right kidney after seven days of intervention (Bhat et al., 2017).	
4	Sahoo & Balaram	1018	Two group pre-post design	21 healthy male volunteers in the age range of 18-30 years.	Electro-photonic imaging (EPI)	Series of eight yogic postures: each asana was held for a minute and there were 30 seconds of resting time after each posture.	Four relaxation postures were given for control session.	There were no significant changes after yoga practices in the experimental and control session. The activation coefficient, Integral Entropy, and Integral Area were compared to their baseline scores (Sahoo & Pradhan, 2015).	Not mentioned
4	Kumar et al.	2018	Randomized controlled trial & repeated measures study	61 volunteers (39 males and 22 females) with mean age of 22.1 years (29 volunteers in the Mudra group and 32 in the control group)	Electro-photonic imaging (EPI)	Prana Mudra practice for 5 min with closed eyes in sitting posture. In second part of the study, Mudra practice was for 10 min (M10) on the 1st day, 15 min (M15) on the 2nd day, and	The control group sat quietly with closed eyes for 5 minutes.	Results did not demonstrate any difference between groups adopting Mudra and sitting quietly with eyes closed for 5 min in the GDV variables. Significant differences were found between the effects of Mudra practiced for 10 min and 20 min in Average Intensity and Entropy (Kumar et al., 2018). .	Not mentioned

						20 min (M20) on the 3rd day.			
6	Sushrutha et al.	2012	One group repeated measures comparative study	18 (6 females, 12 males) healthy volunteers came from various countries	Electro-photonic imaging (EPI)	Saraswati Yajna for 70 minutes	The Yogasana session for 60 minutes	Significant reduction in Activation Coefficient, ($p = 0.021$) was seen after Yajnaa session but not in Yogasana session (Sushrutha et al., 2014).	Not mentioned
7	Sushrutha, Madappa, & Nagendra	2015	Repeated Measures Design	50 subjects (29 in the year 2013 and 21 in the year 2014), both male and female, age ranging from 20 to 40	Electro-photonic imaging (EPI)	Bhaishajya Maha Yajna continuously for 81 hours; the participants were assessed three times; at fixed intervals of 27 hours.	_____	The Area values of three measurements were statistically different in both 2013 and 2014 groups. Average Intensity values between three measurements were statistically different in 2013 and 2014 group. GDV variable Entropy did not show any changes in both groups (Sushrutha et al., 2014).	Not mentioned
8	Gayathri et al.	2018	Two group pre Post Design	60 students studying in grade 8, both genders; 30 in intervention group and 30 in control group	Electro-photonic imaging (EPI)	Integrated Yoga Module for Anger Management developed by Dr. Alaka	Control group attended regular classes and no other special	Significant decrease in Thyroid gland energy, Throat energy, Right ring nervous system and Right ring hypothalamus was found in Yoga group after the intervention. Significant	Bio-Well

						Mani TL for one month, 5 days a week, 40 minutes of each session.	activity was given to them.	increase in the values of thyroid gland, throat energy, endocrine system, hypothalamus, hypophysis, spleen and nervous system was found in control group after the one month (Gayathri et al., 2018).	
9	Deo et al.	2016	Cross Sectional study	184 Long Term Meditators (LTM; practiced Meditation for more than 60 months) and 248 Short Term Meditators (STM: practiced meditation from 6 months to less than 60 months)	Electro-photonic imaging (EPI)	_____	_____	Women had less AC value in LTM group as compared to women of STM. IERW value was more in LTM women than STM women. IALW, IANL, and IARN values were lower in women; IARW and IERN values were higher in women in comparison to men within LTM group. IALW value was lower in women in comparison to men within STM group (Deo et al., 2016)	GDV camera Pro

Abbreviations; IA: Integral Area, IE: Integral Entropy, IAL: Integral Area Left, IER: Integral Entropy Right, IEL: Integral Entropy Left, IAR: Integral Area Right, IALW: Integral Area Left with Filter, IALN: Integral Area Left without Filter, IARW: Integral Area Right with Filter, IARN: Integral Area Right without Filter, IELW: Integral Entropy Left with Filter, IELN: Integral Entropy Left without Filter, IERW: Integral Entropy Right with Filter, IERN: Integral Entropy Right without Filter, STM: Short Term Meditators, LTM: Long Term Meditators, NM: Naive