

---

## Summary and Conclusion

The presence of visceral fat among obese individuals differs depending upon the amount of fat distributed in the abdominal region resulting in metabolic disturbances. The visceral adipose tissue (VAT) is a metabolically active organ, and intra-abdominal obesity is an independent risk factor for the metabolic alterations associated with cardiovascular diseases (CVD) and Type II diabetes mellitus in adults. Among Asian Indians, the fat accumulated can be identified even at lower body mass index as visceral adiposity that leads to dyslipidemia. Visceral Adiposity Index (VAI) and Lipid Accumulation Product (LAP) are becoming novel health assessment indexes and potent markers for stratifying adults for obesity phenotypes. The clinical detection of visceral fat has become increasingly important by deriving the cut-off value for visceral adiposity indices. An early-stage intervention like lifestyle changes and an increase in the prevalence of visceral adiposity affects young women of reproductive age by increasing the risk of further complications. Hence this study was taken with objectives to study the prevalence of obesity, assess and associate visceral adiposity indices to insulin resistance, derive the cut-off value of visceral adiposity indices, associate the dietary and physical activity and evaluate the impact of the intervention on visceral adiposity indices.

The methodology of the study was carried out in four phases.

In Phase I, the prevalence of obesity was studied among 960 purposively selected adult women between 18-30 years of age in Avinashilingam Institute for Home Science and Higher Education for Women and Karuna's Women Clinic, depending on inclusion and exclusion criteria. Due ethical clearance was procured from the Institution. The sample size was calculated, and details on background information like age, education, occupation, income and marital status were elicited for 960 adult women.

In Phase II, to study the prevalence of obesity among 960 adult women, anthropometric measurements, namely height, weight, waist and hip circumference, were measured through standardized techniques and BMI, WHR and WHtR were calculated. From the phase I results, of 960 women, the prevalence of obesity was 25.9 percent (249). One sixty obese women were taken as the experimental group and 160 normal women were selected as the control group for further study. Obese women aged 20 – 30 years, BMI >24.9 and willing to participate in the study were included as experimental group and overweight normal and underweight women were excluded. Adult women of the same age group with a normal BMI range between 18.5 – 22.9 were included as the control group and overweight and obese women were excluded.

The biochemical parameters like lipid profile (total cholesterol, triglycerides, high-density lipoprotein and low-density lipoprotein), fasting blood glucose, and insulin was estimated to calculate the visceral adiposity indices like Visceral Adiposity Index (VAI) and Lipid Accumulation Product (LAP). Insulin resistance was calculated by Homeostatic Model Assessment of Insulin Resistance (HOMA-IR), and blood pressure was also assessed for 160 experimental and 160 control groups (360 adult women).

In phase III, the dietary intake was elicited from experimental and control to study the role of dietary habits, frequency of meal consumption and mean nutrient intake. The nutrient intake was assessed by the 24-hour recall method, and it was compared with Recommended Dietary Allowance (RDA), National Institute of Nutrition (NIN). The physical activity was assessed by International Physical Activity Questionnaire (IPAQ) - Short Form (2004). The IPAQ-SF records the last 7-day recall for four intensity levels of physical activity: vigorous-intensity activity, moderate-intensity activity, walking and sitting.

The anthropogens were assessed for diet, physical activity, smoking, alcohol, sleep pattern and sun exposure for high and low risk among both the groups. The 'diet' anthropogen was evaluated and compared by the RDA value. The high risk was termed to adult women whose consumption was more than or equal to 100 kcal of energy intake and 10 grams of carbohydrate and fat excess

to RDA values, particularly of higher energy-dense, but low nutrient-dense products like excess processed foods, high glycemic index foods, saturated/trans fats, sugars, salt, sugared soft drinks and processed/red meat. On the other hand, less than 100 kcal of energy intake and 10 grams of carbohydrate and fat deficit to RDA values, intake of fruit/ vegetables, adequate dietary fibre, whole grains and healthy eating patterns were termed low risk. The physical activity was assessed by the IPAQ levels by which the physical activity status was determined. Physically active was taken as low risk, and physically inactive like longer sitting/ sedentary work was taken as high risk. The sleep hours were calculated, and above and below 8 hours of sleep was termed as high risk.

In phase IV, the impact of the intervention on adiposity indices among the experimental group. Obese women of 18-30 years of age, willing to participate and whose VAI and LAP were greater than 1.7 and 14.2 respectively, were included in the intervention study. The exclusion criteria were not willing to participate; the intervention study excluded differently-abled, insulin resistant, pregnant and unhealthy women.

Among 160 experimental women, 40 whose VAI >1.70 to 2.30 and LAP >14.02 to 23.00 were selected for experimental group I (diet intervention), 40 whose VAI >2.40 to 2.70 and LAP >24.00 to 37.00 in experimental group II (physical activity intervention) and 40 whose VAI >2.80 to 9.30 and LAP >38.00 to 65.80 were in experimental group III (diet and physical activity intervention). A control group (obese) of 40 experimental women whose VAI >1.70 and LAP >14.02 represented from each group were selected. The intervention phase was carried out for 90 days.

The pre-intervention phase included the prior consent before the onset of the intervention study period. The data was recorded using pre-evaluated Google forms to re-assess the weight, dietary habits and physical activity pattern to check whether there was any difference compared to the initial data collected. Before the intervention, a general health education session was carried out for adult women. The session lasted about 20-30 minutes through educational tools like

PowerPoint presentations. The adult women were educated on basic nutrition principles, basic food groups, good eating practices, food hygiene and the importance of good nutrition was educated and stressed among the adult women.

Diet Intervention included cycle menus which involved formulating three diet plans. Depending on the VAI and LAP values, the experimental group I women were recommended the calories based on the RDA and energy was reduced as 500 kcal for VAI 2.14 to 2.30 and LAP 19.03 to 23.00, 300 kcal for VAI 1.94 to 2.13 and LAP 17.03 to 19.02 and 200 kcal for VAI 1.70 to 1.93 and LAP 14.02 to 17.02. Information on sample meal plates, food included and restricted, cooking methods, dietary modifications and general guidelines were provided. Food Plate Surveillance was done to check the quantity of food intake and to include new food. Depending on the food plate, Real-Time Counselling was carried out. Food Plate Adjustments were made accordingly and were followed throughout the study period.

Physical Activity Intervention included developing high-intensity training exercises with gradually increasing the counts. The intervention comprised 30 minutes of brisk walking and cyclic aerobic exercises like jumping jacks, super brain yoga, wall push-ups, side-lying leg lift (left and right), abdominal crunches, bicycle crunches, mountain climbers and toe touch. The aerobic exercises were shared by .GIF files and videos to show the performance of the activity. The intensity of the aerobic exercises was increased every 20<sup>th</sup> day after the feedback. Physical Activity Surveillance was done virtually. For experimental group III (Diet and Physical Activity), information on both Diet Intervention and Physical Activity Intervention was explained wherein both the diet and physical activity components were included. The VAI 2.80 to 4.99 and LAP 38.00 to 48.00, VAI 5.00 to 7.99 and LAP 48.01 to 57.99, VAI 8.00 to 9.30 and LAP 58.00 to 65.80 were given 200 kcal, 300 kcal and 500 kcal energy-restricted diets.

The post-intervention included the assessment of the participants monthly and to evaluate the anthropometric measurements and biochemical parameters and the adiposity indices like visceral adiposity index (VAI) and lipid accumulation product (LAP) was performed and calculated using standard procedures after the

end of the study period to compare the results and to find the impact of the intervention. The pre and post-evaluation were done to calculate the mean weight loss.

The finding of the study was:

### **PHASE I: BACKGROUND INFORMATION**

- Among the 960 adult women, 54.2 percent of adult women were 18 – 21 years old, and 13.5 percent were 26-30 years old. The mean average age was found to be  $21.54 \pm 1.69$ .
- Eighty-two per cent were undergraduates, and 18.2 per cent were postgraduates since the participants were mainly from the university.
- The income status revealed that 52.1 per cent were in middle income and 24.3 per cent were in the high-income level.
- Among the adult women, 86 per cent (825) were unmarried.

### **PHASE II: PREVALENCE OF OBESITY AMONG ADULT WOMEN**

#### **Results on Screening of Obesity**

- The body mass index among adults shows that 15 per cent were underweight, 12.9 per cent were overweight, and 25.9 per cent were obese.
- The waist-hip ratio ( $>0.80$ ) was found higher among obese (66.7 per cent), followed by overweight (55.6 per cent). The table also pointed out that underweight and normal adult women also had a higher waist-hip ratio of 34 per cent and 15.8 per cent respectively, which signifies the 'Asian Indian Phenotype.' On the other hand, the waist-hip ratio ( $<0.80$ ) was found predominantly among normal (84.2 per cent) adult women.
- Among the 960 adult women, WHtR greater than 0.5 ( $>0.50$ ) indicates abdominal obesity, which was found predominantly among obese of 69.5 per cent and overweight adult women of 34.7 per cent. At the same time, considering the WHtR ( $<0.50$ ), normal and underweight women had 93.5 per cent and 83.3 per cent respectively.

- The prevalence of obesity was observed among 25.6 per cent (249) adult women. On considering the waist-hip ratio and waist-height ratio, 36.9 per cent had WHR ( $>0.80$ ), whereas the WHtR ( $>0.50$ ) was seen among 27.9 per cent of adult women.

### **Relationship of the Socio-economic Attributes with Obesity**

- The chi-square analysis of age with BMI showed that among the age of 22-25 years the prevalence of obesity, overweight and underweight was significantly higher of 27.1 per cent, 13.5 per cent and 19.7 per cent adult women respectively. Comparatively, obesity was seen predominantly among 22-25 years of 27.1 per cent, 18-21 years of 25.5 per cent and 26-30 years of 24.7 per cent.
- The WHR ( $>0.80$ ) was seen higher among the age group of 18-21 years of 40.8 per cent whereas WHR ( $<0.80$ ) was seen among higher the age group of 26-30 years of 73.1 per cent. Likewise, considering the WHtR ( $>0.05$ ), 79.8 per cent was seen among the age of 18-21 years and WHtR ( $<0.05$ ) was seen among 36.9 per cent of 26-30 years of age.
- The chi-square value of income with BMI showed that 36.5 per cent and 13.3 per cent were obese and overweight among high-income levels respectively. On the other hand, 50.9 per cent were normal among the low-income levels.
- While considering the WHR, 29.6 per cent had greater values ( $>0.80$ ) among the high-income levels, whereas WHR ( $<0.80$ ) was seen among 94.2 per cent of low-income levels. The WHtR ( $>0.5$ ) was seen predominantly among high-income levels of 40.8 per cent and WHtR ( $<0.05$ ) was seen among low-income levels of 80.1 per cent.
- The chi-square analysis of education with BMI showed that 38.8 per cent of postgraduates were obese compared to undergraduates. The underweight and normal were seen predominantly among undergraduates of 18 per cent and 46.4 per cent respectively.
- The WHR with education revealed that 40.6 per cent of postgraduates had greater WHR ( $>0.80$ ), whereas 87.4 per cent of undergraduates had lesser

WHR (<0.80). The WHtR (>0.50) was seen among 47.4 per cent of postgraduates and 76.4 per cent of undergraduates had WHtR (<0.05). The chi-square analyses between education with BMI, WHR and WHtR showed a 1% significance level between the variables.

- It was evident from the table that a 1% significance difference was found on the mean of age, weight, body mass index, waist and hip circumference, waist-hip, and waist-height ratio. The results revealed that the BMI of the experimental ( $27.13\pm 3.36$ ) was higher compared to the control ( $20.25\pm 1.37$ ).
- It was also evident that the mean WC of the experimental group (n=115) was  $87.87\pm 6.44$  and the control group (n=12) was  $82.58\pm 4.40$  had abnormal waist circumference (>80 cm). The waist circumference between experimental and control women below 80 cm and above 80 cm was statistically significant, of p-value <0.0001 and 0.0064 respectively.
- The WHR of greater than 0.80 shows the severity of the risk. It is evident from the table that the mean WHR of the experimental group (n=125) was  $0.89\pm 0.08$  and the control group (n=60) was  $0.87\pm 0.06$  which was not significant. The high WHtR (>0.05) was found among the n=127 experimental group with a mean of  $0.53\pm 0.03$ , whereas among control was found among n=16 ( $0.52\pm 0.01$ ) which was not statistically significant.

### **Biochemical Details of the Experimental and Control Groups**

- The mean lipid fractions, namely total cholesterol (TC) and triglycerides (TG), were within the normal range for the experimental and control groups. The high-density lipoprotein (HDL) fraction was less than the recommended values, i.e.,  $41.12\pm 8.31$  and  $47.42\pm 9.06$  among experimental and control groups, but comparatively, the control group had a high HDL level of HDL ( $47.42\pm 9.06$ ).
- The mean low-density lipoprotein (LDL) levels were higher than the risk level but to a negligible extent  $112.23\pm 29.54$  for experimental and  $102.36\pm 27.00$  for control. TG, HDL and LDL were significant at 1% while TC was 5% significant.

- An interesting finding was that the HDL levels were lower and LDL levels were higher even among control individuals, signifying that the control group individuals were at risk. It shows the need to assess the visceral adiposity to analyze the additional risk.
- The mean fasting blood glucose was less than the recommended risk values, i.e.,  $84.24 \pm 14.76$  and  $79.78 \pm 9.94$  among experimental and control respectively but, comparatively the experimental group had a higher level. The mean fasting insulin levels were lower than the risk level of  $12.70 \pm 18.12$  for experimental and  $5.86 \pm 3.09$  for control. It was also found that the mean fasting insulin levels were twice among the experimental than the control group. FBG and FI were significant at the 1% level.
- The systolic blood pressure among the experimental was slightly higher than the control group adult women of  $108.88 \pm 8.61$  and  $102.20 \pm 9.65$  respectively. A similar increase was seen in the diastolic blood pressure as  $71.06 \pm 8.29$  among experimental and  $66.19 \pm 7.64$  among control which was statistically significant at 1% level ( $p < 0.001$ ).

### **Details on Visceral Adiposity Indices**

- The study found that the mean VAI among the experimental group was higher at  $2.27 \pm 1.27$  and the control group was  $1.61 \pm 0.92$ . The VAI value was higher among experimental women compared to control women. There was a 1% significance seen between the experimental and control women.
- The mean LAP among the experimental group was 27.52, double that of the control group of 12.27 which showed a 1% significant difference between the groups.
- The mean IR value among the experimental was doubled as of 2.71 compared with control of 1.17, which was found to be at a 1% significance difference between the groups. The higher the levels of IR were associated with higher levels of body fat. Thus, indicating that high BMI and body fat percentage were strongly related to insulin resistance.

### Association of VAI and LAP with Insulin Resistance

- The correlation analysis of VAI showed a positive correlation on age, weight, BMI, WC, HC, WHtR, TC and TG with 1% significant and r-value of 0.161, 0.228, 0.245, 0.255, 0.208, 0.249, 0.206 and 0.835 respectively. VAI and HDL were negatively correlated ( $r = -0.636$ ,  $p < 0.001$  with 1% significance), which indicates if HDL increases, there will be a decrease in VAI.
- This study points out that VAI and insulin resistance were not correlated among the general adult population. Hence  $H_0$  of hypothesis 1 was accepted.
- The correlation analysis of LAP resulted that there was a positive correlation (1% significance) seen between LAP with age, weight, BMI, WC, HC, WHR, WHtR, FI, IR and VAI of 5% significance and LAP has a strong relationship with insulin resistance.
- Hence the  $H_1$  of hypothesis 1 was accepted. A significant negative correlation was seen between LAP and HDL levels ( $r = -0.166$ ,  $p = 0.003$ ). The results also showed no correlation between LAP with total cholesterol, triglycerides, LDL, and fasting blood sugar levels.
- The R-value derived from the regression analysis was 0.940 and the degree of determination R square value was 0.884 for VAI. The adjusted R square value (0.879) shows the extent to which BMI, WHtR, TC, TG, HDL and LDL influences the value of VAI. The results show that the VAI was determined to the extent of 88% by all the other confounders.
- The R-value derived from the regression analysis was 0.778 and the degree of determination R square value was 0.606 with an adjusted R square value of 0.588 for LAP. The R and R square value found was lower than VAI and showed the extent to which BMI, WHR, WHtR, TC, TG, HDL, LDL, FBS, FI, IR and VAI influences the value of LAP and signified the determination to the extent of 57.8% by all the other confounders.
- The LAP has a strong relationship with IR, and among the other confounding indices, WHtR was related.

- From the derived R and R square value, it was observed that VAI and LAP have the predictive ability in which the model value of VAI (R=0.940, R square value=0.884) was higher compared to LAP (R=0.778, R square value=0.606), which shows to be a good predictive indicator of visceral adiposity. The result also signifies that the LAP had a strong relationship with IR, whereas VAI was insignificant.

### **Deriving the cut-off Value for the Assessment of Visceral Adiposity Indices**

- The receiver operating characteristic (ROC) area under the curve (AUC) of WC was greater than other predictors of 0.944 (0.920-0.967 95%CI) with a 73.5 cut-off value and high sensitivity of 92.5.
- The cut-off value of WHtR was found to be 0.49, whereas for WHR, the cut-off value found was to be 0.80 for adult women. WHtR has predictive ability than WHR.
- The LAP cut-off was 14.02 and AUC of 0.827 (0.784-0.871 95%CI) with the highest sensitivity (%) of 86.0 and 1-specificity (%) of 54.4 compared to other indicators.
- The VAI had the least AUC value of 0.716 (0.636-0.751 95%CI), and the cut-off was calculated to be 1.70 for adult women. While comparing the AUC of LAP and VAI, LAP had higher AUC depicting higher sensitivity and specificity. It was also observed that LAP has a good predictive ability than VAI.
- The IR had an AUC of 0.777 (0.726-0.828 95% CI) with a derived cut-off value of 1.18.
- A unit increase in WHtR value was associated with a 4.7 times greater risk of visceral adiposity (AOR= 4.737, 3.464-6.477 95%CI), whereas considering a unit increase in LAP value, has 2.9 times greater risk of visceral adiposity (AOR= 2.966, 2.158-4.075 95%CI).
- The Youden's Index performs the diagnostic ability. Among all the variables, LAP showed the highest Youden's index of 0.462, which showed great diagnostic ability.

- The prevalence of visceral adiposity among the experimental and control groups was 59 per cent and 33.7 per cent respectively, using the derived VAI cut-off value.
- The mean of greater visceral adiposity cut-off value ( $>1.70$ ) among the experimental group was higher ( $2.91\pm 1.26$ ) than among the control group ( $2.58\pm 0.91$ ), which was not statistically significant ( $p < 0.05$ ).
- The VAI value for normal body weight women was higher than the derived cut-off value.
- The experimental group having visceral adiposity was relatable, but nearly 34% of adult women had visceral adiposity among the control group.
- Using the derived LAP cut-off value, the prevalence of visceral adiposity among the experimental was 80 per cent, and among control was found to be 34.4 per cent.
- The mean of greater LAP cut-off value ( $>14.02$ ) among the experimental group was  $31.69\pm 16.59$ , which was higher than the control mean of  $21.72\pm 7.12$  and was found statistically significant ( $p = 0.0001$ ).
- The prevalence of visceral adiposity using LAP cut-off value, it was evident that 20 per cent of the experimental group were metabolically healthy obese (MHO), and 80 per cent were metabolically unhealthy obese (MUO).
- On the other hand, among the control group, 65.6 per cent were metabolically healthy non-obese (MHNO), and 34.4% were metabolically unhealthy non-obese (MUNO).
- A significant 1% difference was seen between the metabolically healthy and unhealthy obese (experimental) and metabolically healthy and unhealthy non-obese (control).

### **PHASE III: DIETARY PATTERN, PHYSICAL ACTIVITY AND THE CORRESPONDING ANTHROPOGENS**

#### **Details on Dietary Pattern**

- The dietary habits results showed that among the control, 67.5 per cent were non-vegetarians which was higher than the experimental of 54.38 per

- cent. Surprisingly, in the experimental group, non-vegetarians were low compared to the control group, but ova-vegetarians were high (15.62 per cent).
- Three times/ day meal consumption was seen among the 61.9 per cent control group, which was higher than the 36.2 per cent experimental group. The consumption of 3-4 times/ day showed that 54.4 per cent of the experimental group, whereas only 31.9 per cent of the control group.
  - The frequency of meals of 4-5 times was higher among experimental whereas among the control group was higher the frequency of 3 times meal/week. Only five experimental and 17 control adult women reported skipping breakfast.
  - The results revealed that the mean energy intake of the experimental was  $1835.51 \pm 410.15$ , which was higher than the control of  $1363.74 \pm 157.61$ . The result also signified that the per cent of energy was excess among the experimental group of +175.51 and was a deficit of 296.26 among the control group, and the higher energy intake could be a reason for higher body weight among the experimental group.
  - The mean nutrient intake of both the experimental and control groups showed an excess for fat (+14.41 and +12.77 respectively) and carbohydrate (+84.22 and +73.69 respectively) consumption compared with RDA. The mean fat and carbohydrate intake among the experimental and control group was  $34.41 \pm 6.03$  and  $32.77 \pm 4.12$ ;  $214.22 \pm 39.69$  and  $203.69 \pm 35.25$ , respectively.
  - On the other hand, protein and dietary fibre were less than RDA. It was evident from the table that the mean protein intake was high among the experimental ( $35.77 \pm 6.42$ ) than control ( $33.93 \pm 6.80$ ). The mean dietary fibre intake was only in the range of 9-14 grams, less than 50% among both groups. This finding shows the need to educate women to include foods rich in dietary fibre daily.
  - The results of partial correlation between VAI and nutrient intake showed a positive correlation between energy with protein ( $r= 0.204$ ,  $p= 0.000$ ) and fat ( $r= 0.246$ ,  $p= 0.000$ ) by controlling for VAI. The carbohydrate has a

negative partial correlation between carbohydrate and dietary fibre ( $r = -0.119$ ,  $p=0.034$ ) with 5% significance.

- The partial correlation between LAP and nutrient intake showed that there was positive correlation seen between energy with protein ( $r = 0.153$ ,  $p= 0.006$ ) and fat ( $r = 0.201$ ,  $p= 0.000$ ) with 5% and 1% level of significance by controlling for 'LAP'. The result also showed that protein was positively correlated with highest  $r$  value of 0.593 ( $p= 0.000$ , 1% significance difference) and additionally associated with dietary fibre ( $r = 0.115$ ,  $p= 0.040$ ; 5% significance).
- 'LAP' showed a considerable influence controlling relationships with energy, protein, fat, carbohydrate and dietary fibre among adult women.

### **Details on Physical Activity Pattern**

- The physical activity performance was seen among 30.6 per cent (49) of the experimental group and 38.1 per cent (61) control group. The result showed that none of the experimental and control adult women performed physical activity daily.
- Experimental of 22.5 per cent and 44.3 per cent control performed physical activity only once a week. On the other hand, 67.3 per cent experimental and 37.7 per cent control reported physical activity occasionally.
- The results revealed that walking was the predominant physical activity performed among 55.1 per cent experimental and 63.9 per cent control group.
- The results of the duration of physical activity showed that 81.6 per cent experimental which was lower than 93.4 per cent control group exercise less than 30 mins whereas 18.4 per cent experimental, which was also significantly lower than the 6.6 per cent control group exercise between 30-45 mins.
- The IPAQ levels among control were higher, about 564.26 MET-min/week compared to experimental adult women of 475.55 MET-min/week. It was noted that there was a statistical significance of 1% level seen among

- experimental and control women ( $p= 0.002$ ). Overall, the MET-min/week levels were lower and indicated a sedentary lifestyle among the population.
- The status of the physical activity revealed that 74.4 per cent (119) experimental were involved in low/ inactive physical activity whereas 25.6 per cent (41) experimental involved in moderate physical activity. Among control, 66.3 per cent (106) were inactive/ low and 33.8 per cent (95) were under moderate physical activity.
  - The partial correlation analysis between VAI and physical activity showed a significant positive correlation between IPAQ and physical activity status ( $r= 0.566$ ,  $p= <0.001$ ) by controlling for 'VAI.'
  - On the other hand, 'LAP' as the control variable showed a significant positive relation between IPAQ and physical activity status ( $r= 0.567$ ,  $p= <0.001$ ). Controlling for 'VAI' and 'LAP' had a minimal influence on relationships with physical activity status and IPAQ.

### **Anthropogens and Risk Assessment for Metabolic Dysfunction**

- The diet factor among the experimental group showed that 60 per cent were at the high risk, which was much higher than the control high risk (1.9%). On the other hand, 40 per cent experimental and 98 per cent control were at low risk.
- The physical activity risk factor revealed that the 33.8 per cent control group, which was higher than the 25.6 per cent experimental group, was at low risk. The high risk was predominant among the experimental group of 74.4 per cent than control of 66.2 per cent.
- The sleep pattern resulted in 23.1 per cent being at low risk and 76.9 per cent being at high risk among experimental whereas among the control group, 17.5 per cent were at low risk and 82.5 per cent were at high risk.
- The sun exposure revealed that only adult women were exposed to the sun while traveling. The results showed that among the experimental 11.9 per cent and control 13.7 percent were at low risk, and 88.1 per cent and 86.3

per cent were at high risk among experimental and control groups, respectively.

#### **PHASE IV: IMPACT OF INTERVENTION ON VISCERAL ADIPOSITY INDICES AMONG SELECTED EXPERIMENTAL GROUP**

- The t-test of pre and post-evaluation of diet intervention resulted among the experimental group result showed that variables such as weight, BMI, WC, HC, TC, TG, HD, LDL and LAP had a strong relationship between the pre and post-intervention among the experimental group with the diet intervention induced as those variables were statistically significant at 1% level of significance.
- The VAI and LAP were reduced post-intervention significantly but not below the derived cut-off value. The mean VAI post-intervention was  $1.86\pm 0.97$  from  $2.04\pm 1.12$ , whereas the mean LAP post-intervention was  $19.11\pm 13.83$  from  $22.18\pm 14.73$ . The mean weight reduction was calculated to be  $3.15\pm 0.93$  (kg).
- The pre and post physical activity intervention results revealed that the variables such as weight, BMI, WC, TC, TG, HDL, LDL, VAI and LAP were strongly associated among the experimental group, as these variables were statistically significant 1% level of the significance level.
- The mean VAI post-intervention was  $1.96\pm 1.01$  from  $2.51\pm 1.22$ , whereas the mean LAP post-intervention was  $21.00\pm 15.87$  from  $34.89\pm 16.94$ . The mean weight reduction in the post-intervention of physical activity was found to be  $4.13\pm 0.98$ .
- The pre and post-diet and physical activity intervention results revealed that the variables such as Weight, BMI, WC, TC, TG, HDL, LDL, VAI and LAP showed a strong association on visceral adiposity (by visceral adiposity indices) which showed a 1% level of significance.
- Additionally, the VAI and LAP post-intervention reduced to  $1.70\pm 0.49$  and  $16.49\pm 11.49$ , similar to the derived cut-off value. Hence diet along with appropriate physical activity aids in reducing the visceral adiposity more effectively in the specified study period.

- The control group results of pre and post-evaluation showed that weight, BMI, WC, HDL, and VAI were statistically significant at a 5% level of significance, indicating a difference between pre and post-evaluation.
- The other variables were not statistically significant between and within four groups, indicating no difference between the pre-intervention groups.
- The results showed that considering the variables, there was statistically significant seen between waist circumference, waist-hip ratio and HDL at 1% significance and body mass index, LDL, VAI and LAP showed a 5% significance difference between and within the groups. Hence  $H_0$  was rejected, and  $H_1$  was accepted.
- The visceral adiposity indices like visceral adiposity index and lipid accumulation product reduced significantly within and between the groups. Additionally, the diet and physical activity intervention experimental group saw high mean weight reduction.

### **Hypothesis**

#### ➤ **Hypothesis 1**

- This study points out that VAI and insulin resistance were not correlated among the general adult women population. Hence  $H_0$  of hypothesis 1 was accepted.
- The correlation analysis of LAP resulted that there was a positive correlation (1% significance) seen between LAP with age, weight, BMI, WC, HC, WHR, WHtR, FI, IR and VAI of 5% significance and LAP has a strong relationship with insulin resistance. Hence the  $H_1$  of hypothesis 1 was accepted

#### ➤ **Hypothesis 2**

- The results showed that considering the variables, there was statistically significant seen between waist circumference, waist-hip ratio and HDL at 1% significance and body mass index, LDL, VAI and LAP showed a 5% significance difference between and within the groups. Hence  $H_0$  was rejected, and  $H_1$  was accepted.

## **Conclusion**

Visceral adiposity fat has been found to play a role in our body's metabolic, endocrine, and immune functions. Visceral adiposity increases the risk of metabolic and cardiovascular disorders and, hence, is important as an anthropometric tool. The visceral adiposity indices (Visceral adiposity index and Lipid Accumulation Product) might be used as valuable and surrogate indexes of visceral tissue dysfunction since they are cost-effective and non-invasive tools that can be performed easily and utilized for a screening assessment. It can also be used as a criterion to assess the risk of NCDs among population studies and in clinical practices if the cut-off values are validated. VAI, LAP and IR association prove to be the key factors in finding out the risk of chronic diseases and can be used at the community level in identifying risks so that the SDG of Good Health and Well-being can be achieved.

## **Limitations**

- The intervention study duration was not prolonged, and insulin resistance was not assessed pre and post-intervention due to COVID.

## **Recommendations**

- Visceral adiposity indices in varied age groups and ethnicity with a larger sample size to validate among general and NCD populations can be carried out.
- The study did not include men since it was a women-centered study.