8. DISCUSSIONS


This study aimed to report the prevalence of PCOS in South Indian adolescents and to provide anthropometric and biochemical characteristics for all the phenotypes as there is not much information available in India. This survey on 460 adolescent girls between 15 to 18 years from a residential college in Anantapur, Andhra Pradesh, India has shown 9.13% prevalence of PCOS according to Rotterdam criteria, However by assuming that the girls who did not have an ultrasound had a similar prevalence of polycystic ovaries and including the imputed data, the total prevalence estimates increased to 10.97%. If compared with NIH criteria, out of 42 girls who had PCOS, 12 (2.61%) satisfied the NIH criteria. Hence it is important that the girls with above said symptom should be referred for ultrasound and blood tests to facilitate early identification.

8.1.1 Differences in prevalence of the three factors/components of PCOS

8.1.1.1 Oligo/Amenorrhea

In comparison with other studies that have used Rotterdam criteria, among 42 confirmed PCOS in our study, the prevalence of oligo/amenorrhea observed (97.62%) was similar to that found in the Srilankan population (95.1%) but much higher as compared to that found in South Australian population (23.8%). This indicates a higher prevalence of oligo/amenorrhea in the Asian scenario.

8.1.1.2 Hirsutism

The prevalence of hirsutism observed (30.95% with an mFG score of 6 or higher) was less than that found in the Srilankan population (53.1% with an mFG score of 8 or higher).
8.1.1.3 Polycystic Ovaries

In comparison to the Sri Lankan population (96.7% as presence of >12 follicles, 2-9mm in diameter, with increased ovarian volume of >10cm³) were seen to have Polycystic ovaries, present study observed higher (97.62% as presence of >10 cysts, 2-8mm in diameter, with increased ovarian volume of >10cm³, and an echo-dense stroma in pelvic ultrasound scan.) prevalence.

8.1.2 Comparisons of prevalence in other countries

Other studies on Asian population have reported lower prevalence rates: 6.3 percent in Sri Lankan population (Kumarapeli V, Seneviratne RD et al. 2008) and 2.4 percent in Chinese population (Chen X, Yang D et al. 2008). This higher prevalence in India as compared to other Asian countries could be expected as we know the strong etiological link between PCOS and diabetes, and India has a higher prevalence of diabetes.

The prevalence of 10.97 percent reported in our study is comparable to that reported by March et al. in an Australian population which showed a prevalence of 11.9 percent, (March AW, MooreVM et al. 2009) although there are small differences in the diagnostic criteria used in the two studies. Their inclusion for clinical examination was based on menstrual irregularity and/or self reported hirsutism of mF-G score ≥8. They defined menstrual irregularity as a cycle length of ≤21 days or ≥35 days, or ≥ a 4 day variation. Only those satisfying these criteria were invited for ultrasound of the ovaries and blood tests and the remaining women were considered to not have PCOS. In our study the inclusion was based on menstrual irregularity of ≥45 days and/or presence of hirsutism with an mFG score greater than 6. All of these girls were invited for pelvic ultrasound. Inclusion in the study based on the mF-G score is still debatable because determination of hirsutism using mF-G scale is subjective, with significant inter-observer variation and also it depends on the ethnicity of the
population. Only 5.65 percent of girls out of 460 girls screened in our study had clinical hyperandrogenism with a mF-G score ≥6.

The age groups studied in Chinese (20-45 years), South Australian (27-34 years) and Sri Lankan (15-39 years) populations had a wide age range while our study was restricted to adolescents with a narrow age range of 15-18 years. The lowest age limit for inclusion has been recognized as 15 years, since the mean age of menarche reported among Indian girls is 13.34 years (standard deviation 1.26) (Acharya A, Reddaiah V P et al. 2006) and 1.5 years after menarche is required to exclude the period of menstrual irregularity that usually follows menarche. (Chang RJ and Katz SE 1999) We also tried to minimize the selection bias of the participant in the study by recruiting the girls from one educational institution who had not sought medical help for any of these symptoms pointing to PCOS.

8.1.3 Conclusion of Study 1

India being the epicenter of diabetes it is important to diagnose young females for possible metabolic disorders. Studies show that Indian patients with PCOS have higher fasting insulin levels and greater IR compared to British and Australian white women with PCOS. (Norman RJ, Mahabeer S et al. 1995; Wijeyaratne CN, Balen AH et al. 2002) We now know that glucose intolerance and diabetes is common in young and asymptomatic PCOS females and especially in Asian population. (Weerakiet S, Srisombut C et al. 2001) Early recognition and treatment can avoid the long term health risks.

This is the first report on prevalence of PCOS in South Indian adolescents which is 9.13 percent in the age group of 15-18 years. The findings of this report may be used as normative data for future studies.
8.2 Part 2: RCT to evaluate the efficacy of IAYT in adolescent PCOS

This was a prospective, randomized, active interventional controlled trial on 90 girls (aged 15-18 years) with PCOS. This study compared the changes after 12 weeks of holistic yoga program with that of physical exercise program on Hormonal, Biochemical, Psychological and anthropometric variables. Mann-Whitney U test to compare difference scores showed that the changes in most of the variables were significantly different between the two intervention groups. Mean for difference scores showed that there were better improvements in yoga group as compared to the exercise group.

8.2.1 Hormonal Assessments

8.2.1.1 Anti-mullerian Hormone

The baselines mean AMH (6.01ng/ml) in our population was comparable to earlier observations that ranged from 3.3 to 15.3ng/ml. (Carlsen SM, Vanky E et al. 2009; Thomson RL, Buckley JD et al. 2009) in normal weight and obese adult PCOS. After 3 months of intervention, there was better reduction (p=0.006) in AMH levels after yoga (mean change= -2.51ng/ml) than physical exercise (-0.49ng/ml).

Piltonen et al (Piltonen T, Morin-Papunen L et al. 2005) studied the effect of Metformin on 26 adult PCOS and showed a significant (p=0.01) reduction (mean change 6.0) in AMH after 6 months of treatment. A well designed RCT by Carlsen et al (Carlsen SM, Vanky E et al. 2009) on 50 PCOS women undergoing 26 weeks of diet, lifestyle, Metformin and Androgen suppression by Dexamethasone showed no significant change in AMH levels and on the contrary observed an anomalous increase in AMH levels (12.6ng/ml to 14.1ng/ml) in the group who were given Dexamethasone. Thus a significant decrease in AMH after yoga in our study as compared to a non-significant change after 20 weeks of weight reduction program (Thomson RL, Buckley JD et al. 2009) or to an increase in AMH after Dexamethasone suppression therapy (Carlsen SM, Vanky E et al. 2009) is noteworthy. Thus,
it is interesting to note that yoga therapy for 3 months seems to offer better changes in AMH than physical exercises (our study and Thompson’s study) or Metformin therapy for 6 months or Dexamethasone suppression therapy for 3 months.

8.2.1.2 Gonadotropins

The baseline mean value for LH (9.7mIU/ml) and FSH (5.8mIU/ml) in our population was lower than a similar adolescent population of PCOS girls from Italy by V De Leo et al (Vincenzo De Leo, M.C.Musacchio et al. 2006) (LH = 12.1mIU/ml and FSH =3.85mIU/ml). The LH/FSH ratio was 1.96 in our study and 2.23 in their study. These differences between the study groups could be due to ethnicity, BMI and or the timing of hormonal assessment in relation to the menstrual cycle.

After 3 months of intervention, our study showed significant reduction in LH (Y: - 4.09 mIU/ml, E: 3.00 mIU/ml, p=0.005) and LH/FSH ratio (Y: - 1.17, E; 0.49, p= 0.015). This is similar to V De Leo’s study (Vincenzo De Leo, M.C.Musacchio et al. 2006) on the effect of Metformin for 6 months in obese PCOS teenage girls. Although these changes in Gonadotropins after yoga are significant and remarkable, it is difficult to arrive at a conclusion with certainty because of non uniformity in the timing of hormonal assessment in our population.

8.2.1.3 Testosterone

Although it is known that high Androgen level is one of the characteristic features in PCOS women, the baseline testosterone value in our study group was well within the normal range (< 82ng/dl). Since none of our girls had high testosterone there was no need to perform 17-OHP test (to exclude the possibility of Congenital Adrenal Hypertrophy) before inclusion in the study. Hoeger K et al (Hoeger K, Davidson K et al. 2008 November) observed similar values (<82ng/dl) of testosterone in obese adolescent PCOS girls in their study.
In the present study a 12 week yoga intervention showed significant (p=0.014) reduction in testosterone (-6.01ng/dl) as compared to another study on obese adolescent PCOS girls where significant reduction in the oral contraceptive group (-27.5ng/dl), and non-significant increase in the metformin (+1.9ng/dl) and lifestyle modification (+3.8ng/dl) groups were observed after 24 week (Hoeger K, Davidson K et al. 2008 November).

8.2.2 Biochemical Assessments

8.2.2.1 Fasting Blood Glucose

The baseline value for FBG was 4.24mmol/l in our population of adolescent PCOS girls which is similar to the 5.28mmol/l observed by Vigorito et al (Vigorito C, Giallauria F et al. 2007) in young PCOS girls. After 12 weeks of intervention, our study showed a highly significant reduction in yoga group (-0.24mmol/l) in comparison to the non-significant increase in exercise group (+0.04mmol/l). The non-significant change in exercise group is similar to the non-significant reduction (-0.061mmol/l) observed by Vigorito et al after 12 weeks of structured exercise training program for young PCOS girls (Vigorito C, Giallauria F et al. 2007).

8.2.2.2 Fasting Insulin & HOMA-IR

The baseline value for FI was 68.11pmol/l in our population of adolescent PCOS girls which was lower than 120.9pmol/l as observed by Vigorito et al (Vigorito C, Giallauria F et al. 2007) in young PCOS girls. Similar to the significant reduction seen after 12 weeks of structured exercise training program (-10.8pmol/l) as compared to the non-significant increase after no training (+1.2pmol/l) in Vigorito et al study, our study observed a significant reduction after 12 weeks of yoga (-9.04pmol/l) in comparison to the increase after exercise program (+11.09pmol/l).
In our study, the reduction in HOMA-IR values after 12 weeks of yoga intervention (-0.38) was significant as compared to the non-significant increase after exercise program (+0.29). This is comparable to the Vigorito et al study where reduction is observed after exercise training (-0.47) in comparison to the increase in non-exercise group (+0.05) (Vigorito C, Giallauria F et al. 2007).

It is interesting to note that our exercise group showed no reduction in FBG, FI and HOMA after exercise. We propose that this unexpected change after exercise could be due to the fact that the acute effect of exercise may have been washed off as the post blood sample was collected 5 days after concluding the intervention. This is supported by the observations by Mikines et al. on exercise detraining effect which showed that the training induced improvements in insulin sensitivity reduces significantly after 5 days of not doing any exercise (Mikines KJ, Farrell PA et al. 1988), and a study by Segal et al. (Segal KR, Edano A et al. 1991) who documented that aerobic exercise is not associated with improved insulin sensitivity after controlling for the effects of the last exercise bout.

8.2.2.3 Lipid Profile

The baseline mean values for lipid profile observed in our study are similar to earlier published studies on PCOS girls (Ibáñez L, Valls C et al. 2000; Fulghesu A, Magnini R et al. 2010). The reduction in triglycerides after 12 weeks of yoga intervention (-0.15) was significant as compared to the non-significant increase after 12 weeks of exercise training program (+0.55) on young PCOS girls by Vigorito et al (Vigorito C, Giallauria F et al. 2007). Similar to that total cholesterol values also reduced significantly after yoga practice (-0.24) as compared to the non-significant reduction after exercise training program (-0.11). Also, after yoga practice high density lipoprotein (+0.03) and low density lipoprotein (-0.21) values changed significantly in the present study as compared to the non-significant change (HDL: +0.08, LDL: -0.16) after exercise training program as observed by Vigorito et al (Vigorito C, Giallauria F et al. 2007).
8.2.3 Psychological Assessments

8.2.3.1 State & Trait Anxiety

Present study observed higher values for baseline state and trait anxiety as compared to Spielberger’s (Spielberger CD, Gorsuch RL et al. 1970) normative data on 377 high school juniors (190 males, 187 females) at Long Beach, New York, Senior High School. These American normal female students had a mean±sd of 37.57±11.76 with an α of 0.92 for A-State while in the present study mean±sd was 55.67±10.85. The mean±sd for A-Trait in their study was 41.61±11.29 with an α 0.92 while in present study mean±sd was 58.00±8.09.

The baseline scores in our study were higher than healthy Indian girls also; the A-trait score was 22.5±5.6 (our PCOS girls = 58.00±8.09) as reported by Deb et al (Sibnath Deb, Chatterjee P et al. 2010) in their study on 240 healthy adolescent girls from Kolkata city, West Bengal, India.

The changes in trait anxiety were significantly different between the two groups after 12 weeks of intervention, wherein yoga group (-14.97) observed a higher reduction than the exercise group (-7.57).

8.2.3.2 Perceived Stress

Mean Perceived Stress Scores for present study (24.95±5.88) is comparatively higher than those reported for African American adolescent females (23.33±6.98) with a mean age of 16.92 (Sweet E 2010 Jun).

After 12 weeks of intervention, our study showed a highly significant difference between the changes in two groups (p<0.001) with yoga group (-8.18) observing a high reduction in perceived stress as compared to the exercise group (-3.06). It may be considered evidence for the yoga intervention’s efficiency to reduce deep-rooted stress.
8.2.3.3  **Positive & Negative Emotions**

Watson et al (1988) studying a student sample from US reported PA as 33.3±7.2 and NA as 17.4±6.2 (Watson D, Clark LA et al. 1988) which is broadly consistent with the Crawford et al (2004) normative data for the non-clinical adult female population from UK (n=537), in which the mean for PA was 30.62±7.89 and NA was 16.68±6.37 (Crawford JR and Henry JD 2004), whereas present study observed a mean of 26.44±8.77 for PA and mean of 33.3±6.68 for NA which is higher than both the above normative values.

The above differences are perhaps not surprising given that our study population is adolescents with PCOS who are expected to be more stressed as compared to their healthy counterparts.

After 3 months of intervention, observed significantly different changes between the two groups (p=0.018) in negative affect with yoga group observing a higher reduction (-9.35) as compared to the exercise group (-4.28). Also, positive affect changed significantly between the two groups (p=0.002), wherein yoga group (+9.29) observed a greater increase than the exercise group (+3.37).

8.2.3.4  **PCOSQOL**

Present study observed higher values for weight domain although majority (84%) of the girls were within the normal range of BMI as compared to a study in United States by Ladson et al (Ladson G, Dodson WC et al. 2011) on PCOS adolescents (aged 13-18yrs) . Ladson et al enrolled girls with a BMI>27kg/m2 in comparison to the present study in which PCOS girls with a BMI>18.5 kg/m2 were included in the study.

This higher value for the weight domain in PCOSQOL appears to be due to the perception of our girls about their body weight image as this was a self administered questionnaire.
It is perhaps not surprising given that recent research points to measuring waist circumference (WC) and not just BMI as an important indicator. WC seems to be more directly proportional to total body fat and the amount of metabolically active visceral fat and therefore is a more accurate measure of metabolic risk. (Haslam D, Sattar N et al. 2006) Our girls did not show any change in their WC or WC/HC ratio in both groups. The scores on infertility domain were lower in our study as compared to Ladson et al (Ladson G, Dodson WC et al. 2011) study. Unlike other RCTs where subjects are recruited from hospital or medical colleges, subjects in our study were screened from a girl’s college. They were not previously diagnosed and hence they were not aware of the long term impact of PCOS, one of which being infertility. This might have skewed the responses on the infertility domain.

Although, scores for emotion domain, body hair domain and menstrual problem domain in our study were similar to the Ladson et al (Ladson G, Dodson WC et al. 2011) study.

After 3 months of intervention, the changes in all domains were significantly different between the two groups (p<0.05) except for infertility (p=0.879). Yoga group observed consistently greater effect in all domains except for infertility. It is unclear why participants in exercise group didn’t improve in comparison to the yoga group, possibly due to the calmness of mind achieved after the yoga practice as compared to practicing only physical movements. There are evidences proving efficacy of yoga in reducing stress arousal by modulating sympathetic nerve activity (Vempati RP and Telles S 2002) and reducing anxiety levels (Telles S, Gaur V et al. 2009 Dec). Also, the mental silence facilitates greater awareness by altering the individual's cognitive appraisal and perceived self-efficacy with regard to stressors and thus reduces anxiety symptoms (Smith JC 1986). The cognitive-behavioral effects are also known to result by achieving more clear perception, reduced negative emotions, and improved vitality and coping (Grossman P, Niemann L et al. 2004).
Practicing yoga as a means to manage and relieve both acute and chronic stress helps individuals overcome other co-morbidities associated with diseases and leads to increased quality of life (Michalsen A, Grossman P et al. 2005 Dec; Oken BS, Zajdel D et al. 2006). Another explanation could be the popularity and acceptance of yoga in Indian population.

8.2.4 Clinical Parameters

8.2.4.1 Menstrual Frequency

Our results on increased menstrual frequency noted in both yoga and control groups was comparable to that reported by Tang et al in their 6 months’ trial through Metformin and lifestyle modification (Tang T, Glanville J et al. 2006).

8.2.4.2 Hirsutism

There are differences of opinion by researchers from different parts of the globe on the definition of clinical hyperandrogenism based on mF-G scores which vary from 3-8. Based on a South Asian study by Chen et al (Chen X, Yang D et al. 2008) we have used a score of 6 - as the upper normal limit. Accordingly, only a small proportion (31.11 %) of girls had hirsutism. The reduction in mF-G scores in the yoga group was similar to the observation by Ganie et al after 12 weeks of Metformin therapy on 82 adolescent and young women with PCOS (Ashraf Ganie M, Khurana M L et al.).

8.2.5 Anthropometry

In our study population 84% were of normal weight (BMI=18.5 to ≤ 23) and did not show significant changes in their anthropometric parameters either after exercise or yoga. Largely, other exercise trials that showed a significant reduction in BMI and WHR were carried out on obese PCOS females. Earlier exercise trials also showed a positive association between reduction in FBG and FI levels with changes in BMI (Vigorito C, Giallauria F et al. 2007). It is interesting to note that our girls had significant reductions in FBG, FI and lipid profile
without significant change in weight, BMI or waist to hip ratio after yoga. This may point to other factors involved in producing the desirable results. This may be traceable to Hypothalamic-pituitary-adrenal axis (HPA) and sympatho-adrenal pathways (Stener-Victorin E, Ploj K et al. 2005 Sep).

8.2.6 Distinct features of the present study

The current study is distinct from earlier existing literature in many ways.

1. **Prevalence estimates**: First study ever providing an estimate of PCOS prevalence in India.

2. **Sample size**: The previous studies had lower sample size compared to current study.

3. **Duration of Intervention**: Previous studies were of longer duration than current study.

4. **Yoga as an intervention**: Different studies have used diet or exercise as an intervention primarily focusing only on weight loss. IAYT intervention based on *Panca Kośa* concept from the traditional yoga texts was the uniqueness of the present study. IAYT has a holistic approach with multidimensional interventions at physical, mental, emotional, intellectual and spiritual levels in keeping with the WHO definition of health.

5. **Duration of practices**: unlike most of the previous studies where dietary modules or exercise modules were provided to take home and visit to investigator was only for follow up, present study was able to monitor the participation as the intervention was provided in the college premise as part of the student’s daily routine activity.

6. **Monitoring**: The daily progress was monitored by a team of well-trained yoga therapists, and counselors.

7. **Lifestyle**: Their lifestyle including simple vegetarian wholesome diet as per their calorie requirement, non smoking, and regular hours of sleep (early to bed and early to rise) etc was easy to ensure as both the groups were students of a residential college.
8. **Objective Outcomes**: This is the first study that has looked at the effect of yoga on hormonal and biochemical profile of PCOS adolescents in an RCT with significant results.

The difference in these remarkable observations of the present study as compared to earlier ones seems to be because of:

a) Daily actively supervised practice as compared to take home modules or follow up supervision of the interventions.

b) Holistic approach: The integrated yoga module used in this study included āsanas, prāṇāyāma, meditation, deep relaxation, chanting and personalized counseling sessions thus taking in consideration not just the physical need for weight loss but also involving the components for emotional intellectual and spiritual needs.

It appears from these that the cumulative effect of intensive daily practices are more effective than single target oriented modules which may not be as effective.

### 8.3 Mechanisms

#### 8.3.1 Annamaya Kośa Mechanisms

**8.3.1.1 Exercise effect**

It is known that physical exercise has an important role in adolescent PCOS. Studies on exercise and nutritional counseling as interventions have demonstrated significant decrease in fasting insulin and tendency towards normalizing hormone values in the absence of significant weight loss. These observations suggested that changes in body composition, specifically a decrease in body fatness, independent of change in body weight, may be beneficial in reducing metabolic abnormalities associated with obese PCOS, emphasizing on continuing positive lifestyle modification on a long term basis (Bruner B, Chad K et al. 2006).
Similar or better effects on hormonal and biochemical variables, independent of changes in body weight or waist hip ratio, was observed in the present study after 3 months of yoga practice. This observation points to mechanisms other than just reduction of adiposity. Literature suggest that apart from the psychological components that could be the major contribution of yoga, the stretching and strengthening of muscles would have improved the feeling of well being (Oken BS, Zajdel D et al. 2006).

8.3.1.2 Rest effect

According to yoga, relaxation is the healer for all ādhiya-vyādhi. Yoga postures, though appearing to be similar to physical exercises, have several fundamental differences. Yogāsanas (physical practices) bring about muscle stretches that are maintained with ease and effortlessness.

| Sthirasukhamāsanam || pa yo sū | 2 | 46 |
|----------------------|-----------------|
| The posture should be steady and comfortable.

Sage Patanjali recommends two clear instructions to be followed while practicing āsana in order to achieve the main goal, which is the mastery over the modifications of the mind.

1. Conscious relaxation of the stretch (prayatna śaithilya) and a
2. Feeling of unlimited expansion (anantasamāpatti)

| Prayatnaśaithilyānantasamāpattibhyām || pa yo sū | 2 | 47 |
|-------------------------------------|-----------------|
| Prayatnaśaithilyānantasamāpattibhyām || pa yo sū | 2 | 47 |
| Tato dvandvānabhīghātāḥ || pa yo sū | 2 | 48 |
| It results in relaxation of effort and the meeting with the infinite. From then on, there are no botherations from the dualities like happiness and distress, heat and cold. |
Thus yoga postures offer voluntary introspective relaxation of the parts that are stretched and they are not just isometric exercises.

The conscious effortlessness and relaxation in the muscles that are stretched may change the basic muscle tone that results in lower Basal metabolic rate (BMR). Chaya et al (2006) showed that the BMR was significantly lower in senior yoga practitioners than their age, sex and BMI matched controls.

8.3.1.3 Balancing effect

According to yoga texts, balance between exercise and relaxation is very essential for healing. Stretch and relax while in complete awareness is a technique to develop mastery over local cellular functions. This is achieved in all āsanas as it emphasizes on alternation between prayatna (effort) and prayatna shaithilya (effortlessness). This when done with internalized awareness brings about mastery.

8.3.1.4 Detoxification

Oxidative stress measures are talked of as tissue toxins (āma) according to yoga and āyurveda (Narasimhan S 2012). These systems of medicine recommend several techniques called kriyas for cleansing these endotoxins. Amongst these kriyas, kapalabhati was practiced.
as part of the yoga intervention in this study. Oxidative stress has been implicated, as the root cause underlying the development of insulin resistance (Hegde SV, Adhikari P et al. 2011). It was observed that oxidative stress reduced in yoga practitioners while aerobic exercise and resistance training increased these parameters (Laaksonen DE, Atalay M et al. 1996; LL 1999).

**Figure 41: Mechanisms of action in PCOS**

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<tr>
<th>Table 42: Practices at annamaya kośa</th>
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<tr>
<td><strong>Annamaya Kośa</strong></td>
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<td><strong>Suryanamaskāra</strong></td>
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<td><strong>Āsana</strong></td>
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8.3.2 Prāṇamaya Kośa Mechanisms

Prāṇa is the subtle vital-energy that orchestrates all cellular functions of a living body. A healthy homeostatic physiology of the body is kept up by a steady and balanced supply which increases or decreases based on demand driven dynamic mechanisms. A breakdown of these mechanisms leads to ill health, primarily caused due to lack of mastery over the prāṇa flow to tissues. This is a result of disorganized release of prāṇa and results in blockages in the energy channels (nāḍīs) in which they flow. This phenomenon, in turn, is an outcome of a high demand from the mind (manomaya kośa). This high demand is created because the mind is stuck in uncontrolled speed due to habituated, negative, emotional suppressions and responses. Since the physiological functions are a manifestation of prāṇa, the imbalance in prāṇa, would reflect as hormonal or biochemical dysregulation in the body in the case of PCOS.

The etiology of PCOS is unknown, likely reflecting multiple pathophysiological mechanisms. It appears that multiple models may be needed, depending on whether the goal is to investigate ovarian morphology or a particular PCOS-related disorder to explain the pathophysiology of PCOS (Szukiewicz D and Uilenbroek JTJ 1998).

One model of PCOS posits that the feedback loop between the hypothalamus, pituitary and the ovary is disturbed (HPO axis). Dysregulation of the HPO axis leads to increased luteinizing hormone (LH) production and, consequently, to increased ovarian androgen production.(Abbott DH, Barnett DK et al. 2005) Also, excessive production of Anti Mullarian Hormone (AMH), which inhibits FSH-induced aromatase activity in human granulosa cells, may contribute to the characteristic high androgen levels.(Franks S 1995)

Insulin, released from the pancreas, affects circulating androgen levels. High insulin levels decrease circulates levels of sex hormone binding globulin (SHBG), (Plymate SR, Matej LA et al. 1988) resulting in increased levels of circulating androgens. This is responsible for the symptoms of hypergonadism in PCOS. The fasting insulin levels correlate
positively with androgen levels, and some studies have shown that hyperandrogenism causes insulin resistance in humans (Polderman KH, Gooren LJ et al. 1994) and in rats (Holmäng A, Svedberg J et al. 1990).

Another model suggests that abnormalities detected in PCOS have been attributed to primary defects in the hypothalamic-pituitary-adrenal (HPA) axis, the adrenal gland, and the insulin/insulin-like growth factor (Tsilchorozidou T, Overton C et al. 2004) enhances sympathetic-adrenal medulla (SAM) activity (Reaven GM, Lithell H et al. 1996). Thus an exaggerated stress response mediated by the SAM and HPA axes has been implicated. Activation of the HPA axis increases the secretion of adrenocorticotropic hormone (ACTH) and leads to glucocorticoid release from the adrenal cortex. The HPA axis and intra-adrenal mechanisms involving the adrenal medulla might also regulate adrenocortical steroid genesis.

Yoga proposes a model of prāṇa imbalance that is to be understood in the light of the concepts portrayed by the introspective masters. Using several scriptural references and personal discussions with the expert yoga practitioners, we propose the following models of prāṇa imbalance. We used this model to prepare the yoga techniques designed for this study.

According to yoga, these imbalances are caused by abnormal prāṇa channels which are used by the five divisions of prāṇa. PCOS has distinct prāṇa related imbalances which are identified based on the presenting symptoms and other diagnostic data available. Oligo/amenorrhoa may be considered as deficient flow of apāṇa prāṇa (downward functions); Excessive balding or acne reflects excessive mukha prāṇa; central obesity as dysfunctional samāna; excessive body hair and acanthosis nigricans as too much vyāna.

Correcting the imbalances by reducing the excess prāṇa through manāḥ praśamana and prāṇa praśamana is the trick.
When in that location, there is one continuous threadlike flow of one’s instinctive interest that is the effortless linking of the attention to a higher concentration force or person. Once this is accomplished, breath regulation, which is the separation of the flow of inhalation and exhalation, is attained.

This is not only possible through breathing but is also possible by focusing the mind on the stretched part of the body during āsana practice.

Internal Awareness and focusing (dhāraṇa) followed by relaxation (prayatna šaithilya) in the part that is stretched helps in releasing the blocks and restoring free flow of prāṇa (yoga vasiṣṭha). Based on this understanding the sequence of the āsanas performed with intense awareness of stretched parts was designed.

Also described in the yogic literature “Swarā Yoga” (Muktibodhananda 2009) there are two major energy channels (right = pingala or sun and left = ida or moon) through which the prāṇa has to be drawn for all physiological functions. When there is a need for heightened activity (e.g. stress response) the prāṇa rushes through the right and when there are restful basal functions it flows through the left. It is believed that when there is perfect harmony in healthy persons there will be a balance in the functioning of the right (sūrya) and left (chandra) nādiis reflected as nasal dominance on the corresponding side.
This can be perceived as dominance of the right or the left nostril breathing. Several studies on uni-nostril breathing prāṇāyāma provide support to these (Telles S, Nagarathna R et al. 1996). In 24 hours interval, nostril dominance is equally distributed between right and left when the individual is healthy (Dahiya R 2003). Nostril dominance as a characteristic of changing every 2-6 hours and illness results when this ultradian rhythm is disturbed. This could be used as a physiological diagnostic measure of health and illness. Studies have shown that the right nostril breathing prāṇāyāma called sūrya anuloma viloma corresponds to sympathetic dominance (Telles S, Nagarathna R et al. 1996) and increases metabolic rate. It has been proven that sūrya anuloma viloma can alter your metabolic rate which can be used for therapeutic purposes such as weight loss (Telles S, Nagarathna R et al. 1994 Apr). Based on these observations the imbalance that occurs in PCOS can be hypothesized as being a dominance of chandra nāḍi. Hence we advised the restoration of balance between the two nāḍis by practice of sūrya anuloma viloma and alternate nostril breathing (nāḍi śodhana) as had been included in our study, as part of the yoga intervention for PCOS.

<table>
<thead>
<tr>
<th>Prāṇāyama Koça</th>
<th>Kriyās</th>
<th>Development of deep internal awareness Titiksha – stamina building</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prāṇāyama Koça</td>
<td></td>
<td>Regulate the breath Remove the random agitations in Pranic flows</td>
</tr>
</tbody>
</table>

### Table 43: Prāṇamaya kośa practices

#### 8.3.3 Manomaya Kośa Mechanisms – Psychological Management

We have seen in chapter 2 that according to yoga, the problem of PCOS, a mind body disease, begins as an imbalance in manomaya kośa (Figure 42) between heightened arousal
and restful state of mind. Excessive uncontrolled speed of the mind causes these heightened state of arousal. Yoga as therapy brings about a reversal of *prasava* pathway by shifting the awareness from the physical body (*annamaya kośa*) to finally reach bliss (*ānandamaya kośa*).

**Figure 42: Mechanisms in Manomaya Kośa**
This is achieved by a systematic process that passes through prāņa, involves the mind, and corrects the intellect by several practices at each level. The manomaya kośa practices include practice of dhāraṇa (focusing), dhyāna (effortless focus) and bhakti (emotion culture).

Dhāraṇa trains the mind to focus intensely without any distractions on a single spot. This evolves into dhyāna wherein the focus becomes effortless. This helps in providing deep rest through slowing down the rate of flow of thoughts in the mind (Telles S, Nagarathna R et al. 1995). This phenomenon of slowing down and resting the mind provides a congenial environment for healing from within. On the contrary, negative emotions (stress) form the root cause of disease resulting in problems of hormonal and biochemical abnormalities. We used ‘Om Meditation’ (Nagarathana R and Nagendra HR 2001) as part of the intervention in this study in order to introduce the girls to the experience of effortless focused healing. The reduction in stress (PSS scores), anxiety (STAI) and negative affect (PANAS) noted in our study supports this effect.

The feedback received through interactions provided interesting inputs. One girl expressed her requirement of far less sleep and increased ability to divert the gained time to studies as a result of these yoga sessions and the calm and relaxation it provided. Another opined that examination anxiety reduced considerably and was reflected by her parents noticing that she had become more cheerful.

Thomson RL (Thomson RL, Buckley JD et al. 2009) studying the effect of a 20 week randomized controlled trial in three groups with diet only, diet and aerobic exercise or diet and combined aerobic-resistance exercise concluded that exercise provided no additional improvement in depression or HRQOL to that seen with diet alone. Further studies are required to determine whether the observed effects are attributable to the achievement of weight loss or to involvement in an intensive, clinically supported lifestyle modification.
program. Our study supports the above findings as there is an improvement observed in stress, anxiety and quality of life without a weight loss.

Unlike previous studies that used non-pharmacological interventions with focus on weight reduction, the present study for the first time incorporated a yogic lifestyle change, with focus on restoration of mind and body balance, as an intervention for PCOS. Therefore, better changes observed in the yoga lifestyle group seem to be a result of the component of direct mind (stress) management. These components included Om meditation, deep relaxation technique, yoga hymns for emotional culturing and yoga counseling as techniques of direct mind mastery.

Studies on different types of meditation have consistently shown increased mental alertness even while being physiologically relaxed. Om meditation and cyclic meditation have shown reduced oxygen consumption suggesting psycho-physiological rest in a previous study. (Telles S, Nagarathna R et al. 1995) In the present study also, Om meditation that was used, showed concurrent effects. This suggests that the consolidated effects of physical activity, breathing and meditation bring about better mental alertness even while being physiologically relaxed. This expresses as reduced anxiety and depression amongst individuals with infirmity. (Telles S, Nagarathna R et al. 1995) Anxiety and depression, prevalent in individuals with PCOS also decreased by the practice of yoga as shown by the present study.

8.3.4 **Manomaya Kośa Mechanisms – Emotions Management**

Demanding situations that are perceived by the individual invoke emotional responses. This happens through a phase when perceived information starts to build up speed and repetitiveness. This habituated emotional response that is intrusive, is either expressed or suppressed. The key attribute of such a response is the lack in mastery or awareness of how the response is building up. Mastery over emotions happens by yoga techniques like chanting hymns and counseling that provide an opportunity to recognize the speed and consciously
slow it down in order to remove the repetitive intrusiveness. By this, emotional expression or suppression happens in a controlled manner with awareness such that it does not form ādhi and further does not percolate as vyādhi. This is called mastery over the emotions.

Studies on yoga have shown reduction in negative affect in healthy volunteers after yoga as a lifestyle (Narasimhan L, Nagarathna R et al. 2011) and stress reduction intervention has shown to decrease negative affect in diseased patients (West J, Otte C et al. 2004; Danhauer SC, Tooze JA et al. 2008). This change in affect could have contributed to improvement in quality of life concerns in these patients.

<table>
<thead>
<tr>
<th>Table 44: Manomaya kośa practices</th>
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<tbody>
<tr>
<td>Manas</td>
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<tr>
<td>Dhyāna</td>
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<td>Bhakti</td>
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8.3.5 Vijñānamaya kośa Mechanisms

Vijñanamaya kośa is characterized by correct information that directs the mind and the body towards right actions. In the present study, the girls were educated regarding PCOS and provided sessions for clarifying their doubts. Such techniques paved the way to replace wrong notions with right information by correcting cognition and influencing behavior.

Regular interaction sessions by the therapists and involving all girls, at the end of each week were organized. The prime objectives of these sessions were to find out the sources of their stress and suggest generic solutions. Apart from this, time was provided for girls to approach the therapists individually in order to clarify more subjective issues. Care was taken to avoid references to yoga based suggested to the physical therapy group and to emphasize scriptural concepts for the yoga group. These scriptural suggestions included popular concepts
like happiness analyses, knowledge of the panca kośa, historical anecdotes that demonstrate correct understanding and moral behavior were introduced in a manner that were relevant and interesting to the age and ethnicity of the girls in this study.

The science of yoga and vedānta (Nagarathana R and Nagendra HR 2001) has a systematic methodology to train a person to be established in the experiential knowledge of one’s true nature which is a state of unchanging state of bliss (satcidānanda). This is the major cognitive behavioral change that makes the participant stable under all demanding situations (samatvam) that manifests as improved quality of life.

A small pilot study by Rofey et al (Rofey DL, Szigethy EM et al. 2009) studying the effect of CBT for physical and emotional disturbances in adolescents with PCOS, concluded that a manual-based CBT approach to treat depression in adolescents with PCOS and obesity appears to be promising.

8.3.6 Ānandamaya Kośa Mechanisms – balance and rest

The ānandamaya kośa comprises of the state of happiness and bliss. All activities that individuals do are directed towards achieving happiness. When this desire for happiness is coalesced with correct knowledge, proper mental balance and emotional culturing, regulated energy flow within a fit and supple body, all activities are efficient and provide joy to the individual.

This unison is achieved by inculcating concepts of ananda into all yoga techniques in all the previous kośas. During āsanas it is suggested that the final posture be maintained and the stretch observed and relaxed (ananta samāpati); during prāṇāyāma sessions slowness and relaxation with special attention on the kevala kumbhaka (passive cessation of breath) is emphasized; in Om meditation sessions and DRT session the mental emptiness and visualization are suggested; while notional correction, the logical analyses of happiness leads
one to relearn its nature and methods of reaching it. These have all been practiced as part of the yoga intervention in the present study and have shown to affect the joy that the PCOS individuals experience. Being aware that happiness lies within oneself and experiencing it can be seen as a change in their positive attitude towards their surroundings. Hence, an increase in the positive emotions (affect) could indicate that the individuals who participated in the yoga intervention were happier.

In conclusion a yoga based lifestyle is a comprehensive method to develop awareness, remove ill health and transition towards positive health at physical, mental, emotional, social, intellectual and spiritual levels. The etiopathogenesis of PCOS originates as wrong notions spiraled into a repetitive, uncontrolled intrusive speed which percolates through the astral body as improper flow in the vital energy levels, ultimately leading to physiological and physical manifestations. Hence corrections at all these stages through a yoga based lifestyle are necessary so that syndromes like PCOS can be cured completely as opposed to symptomatic and pathological relief offered by modern medicine. Yoga achieves this by setting right incorrect notional constructs in the intellect, bringing mastery over the mental speed and emotions, balancing the flow of vital energies and providing stimulation and relaxation to the body in order to instill alert rest. The mechanisms suggested above are combined and presented in Figure 43. Here, we see that the integrated approach of yoga therapy has many techniques that that correct the imbalances at various levels of existence that would have contributed to a holistic correction of both the basic and the manifest imbalances found in PCOS.
Figure 43: Etiology of PCOS and mechanisms by which yoga reverses it.