Dyslipidemia, Insulin Sensitivity Indices, Metabolic Risk Factors, And Anti Müllerian Hormone Levels In Egyptian Women With Polycystic Ovary Syndrome

Abstract

Objective: To determine the levels and relationships between lipoproteins, triglycerides (TG), insulin sensitivity measures, and anti müllerian hormone (AMH) levels in polycystic ovary syndrome (PCOS) women as compared to healthy eumenorrheic controls.

Patients and method

We examined 110 PCOS and 36 controls aged 19-34 years old, body mass index (BMI), waist hip ratio (WHR), were determined, plasma levels of glucose, insulin, TG, total cholesterol (TC), low density lipoprotein-cholesterol (LDL-C), high density lipoprotein-cholesterol (HDL-C), lipoprotein a LP(a), Apolipoprotein B (Apo B), total testosterone, sex hormone binding globulin (SHBG) and AMH were measured, homeostasis model assessment of insulin resistance (HOMA-IR) and quantitative insulin sensitivity check index (QUICKI) were calculated.

Results

According to BMI level 29.1%, 37.2% and 33.6% were lean, overweight, and obese in PCOS group which did not differ significantly from controls. High LP (a) levels were found in 68.2% followed by low HDL-C in 63.7% of PCOS women. At all BMI levels HDL-C, and QUICKI levels were significantly lower, whereas TG, FAI, HOMA-IR levels were significantly higher in PCOS than normal women. AMH levels were significantly higher in PCOS vs. control women, yet, significantly lower in obese vs. lean PCOS women. HDL-C, and FAI were independently associated with HOMA-IR, (p=0.037), and LP (a)(p=0.23) respectively.

Conclusion

Dyslipidemia is common in PCOS and is positively correlated to FAI, BMI, and HOMA-IR.

Keywords: Dyslipidemia, polycystic ovary syndrome, anti müllerian hormone, HOMA-IR.

Introduction

Polycystic ovary syndrome (PCOS), a condition of chronic anovulation and hyperandrogenism, constitutes the most frequently encountered reproductive endocrinopathy affecting 6-10% of all women (1). Women with PCOS are hyperinsulinemic (2) and fully 40% of all cases will develop type 2 diabetes by age of 50 (30). PCOS increases the risk for cardiovascular disease, a finding consistently reported across several geographic areas and ethnic groups (4). Up to 70% of women with PCOS have dyslipidemia (5), particularly increased levels of low-density lipoprotein cholesterol (LDL-C) and decreased high-density lipoprotein cholesterol (HDL-C) levels (6).

Some studies, however, did not record any differences in lipid or lipoprotein profiles between PCOS patients, and weight matched controls (7), (8). Genetic environmental and ethnic factors may be responsible for the conflicting results. Polycystic ovaries are characterized by greater amounts of primary and preantral follicles than their normal counterparts (9), yet the antral follicle growth is arrested at the 4-7 mm stage due to production of local inhibitors as anti müllerian hormone (AMH) or inhibit (10).

AMH is produced in the granulosa cells of early developing follicles (11), and strongly correlates with the number of antral follicles (12). Women with PCOS display elevated levels of AMH when compared with age and body mass index (BMI) matched normally cycling women (13), (14). As asserted by a number of studies, AMH is a useful marker of ovarian...
responsiveness, embryo number or assisted reproductive technology outcomes (15), (16).

This study was conducted to assess the differences between Egyptian PCOS and healthy eumenorrheic women in plasma lipids and lipoproteins, insulin sensitivity index, metabolic risk factors, and AMH serum levels and to determine their relationship to each other.

Subjects and methods

The study group consisted of 110 PCOS patients recruited from women attending the obstetrics and gynecology outpatient clinic of Zagazig University affiliated hospitals in 2007 to 2009. The criteria for PCOS included the Rotterdam consensus (17), with the Androgen Excess Society (AES) modification (18) namely: oligo or anovulation with oligomenorrhea or amenorrhea and/or polycystic ovaries (> 12 follicles 2-9 mm, or ovarian volume >10 ml) on transvaginal ultrasound, clinical or biochemical evidence of hyperandrogenism (Ferriman-Gallway score > 8) (19) free androgen index > 8, respectively.

Patients with thyroid dysfunction, hyper-prolactinemia, Cushing syndrome, late onset non-classical 21-hydroxylase deficiency, and androgen secreting tumours were excluded after appropriate testing.

Thirty six women with menstrual cycles in the normal range (25-34 days) for at least 12 months, who were age and body mass index (BMI) matched with the PCOS group and having normal androgen and 17-hydroxyprogesterone levels were enrolled as controls. On admission, all subjects had a full medical examination including past medical history and use of medications. Exclusion criteria for all subjects were hormonal therapy including contraceptives, the presence of diabetes mellitus, renal or hepatic diseases, and hypolipidemic drugs. All subjects provided informed consent to participate in this study.

All subjects underwent anthropometric measurements, a blood draw within the first 4 days of menstrual cycle in the control group and after a spontaneous bleeding episode in the PCOS group. Height (without shoes) was measured to the nearest 0.5 cm with a vertical ruler. Weight (in light clothing) was measured to the nearest 0.2 kg with a portable scale. BMI was calculated as weight (kg)/height (m2) and women were classified as: lean < 25 kg/m2, overweight ≥ 25 kg/m2, and obese ≥ 30 kg/m2. Waist circumference (WC) was measured according to the American Heart Association/National Heart, Lung and Blood Institute guidelines (20). At the narrowest circumference between the top of iliac crest and the lower margin of ribs, an inelastic tape was placed in a horizontal plane, around the abdomen. The tape must be snug, not compressing skin, and parallel to the floor. Measurement was made at the end of normal expiration. Hip circumference (HC) was measured at the widest circumference of the buttocks at the area of the greater trochanters, then the waist hip ratio (WHR) was calculated. Blood was collected early in the morning after a 12 hour overnight fast for lipid and hormone assays. Plasma total cholesterol and TG were measured on a Roche Modular System using commercial kits (Roche Diagnostics, Rotkreuz, Switzerland) with a coefficient of variation of 2.3 and 2.4% respectively.

HDL-C, lipoprotein (a) [Lp(a)], and apolipoprotein B (apo B) were measured using commercial assays (Roche Diagnostics) with a coefficient of variation 4.1, 2.3, 1.2% respectively. LDL-C was calculated using the Friedewald formula (21). Plasma AMH was measured using an Immunotech immunoenzymatic assay (Beckman Coulter, Marseille, France). The detection limit of the assay was 0.1 ng/ml. Fasting venous blood samples were taken for the assessment of plasma glucose, insulin, serum testosterone, and sex hormone binding globulin (SHBG). Glucose (mg/dl) was assayed by using enzymatic assay (Yellow Springs Glucose Analyzer), insulin (IU/ml) was measured by a solid-phase enzyme-amplified sensitivity immun assay (INS-EASIA; Biosource Technologies, Nivelles, Belgium). Total testosterone (T) (ng/dl) was measured by testosterone enzyme immunoassay test kit (L17603; Linear Chemicals). Dehydroepiandrosterone sulfate (DHEA-S) (µg/ml) was measured by radioimmunoassay (Ciba International, France).

Sex hormone binding globulin (SHBG) serum levels (nmol/L) were measured by ELISA (SHBG ELISA, MAY 520 11:BIL, Hamburg, Germany). Glucose tolerance was determined by a 75-gram oral glucose tolerance test. The quantitative insulin sensitivity check index (QUICKI) (22), and homeostasis model assessment of insulin resistance (HOMA-IR) (23) were used as surrogate measures of insulin sensitivity. They were calculated as follows: QUICKI= 1/log fasting insulin (µ IU/ml) + log fasting glucose (mg/dl) [µg/dl for glucose= mmol/L * 18.182]. HOMA-IR= fasting blood glucose (mg/dl) * fasting insulin (µ IU/ml)/405.

Free androgen index (FAI) was calculated as T (nmol/L) * 100/SHBG (nmol/L). Dyslipidemia was diagnosed using the definitions proposed by the National Cholesterol Education Program-Third Adult Treatment Panel (NCEP-ATP III) for the metabolic syndrome (20), (25) viz; TG ≥ 1.7 mmol/L (150 mg/dl), low-HDL-C: <1.29 mmol/L (50 mg/dl), high LDL-C: ≥ 4.1 mmol/L (155 mg/dl), elevated Lp (a) if > 30 mg/dl and, elevated apo B if > 100 mg/dl.

Statistics

Statistical analysis was performed using SPSS (version 15.0) [SPSS, Chicago, IL, USA]. Continuous variables were presented as means ± SD. Normality was assessed by Kolmogrov-Smirnov test. Data which are not normally distributed were log transformed and non-parametric tests were employed. Non-parametric Mann-Whitney u test was used for numeric variables' differences, and Chi-square test for categorical variables. Multiple regression was performed for plasma lipids and lipoproteins, as well as, AMH as dependent variables. Independent variables were the group (PCOS vs. control), FAI, BMI, QUICKI, and HOMA-IR. For all analyses two-tailed p<0.05 was considered to indicate statistical significance.

Results

In this study we found that all PCOS women had menstrual irregularity, 79.7% of them had a Ferriman Gallway score > 8, and 75.8% of them had elevated serum total testosterone levels. As shown in table (1) PCOS women and healthy women had similar age, BMI, and WHR. AMH, total testosterone (TT), FAI, HOMA-IR levels were significantly higher; p<0.01 in PCOS women compared to controls. Levels of LDL-C were higher in the PCOS group than healthy women; however, this did not reach statistical significance. Unlike levels of Total Cholesterol TT and ApoB which did not differ between participant groups. HDL-C and Lp (a) levels were significantly lower in PCOS group p<0.05 than controls. In the PCOS group BMI categorical distribution was as follows; lean 29.1% (n=32), overweight 37.3% (n=41) and obese 33.6% (n=37). For the controls 30.6% (n=11) were lean 36.2% (n=13) were overweight and 33.3% (n=12) were obese. Both groups were not statistically different for BMI categories. Clinical, hormonal and insulin sensitivity indices according to BMI are listed in table (2).

Total Cholesterol and lipoprotein levels according to BMI are presented in table (3). No significant changes were noted with increasing body weight in total cholesterol (p=0.93), ApoA1 (p=0.182), LDL-C (p=0.231), DHEA-S (p=0.772). Lp (a), and HDL-C levels increased significantly at each level of increase in
BMI; for Lp(a) obese vs lean; p=0.016, obese vs overweight; p=0.027 and overweight vs. lean p=0.033, for HDL-C levels obese vs. lean p=0.021, obese vs. overweight p=0.043, and overweight vs. lean p=0.047.

Total testosterone, SHBG, FAI, HOMA-IR were significantly higher in PCOS compared to control group and within the PCOS group they were significantly higher in overweight versus lean, and in obese versus lean women. Obese women in PCOS and control groups had significantly higher fasting blood glucose than overweight and lean women. QUICKI was significantly lower in obese women with PCOS compared to their lean and overweight counterparts. For AMH significantly higher levels were recorded in PCOS than control women for each BMI category. Obese women with PCOS, however, had significantly lower levels than lean PCOS women.

For the control group all variables were not significantly different in different BMI categories except for fasting insulin. HOMA-IR, TG levels which were significantly higher, HDL C, QUICKI values which were significantly lower in obese vs. lean women p=0.032, p=0.032, p=0.047, p=0.041, p=0.029 and p=0.035 re-

Table (1):
Anthropometric Characteristics, hormonal and metabolic profiles in polycystic ovary patients and controls

<table>
<thead>
<tr>
<th>Study Group</th>
<th>POCS</th>
<th>Controls</th>
</tr>
</thead>
<tbody>
<tr>
<td>n=110</td>
<td>n=36</td>
<td></td>
</tr>
<tr>
<td><strong>Age (years)</strong></td>
<td>25.8±4.72</td>
<td>26.2±3.83</td>
</tr>
<tr>
<td><strong>BMI (kg/m2)</strong></td>
<td>28.7±5.13</td>
<td>29.3±4.35</td>
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<tr>
<td><strong>WHR</strong></td>
<td>0.78±0.15</td>
<td>0.76±0.13</td>
</tr>
<tr>
<td><strong>FG score</strong></td>
<td>17.45±7.23</td>
<td>-</td>
</tr>
<tr>
<td><strong>TT (ng/dl)</strong></td>
<td>111.32±25.83</td>
<td>43.29±3.61</td>
</tr>
<tr>
<td><strong>SHBG (nmol/L)</strong></td>
<td>36.0±0.27</td>
<td>45.12±1.37</td>
</tr>
<tr>
<td><strong>DHEA-S (ng/ml)</strong></td>
<td>2753.33±1128.41</td>
<td>2413.44±1215.45</td>
</tr>
<tr>
<td><strong>FAI</strong></td>
<td>15.6±12.92</td>
<td>3.89±1.43</td>
</tr>
<tr>
<td><strong>AMH (ng/ml)</strong></td>
<td>5.8±2.37</td>
<td>2.54±0.95</td>
</tr>
<tr>
<td><strong>Glucose (mg/dl)</strong></td>
<td>98.41±6.52</td>
<td>85.74±1.89</td>
</tr>
<tr>
<td><strong>Insulin (µIU/ml)</strong></td>
<td>17.43±6.82</td>
<td>7.41±4.21</td>
</tr>
<tr>
<td><strong>HOMA-IR</strong></td>
<td>4.87±3.51</td>
<td>1.73±1.26</td>
</tr>
<tr>
<td><strong>QUICKI</strong></td>
<td>0.33±0.005</td>
<td>0.37±0.003</td>
</tr>
<tr>
<td><strong>TC (mg/dl)</strong></td>
<td>184.19±9.47</td>
<td>167.73±10.16</td>
</tr>
<tr>
<td><strong>LDL-C (mg/dl)</strong></td>
<td>121.48±32.62</td>
<td>118.56±18.74</td>
</tr>
<tr>
<td><strong>HDL-C (mg/dl)</strong></td>
<td>42.72±20.13</td>
<td>60.51±6.22</td>
</tr>
<tr>
<td><strong>Lp (a) (mg/dl)</strong></td>
<td>37.32±27.15</td>
<td>7.8±4.2</td>
</tr>
<tr>
<td><strong>ApoB (mg/dl)</strong></td>
<td>83.45±36.24</td>
<td>80.71±27.25</td>
</tr>
<tr>
<td><strong>TG</strong></td>
<td>122.28±69.47</td>
<td>118.39±21.31</td>
</tr>
</tbody>
</table>

- Data are mean ± SD. P<0.05 is statistically significant
- BMI= Body Mass Index; WHR= Waist Hip Ratio; FG score= Ferriman Gallway score; TT= Total Testosterone; SHBG= Sex Hormone Binding globulin; DHEA-S= Dehydroepiandrosterone-sulfate; FAI= Free Androgen Index; AMH= Anti Müllerian Hormone; HOMA-IR= Homeostatic Model Assessment Insulin Resistance; and QUICKI= Quantitative Insulin Sensitivity Check Index; TC= Total Cholesterol; LDL-C= Low Density Lipoprotein Cholesterol; HDL-C= High Density Lipoprotein Cholesterol; Lp(a)= Lipoprotein (a); ApoB=Apolipoprotein B; TG=Triglycerides.
respectively. According to NECP III criteria [20-25], 9 women of the control group (25%) had dyslipidemia. Five women of the dyslipidemic controls (56%) had low HDL-C levels, 4 women (45%) had elevated TG and 2 (22.2%) had high LDL-C levels. Of the dyslipidemic controls, 3 women were obese and the remaining was overweight. All obese dyslipidemic control women had high values of TC, TG, LDL-C and low HDL-C levels, 4 of the overweight women had low HDL-C levels, 3 had high TG, 2 women had low LDL-C level.

In the PCOS group 71.8% (n=79) were dyslipidemic. Most frequent abnormalities were: high Lp (a) levels (n=75/110); 68.2% followed by low HDL-C levels (n=50/110); 63.7%, high TG levels (n=65/110); 59%, high LDL-C levels (n=64/110); 41%, then high total cholesterol levels (n=39/110); 35.4%.

For lean, overweight and obese women low HDL-C levels were reported in 18.5%, 70.7%, 94.6%, high Lp (a) levels in 28.1%, 80.4%, 86.5%; high LDL-C levels in 9.3%, 36.6%, 75.7% and high TC levels in 6.3%, 41.5%, 51.4% respectively. The following variables were positively related to BMI, Lp (a) (r = 0.575; p<0.001), TG (r = 0.419; p=0.001), LDL-C (r = 0.296; p=0.021), HOMA-IR (r = 0.319; p<0.01). HDL-C, and QUICKI levels were inversely correlated to BMI (r = 0.389; p=0.021) and (r = -0.387; p<0.01). When HOMA-IR was correlated to individual variables it was positively related to Lp (a) (r = 0.423; p<0.001), TG (r = 0.252; p<0.05), AMH (r = 0.268; p=0.034) and inversely correlated to QUICKI (r = -0.567; p<0.001), and HDL-C (r = -0.356; p<0.005). FAI was positively correlated to Lp (a), (r = 0.427; p<0.001), AMH (r = 0.553; p<0.001), HOMA-IR (r = 0.453; p = 0.024) and inversely related to HDL-C (r = -0.448; p=0.019) and QUICKI (r = -0.511; p=0.017). The best predictor of Lp (a) was FAI (r=0.244; p=0.023) the model was further improved by adding HOMA-IR (r=0.361; p=0.017) and AMH (r=0.519; p=0.002). For HDL-C best predictor is HOMA-IR (r=0.231; p=0.037) adding FAI (r=0.382; p=0.022) and AMH (r=0.498; p=0.004) improved the model.

Table (2):
Clinical, hormonal, insulin sensitivity indices in different body mass index categories in controls versus polycystic ovary patients

<table>
<thead>
<tr>
<th>Variable</th>
<th>Lean Control</th>
<th>PCOS n=32</th>
<th>Overweight Control</th>
<th>PCOS n=41</th>
<th>Obese Control</th>
<th>PCOS n=37</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>26.9±5.7</td>
<td>24.8±4.7</td>
<td>27.3±2.3</td>
<td>25.9±2.5</td>
<td>23.9±3.4</td>
<td>25.4±3.5</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>22.3±1.7</td>
<td>21.6±2.2</td>
<td>27.5±2.1</td>
<td>28.4±4.3b</td>
<td>32.8±1.8</td>
<td>34.9±3.8c,d</td>
</tr>
<tr>
<td>FG score</td>
<td>-</td>
<td>16.52±5.73</td>
<td>-</td>
<td>19.93±6.84</td>
<td>-</td>
<td>18.55±4.71</td>
</tr>
<tr>
<td>TT (ng/dl)</td>
<td>43.5±26.2</td>
<td>103.7±18.4a</td>
<td>45.7±22.4</td>
<td>110.8±25.4a,b</td>
<td>44.8±30.17</td>
<td>119.2±32.1a,c,d</td>
</tr>
<tr>
<td>SHBG (nmol/L)</td>
<td>47.5±0.9</td>
<td>35.2±1.3a</td>
<td>46.8±0.7</td>
<td>34.2±2.2a,</td>
<td>45.3±1.1</td>
<td>33.6±1.9a,c,d</td>
</tr>
<tr>
<td>FAI</td>
<td>4.1±2.2</td>
<td>10.4±3.6a</td>
<td>3.8±1.7</td>
<td>12.8±9.5a,</td>
<td>4.9±2.5</td>
<td>14.2±6.8a,c,d</td>
</tr>
<tr>
<td>DHEA-S (ng/ml)</td>
<td>2255±924</td>
<td>2371±1100</td>
<td>2334±1207</td>
<td>2501±1197</td>
<td>1989±1313</td>
<td>2421±1125</td>
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<tr>
<td>AMH (ng/ml)</td>
<td>2.3±0.9</td>
<td>6.4±2.5a</td>
<td>2.1±1.2</td>
<td>5.2±2.7a</td>
<td>1.8±1.3</td>
<td>4.7±1.1a,c,d</td>
</tr>
<tr>
<td>Glucose (mg/dl)</td>
<td>85.9±4.2</td>
<td>88.1±0.9</td>
<td>89.3±3.8</td>
<td>88.5±5.2</td>
<td>99.7±10.2</td>
<td>101.2±3.3a,c,d</td>
</tr>
<tr>
<td>Insulin (µIU/ml)</td>
<td>6.2±4.6</td>
<td>14.8±9.6a</td>
<td>10.8±2.7</td>
<td>19.8±12.9a,b</td>
<td>11.1±1.2</td>
<td>21.3±16.5a,c,d</td>
</tr>
<tr>
<td>HOMA-IR</td>
<td>2.1±1.5</td>
<td>3.7±2.1a</td>
<td>1.9±2.2</td>
<td>5.3±3.2a</td>
<td>2.9±0.6</td>
<td>6.2±2.8a,c,d</td>
</tr>
<tr>
<td>QUICKI</td>
<td>0.375±0.004</td>
<td>0.359±0.006</td>
<td>0.344±0.003</td>
<td>0.2275±0.007a,b</td>
<td>0.335±0.012</td>
<td>0.255±0.037a,c,d</td>
</tr>
</tbody>
</table>

- Values are mean ± SD, P<0.05 is statistically significant
- BMI= Body Mass Index; FG score= Ferriman Gallway score; TT= Total Testosterone; SHBG= Sex Hormone Binding globulin; FAI= Free Androgen Index; DHEA-S= Dehydroepiandrosterone- sulfite; AMH= Anti Mullerian Hormone; HOMA-IR= homeostatic Model Assessment Insulin Resistance; and QUICKI= Quantitative Insulin Sensitivity Check Index.

a P<0.05PCOS vs. Controls.
b P<0.05Overweight vs. Lean
c P<0.05Obese vs. Lean
d P<0.05Obese vs. overweight
Table (3):  
Lipid profile according to body mass index categories in controls vs. polycystic ovary syndrome women

<table>
<thead>
<tr>
<th>Variable</th>
<th>Lean</th>
<th>PCOS</th>
<th>Overweight</th>
<th>PCOS</th>
<th>Obese</th>
<th>PCOS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n=11</td>
<td>n=32</td>
<td>n=13</td>
<td>n=41</td>
<td>n=12</td>
<td>n=37</td>
</tr>
<tr>
<td>TC (mg/dl)</td>
<td>158.95±27.72</td>
<td>164.89±29.74</td>
<td>169.34±24.61</td>
<td>185.22±27.13</td>
<td>176.22±31.52</td>
<td>188.33±26.42</td>
</tr>
<tr>
<td>LDL-C (mg/dl)</td>
<td>97.39±32.06</td>
<td>106.61±25.44</td>
<td>105.28±19.91</td>
<td>111.39±23.05</td>
<td>113.47±18.78</td>
<td>116.99±22.23</td>
</tr>
<tr>
<td>HDL-C (mg/DL)</td>
<td>65.37±14.26</td>
<td>50.48±10.33a</td>
<td>52.17±16.51</td>
<td>45.96±14.85a,b</td>
<td>49.56±11.26</td>
<td>38.92±12.14c,d</td>
</tr>
<tr>
<td>TG (mg/dl)</td>
<td>79.39±43.92</td>
<td>99.71±35.13a</td>
<td>122.74±33.65</td>
<td>131.22±37.19b</td>
<td>132.15±28.27</td>
<td>139.48±36.25a,d</td>
</tr>
<tr>
<td>Lp (a) (mg/dl)</td>
<td>7.3±6.2</td>
<td>18.8±31.1a</td>
<td>8.5±5.7</td>
<td>27.4±25.9a,b</td>
<td>7.5±5.3</td>
<td>41.2±85.2</td>
</tr>
<tr>
<td>Apo B (mg/dl)</td>
<td>82.35±19.7</td>
<td>80.82±20.3</td>
<td>82.62±38.6</td>
<td>86.5±29.4</td>
<td>81.7±42.2</td>
<td>87.3±44.6</td>
</tr>
</tbody>
</table>

- Data are mean ± SD P<0.05 is statistically significant
- TC= Total Cholesterol; LDL-C= Low Density Lipoprotein-cholesterol; HDL-C= High Density Lipoprotein-cholesterol; Lp(a)= Lipoprotein (a); APOB= Apolipoprotein B.
  a P<0.05 PCOS vs. Controls.
  b P<0.05 Overweight vs. lean
  c P<0.05 Obese vs. lean
  D P<0.05 Obese vs. overweight

Discussion

It is well-known that healthy women have hormonal protection against cardiovascular diseases delaying their onset by 10-15 years in comparison to men (26). In contrast young women may show increased cardiovascular risk when affected by PCOS (27). In PCOS hyperandrogenemia and chronic anovulation have been associated with metabolic aberrations and metabolic syndrome (28). FAI levels were significantly higher in obese than overweight or lean PCOS women analyzed in this study reflecting the fact that hyperandrogenemia can aggravate visceral obesity in women unlike men (29). Besides, androgen excess is known to lower circulating HDL-C (30) that androgen excess is artherogenic, a fact that was further substantiated in our study that demonstrated the inverse relationship between LDL-C and FAI. Moreover FAI was the best predictor of Lp (a) providing another link between androgen excess and cardiovascular risk disease.

Hyperandrogenemia can also perpetuate insulin resistance by inhibiting muscle glycogen synthase activity, and, by increasing the number of less insulin sensitive type IIb skeletal muscle fibers (31), (32), again here, FAI was positively correlated to HOMAIR and negatively correlated to QUICKI measures of insulin sensitivity. Similar findings were reported in previous studies (33), (34). Lipid alterations are common in women with PCOS (5). Concerning the pattern of dyslipidemia in the PCOS the results of different studies are not entirely congruent in the present study a significant increase only in TG, Lp(a) and a significant decrease in HDL-C in PCOS women compared to healthy women was found, a pattern as that seen with insulin resistance and recorded in previous studies (33), (35), (36). Other authors reported only a single increase in TG (37), (38) or LDL-C (39) or decrease in HDL-C (40) in PCOS women.

When the effect of BMI was illustrated some studies showed decreased HDL-C levels in all PCOS women and an added increased TG levels only in obese PCOS women (41), (42). For all levels of BMI (lean, overweight, or obese) we found that the decrease in HDL-C and increase in TG was significant. Rizzo et al 2009 (4) pointed out that Italian PCOS women had significantly increased TG and LDL-C than healthy controls, however, their concentrations usually remained in the normal range. As we examined Egyptian women with PCOS 59% had TG levels >1.7 mmol/L and 41% had LDL-C levels >4mmol/L were reported which are significantly higher than those of Italian anovulatory women with PCOS 9%, 23% respectively (4). Lp(a) a marker of increased cardiovascular risk was noted to be significantly higher in Egyptian women with PCOS compared to controls with no alterations in ApoB; in agreement with findings by other authors on Mediterranean PCOS women (4), (43), (44).

Nonetheless, contradictory results were shown for ApoB (45), Lp(a) (45) in PCOS women from different genetic backgrounds.

Obese women with PCOS from our locality had significantly higher levels of TG than overweight or lean PCOS women as stated in previous reports (41), (42). HDL-C levels decreased significantly with each level of increase in BMI. Rocha and coworkers (33), however, did not notice a difference between overweight and obese Brazilian women with PCOS. Insulin resistance was postulated to be the connecting factor between dyslipidemia
and PCOS (5), indeed, the best predictor for HDL-C was HOMA-IR in this study.

The present study confirmed previous results on increased serum AMH levels in women with PCOS (47), (48) which is due to increased number of preantral follicles and its increased production per granulosa cell in PCOS patients (49). As mentioned in previous studies (50), (51) a positive correlation between AMH and FAL was demonstrated in Egyptian PCOS women, as well. Our PCOS study women displayed a positive correlation between their AMH levels and HOMA-IR. Previous publications on the relationship between AMH levels and high surrogate measures were conflicting; some reported no association (14), (52) or positive correlation (50).

AMH levels were significantly lower in obese PCOS compared to lean PCOS sub group, this inverse relationship was consistently found in previous reports (54), (55). This can be explained by the fact that Insulin resistance can occur independent of obesity in PCOS women (53), and surprisingly, weight loss results in improvement in insulin resistance but not AMH probably because it has a greater effect on metabolic rather than gonadotropic presentation of PCOS and so far LH levels were found to be the most important independent determinant of AMH (48).

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