CHAPTER 5: DISCUSSION

The present study was designed to determine the effect of 6 months of yoga on physiological parameters, viz., anthropometric variables, body composition, blood pressure, and biochemical variables such as, serum lipid profile, and oxidative stress markers in overweight and obese adults. The major findings of this study are that yoga practice improved body weight, BMI, waist to hip ratio, fat mass, lipid profile, blood pressure and oxidative status in both overweight and obesity groups. Results also indicate that there are significant differences in the overweight and obesity groups in body weight, BMI, fat mass, body water, lean body mass, serum cholesterol, LDL-C and cholesterol to HDL-C ratio of both the genders. It also indicates that there is no significant difference in the results between the genders except in BMI, hip circumference, waist to hip ratio and fat mass in overweight and obese groups.

The most important results detailed in the previous section are discussed under four main categories of variables; anthropometric and body composition variables, blood pressure, lipid profile, and oxidative stress markers.

5.1 Anthropometric variables and body composition

The results of the present study show that following six months of yoga practice, BMI of male and female participants of both overweight and obese groups were significantly reduced. In the overweight group of subjects, out of 22 male participants who had BMI $\geq 23 \leq 24.9$ kg/m$^2$, after three months of yoga practice, the BMI of 14 subjects changed to normal category and 8 subjects retained their BMI within the overweight category. At the end of six months of yoga practice, all the overweight male subjects changed to normal BMI category. Of the 30 female overweight subjects who had BMI $\geq 23 \leq 24.9$ kg/m$^2$, after three months of yoga practice, 23 subjects changed to normal BMI category and 7 subjects retained their BMI within the overweight category. At the end of six months of yoga practice, BMI of all the female overweight subjects changed to normal category. This indicates 6 months of yogic intervention in male and female overweight study participants is highly effective in lowering BMI and achieving the desired results.

In the obese group, out of 41 male subjects, 18 subjects belonged to obese category - II with BMI $32.6 \pm 1.6$ kg/m$^2$ and 23 subjects belonged to obese category - I with BMI $27.8 \pm 1.7$
kg/m². After 3 months of yoga intervention due to a reduction in body weight, BMI of 4 participants changed to overweight category, 24 participants changed to obese-II category and 13 retained their BMI within obese category-I. At the end of six months of yoga practice, BMI of one subject changed to normal BMI category, 10 subjects changed to overweight category, 25 changed to obese-I category and only 5 of them were in obese category–II.

Out of 52 female obese subjects, 26 belonged to obese category - II with BMI 34.2 ± 3.2 kg/m² and 26 subjects belonged to obese category - I with BMI 27.5 ± 1.4 kg/m². After three months of yoga practice, BMI of 8 subjects changed to overweight category, 25 changed to obese-II category and 19 of them retained to obese category–I. At the end of six months of yoga practice, BMI of 3 subjects changed to normal BMI category, 14 subjects changed to overweight category, 13 changed to obese-I category and only 12 of them were in obese category–II.

The results of the present study show a significant reduction in body weight, BMI, waist to hip ratio and fat mass. Uncontrolled gain in body weight is found to be the major contributing factor for metabolic syndrome (186). It is a well-known fact that obesity is an established risk factor for CVD and type II diabetes mellitus (187). According to national weight management guidelines, reduction in body weight is very important in subjects who are either overweight or obese because a modest weight loss of 5 - 10% leads to significant improvement in cardio-metabolic risk factors (182). Results of the present study showed that by following six months of yoga practice 8.8% and 7.4% of body weight is reduced in male and female, overweight subjects, respectively. More marked reduction in body weight is seen in obese participants, i.e., 10.2% in male and 10.7% in female participants.

In the present study, the decrease in body weight observed after yoga training can be related to the highly significant (p<0.01) decrease in fat mass of overweight and obese male subjects and a significant reduction (p<0.05) seen in female participants of both the overweight and obese groups. Studies have shown that several pro-inflammatory factors are produced in adipose tissue with obesity, viz., TNF-α, IL-6, leptin, plasminogen activator inhibitor 1 visfatin, and angiotensin II (189,190). These factors are associated with obesity-related complications like insulin resistance, type 2 diabetes mellitus, non-alcoholic liver disease, and dyslipidaemia (190). Consistent with the present study findings, studies show that yoga practice is very useful in decreasing fat mass in obesity (26, 191). A study which used 8
weeks of resistance exercise training in obese adults showed a decrease in body weight and fat mass (192), and Benavides and Caballero, (2009), reported that Ashtanga yoga training for a period of 12 weeks significantly decreased body weight. Their study concluded that reduction in body weight and fat mass achieved may be related to an increase in BMR found in participants following yoga practice (193). Hence, the results of the present study and previous studies show that both, regular practice of yoga and conventional exercise programs (194,195) help to improve the body composition in obese adults. Therefore yoga may be an alternative option for increasing physical activity levels compared to conventional exercise training programs.

Results of the present study indicate that there is an increase in lean muscle in overweight and male obese subjects who follow yoga intervention. An earlier study has found that any intervention that increases lean mass can be an effective strategy for improving cardio respiratory fitness, especially among high-risk African Americans who are overweight and obese (196).

Even though, the results of the present study and earlier studies show the effectiveness of yoga in improving body weight and BMI, the mechanism underlying weight-related outcomes remains unclear. There are a number of theories which are proposed including increased energy expenditure, decreased pain, increased mindfulness and body awareness, and reduced stress after yoga practice (197). Following yoga practice, it is assumed that there is down-regulation of the Hypothalamic-Pituitary-Adrenal (HPA) axis. The slow and non-strenuous activities of yoga positively affect HPA axis response to stress and this is the main basis for the reduction in weight loss (198). In addition to that, yoga intervention in individuals with eating disorders show a significant reduction in eating disorder examination scores compared to baseline values and preoccupation with food immediately after yoga practice (199, 200).

Earlier studies have elucidated the role of leptin, a hunger inhibitory hormone, and adiponectin, a hormone which helps in the regulation of blood glucose level and break down of fatty acids, both secreted from adipose tissue in healthy individuals and obesity. The anti-inflammatory adiponectin increases insulin sensitivity and is inversely associated with obesity, whereas leptin, which is high, correlated with obesity, insulin resistance, and type 2 diabetes mellitus (201). A study which compared expert yoga practitioners with novices showed that the levels of leptin were 36% higher, and the levels of adiponectin were 28%
lower, in the novice group than in the expert group suggesting that long-term yoga practice can positively change the pattern of metabolism (202). BMI is more commonly used to differentiate obesity and overweight and to measure body composition, but the evidence suggests that the measures reflecting abdominal adiposity, waist circumference are better indicators of metabolic abnormalities and CVD (203). Obesity or overweight patients with high waist circumference are more associated with an increased risk for type 2 diabetes, dyslipidemia, hypertension, and CVD (1). Results of the present study show that yoga practice has a significant reduction in waist circumference. Therefore, yoga practice can be beneficial in overcoming the complications associated with obesity.

5.2 Blood pressure

Results of the present study indicate a significant reduction in systolic BP and diastolic BP after three and six months of yoga practice in overweight and obese participants of both genders. Earlier studies, with overweight and obese adults and other subjects with cardiovascular complications, show similar results using yoga as an intervention (204-206). It is a known fact that obesity alone or combination with other non-communicable diseases increases the risk of high blood pressure (207). Results of population studies indicate that at least two-thirds of the prevalence of hypertension can be directly attributed to obesity (208).

Studies show that there is a positive correlation between loss of body weight and the reduction in blood pressure, and has beneficial effects on the associated risk factors in obesity (209). An earlier study shows that even a modest reduction in body weight decreases the activity of renin-angiotensin-aldosterone systems in the circulation, which makes a major contribution to the blood pressure decrease. A weight loss of 5% is associated with the reduction of angiotensinogen levels by 27%, renin by 43%, aldosterone by 31%, angiotensin-converting enzyme activity by 12% and angiotensinogen expression by 20% in adipose tissue (210). Increased level of leptin found in obesity may be the cause for an increase in BP because the sympathetic nervous system is activated by leptin which increases the BP. Studies show that the practice of yoga is effective in reducing leptin level and may thereby combat changes in blood pressure associated with obesity (202).

The reduction in blood pressure found after yoga practice in the present study was consistent with the earlier studies (204-206). A study by Murugeshan, (2000), which compared the effect of yoga and drugs in 33 hypertensive subjects, aged 35-65 years, shows that yoga is
very effective in the reducing the variables of hypertension (204). The participants underwent yoga practice of 1 hour in the morning and in the evening for a total period of 11-weeks. Another study where the participants have practiced pranayama for 30 min/day and asanas for 30 min/day for three months has shown a significant reduction in diastolic blood pressure (DBP) and systolic blood pressure (SBP) (205). It is reported that reduction of blood pressure indicates a shift in the autonomic nervous system towards parasympathetic dominance. This modulation of autonomic nervous system activity may be brought about through the conditioning effect of yoga on autonomic functions mediated through the limbic system and higher areas of central nervous system following yoga practice (211, 212). Yet another study shows that regular practice of yoga may stimulate the baroreflex activity and decrease the sympathetic tone; thereby restoring BP to a normal level (213). Regular practice of yoga encourages one to relax, and thereby decreases the breath rate and helps to focus on the present, shifting the balance from sympathetic nervous system to parasympathetic system, thereby reducing the BP (214). Studies show that yogic practices like meditation and relaxation techniques bring about a state of bliss and pleasure by stimulating the pleasure centres in the forebrain and other parts of the brain and inhibiting the areas of the brain which trigger fear and aggressiveness. This inhibition results in lower anxiety, heart rate, and respiratory rate, and thus contributes to a reduction in blood pressure (214).

5.3 Lipid profile

Results of the present study indicate significant (p<0.01) improvement in various lipid profile parameters, viz, decrease in total cholesterol, LDL-C, TAG and increase in HDL-C in both overweight and obese adults through yoga practice. Several studies have confirmed that yoga training significantly increases HDL-C and decreases TAG, and LDL-C (215-217). A study on obese patients with hypertension shows a decrease in total cholesterol, VLDL, TAG and an increase in HDL-C after yoga training (218). The positive changes in lipid levels found in the present study can be attributed to the weight loss achieved following the practice of yoga. The improvement in serum lipids with the practice of yoga could be due to increased activity of enzymes required for hydrolysis of TAG of plasma lipoproteins, viz., hepatic lipase and lipoprotein lipase. This increases the uptake of TAG by adipose tissue and affect lipoprotein metabolism (219). Comparison of changes found in fat mass and LDL-C following yoga shows a positive association between those variables. In male overweight and obese participants, fat mass was significantly reduced along with significant reduction in
LDL-C. But in the case of female participants, reduction in fat mass was less, as compared to male participants, which also reflected similar changes in the LDL-C.

Results of the present study indicate that there is a significant decrease in the non-HDL-C level in overweight and obese subjects. Earlier studies have suggested that non-HDL-C may be a better predictor of CVD morbidity and mortality than LDL-C because it contains all the known lipid particles considered to be atherogenic, such as LDL-C, lipoprotein (a), IDL, VLDL (220, 221).

The present study results show a significant increase in HDL-C following yoga intervention which is also documented from the results of an earlier study (222). It is known that an increase in HDL-C is related to a decrease in the CVD and other complications with obesity (223, 224). Physical activity raises HDL levels and decreases the concentration of VLDL-C and TAG (225). The increase in HDL-C is seen in physical activity appears to be linked via HDL’s role in TAG metabolism (226).

5.4 Oxidative stress markers

In obese humans, adipose tissue is characterized by increased local and systemic production of pro-inflammatory adipocytokines (227), which induces the production of reactive oxygen species (ROS). Increased ROS alters the oxidative stress in adipose tissue, leading to important changes in adipose tissue that promote a systemic low-grade inflammatory response with undesirable changes throughout the body (228). The present study results showed a significant reduction in serum malondialdehyde level and improvement in the total antioxidant status. Earlier studies also show a reduction in oxidative stress in patients with diabetes mellitus (229-231) and end-stage renal disease following yoga practice (232). Yoga practice has show reduction of the fat mass in the adipose tissue, which by decreasing inflammation may decrease the synthesis of inflammatory mediators responsible for oxidative stress in obesity (233). The increase in total antioxidant status in the subjects of the present study may be attributed to either yoga, or the diet, or both. A study done on pre-diabetic patients with yoga alone, without modifying the diet has shows significant improvement in the antioxidant status in obese adults (234). The subjects of the study were asked to take a diet rich in fruits and vegetables. However, a number of studies have shown, that consuming less common fruits and vegetables contribute much more to the reduction of free-radical processes, most likely because they contain a large amount of non-vitamin antioxidants, such
as polyphenols and anthocyanins (235). Moreover, earlier studies showed increased expression of superoxide dismutase (SOD) following yoga, which may be contributed to enhance the total antioxidant status (233). Hence there is substantial scientific evidence to support for the beneficial effects of yoga in combating oxidative stress and therefore it may be an effective treatment option preventing the complications caused by oxidative stress in overweight and obese adults.

5.5 Comparison of effect of yoga practice in overweight and obesity with other lifestyle interventions

The review of scientific literature shows multiple lifestyle interventions for the control of weight gain, changes in lipid profile and altered state of oxidative stress are linked with overweight and obesity. The major lifestyle interventions include diet modification, exercise therapy, and yoga-based lifestyle. Pharmacotherapy may be added to a lifestyle program for subjects with a BMI of ≥30 kg/m² or ≥27 kg/m² with concomitant obesity-related diseases (131). Most of the studies use more than one type of lifestyle interventions in the control of overweight and obesity.

5.5.1 Comparison of efficacy of yoga with physical activity as lifestyle intervention

Lifestyle intervention in the form of physical activity, for the management of overweight and obesity, typically prescribe 150-180 min per week of aerobic activity, such as brisk walking or other types of moderate-intensity aerobic exercise (236). There are very few studies which compare the efficacy of yoga and exercise in the management of obesity, and they differ with respect to the yoga module and exercise regimen used. A study which compared the efficacy of low-intensity physical exercises with yoga practice has found significant decrease in the level of stress in the participants of, the yoga group than the participants of low-intensity physical exercise (237). Further a study which examined the effect of yoga practice with aerobic exercise has revealed an increased reduction in oxidative stress in participants of yoga than the aerobic exercise (238). Yet another study done exclusively on male participants (n=51) shows, yoga is more superior to exercise in reducing oxidative stress. Results of the study indicate an increase in the serum reduced glutathione of the yoga group (p<0.05) and
decrease in the exercise group, while the level of glutathione reductase increased significantly only in the exercise group (p<0.001), while total antioxidant status increased significantly in the yoga group (p<0.001) and decreased significantly in the exercise group (239). Physical activity alone, however, contributes minimally to weight loss in the short-term. Individuals who engage in high levels of physical activity in the absence of dietary restriction lose small amounts of weight. This is elucidated from the results of a study which compared the efficacy of calorie restriction alone with a combination of exercise and calorie restriction. The combination has shown only a marginal increase in weight loss after six months of intervention (240). Hence, the results of studies that analyzed the effect of yoga and exercise as lifestyle intervention for the management of overweight and obesity complications have shown yogic intervention may be better or as effective as exercise. But it warrants further studies to confirm the mechanisms of how they are effective in controlling the health-related outcome measures in overweight and obesity.

5.5.2 Comparison of efficacy of diet with physical activity as lifestyle intervention

Studies which have compared diet with exercise show calorie-restricted diet regimens almost always result in more weight loss than do exercise-alone treatments (241). Exercise treatments without a diet component typically result in a little or no weight loss, while calorie-restricted diets achieve reduction in baseline body weight of 5-10%. Studies which used an exercise regimen plus weight-loss diet have shown that a combination of exercise and diet restriction is better in reducing body fat and improving cardio-metabolic risk factors than exercise alone (242-244).

5.5.3 Comparison of efficacy of yoga with diet as lifestyle intervention

The obesity guidelines recommend that patients consume a diet designed to induce a deficit of 500-750 kcal/day and a loss of 0.5-1.0 kg/week. Accordingly, women often are prescribed a diet which provides 1200-1500 kcal/day and for men a 1500-1800 kcal/day (245). Most of the studies which used yoga as a lifestyle intervention also included modification in the diet. But yogic diet not only concentrated on the quantity and quality of food but also emphasized the effect of food on the mind. According to yoga, foods has been classified into three major types, i.e., Sattvic, rajasic and tamasic foods (71).
The *Sattvic* diet (pure and balanced) is believed to increase energy, produce happiness, calmness, and mental clarity. It could enhance longevity, health, and spirituality. According to Maha Narayana Upanishad (~5000 B.C.) it promotes a life expectancy of 100–150 years and it is recommended for “Saints”. All foods included in this diet are fresh, juicy, nutritious, and tasty, thus including the consumption of fresh fruits and vegetables, sprouted grains, roots, tubers, nuts, cow milk, curd, and honey. The *sattvic* dietary pattern appears to be similar to a modern but prudent dietary pattern (246).

The *rajasic* diet (over stimulating) is believed to produce jealousy, anger, unfaithfulness, fantasies, and selfishness. It is recommended to leaders and fighters since it may cause excitement, confidence and increase in intelligence. The foods in this diet are bitter, tart, salty, spicy, hot, and dry; they also include white sugar, radishes, and fried foods (247).

The *tamasic* diet (weakens and makes sleepy) is believed to increase pessimism, weakness, laziness, and doubt. This dietary pattern makes one dull, enhances anger and criminal tendency and impedes spiritual progress. The life expectancy is low, and it is bad for health. The foods in this diet include meats from big tamed animals, onions, mushrooms, stale, undercooked-and highly fried foods, high fat fried foods, salt, sugar, spices, chilies pepper, butter and liquor; medicines and stimulants are also included (247).

*Yoga* based lifestyle intervention is efficacious in weight-loss (248), and it also prevents weight-gain, especially amongst those who are overweight (249) just like exercise and calorie restriction diets. The ability to control the inflammation and stress associated with overweight and obesity makes *yoga*, a better lifestyle intervention compared to other forms of interventions. A study conducted to see the effect of *yoga* practice in obese postmenopausal women has documented reduction in IL-6, IL-8, and CRP, and increased adiponectin, showing *yoga* is effective in controlling inflammation associated with obesity (250). Yet another study conducted with obese menopausal women also provided substantial proof for the efficacy of *yoga* in obesity by improving adiponectin level (251). A study done with overweight and obese subjects with a chronic inflammatory disease with 10 days of short term *yoga* practice, which included asanas and pranayamas has shown a significant reduction in IL-6 and TNF-α level. Another study done with overweight and obese men has resulted in an increase of adiponectin, and decrease in IL-6 and hs-CRP (232). Previous studies showed that short and long term *yoga* interventions reduce anxiety and mood changes (252, 253). *Yoga* is known to induce relaxation via lowering of cortisol and increasing the levels of β-
endorphins and this results in lowered levels of cytokines, leading to a reduction of inflammation (232).

Hence, the present study suggests that in overweight and obese adults yoga with controlled diet help reduce body weight and prevent weight gain along with controlling lipid profile parameters and oxidative stress markers.