Association of dehydroepiandrosterone-sulfate with endothelial function in young women with polycystic ovary syndrome

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Abstract

Objective: The aim of this study was to assess non-invasively endothelial function of young women with polycystic ovary syndrome (PCOS) in comparison with healthy age-matched women and a group of young women with idiopathic hirsutism (IH). The possible role of metabolic and hormonal parameters on endothelial function was also examined.

Design: Descriptive clinical trial.

Methods: Fifty-six women, 27 with PCOS, 16 with IH and 13 healthy age-matched women were studied. Endothelial function of resistance arteries was assessed by venous occlusion plethysmography. Metabolic and hormonal parameters were estimated in this study population.

Results: The duration of reactive hyperemia (durRH) was shorter in PCOS group when compared with normal controls (63.75 ± 13.33 s vs 113.18 ± 20.92 s, P = 0.036). A similar finding was observed when PCOS were compared with IH group (63.75 ± 13.33 s vs 105 ± 17.20 s, P = 0.05). The durRH did not differ between IH and control group (105 ± 17.20 s vs 113.18 ± 20.92 s, ns). A significant positive linear correlation was found between the durRH and dehydroepiandrosterone-sulfate (DHEA-S) levels (r = ± 0.48, P = 0.04) in the PCOS group. The basal insulin resistance index (HOMA) differed significantly between PCOS, IH and control groups. There was no significant correlation between durRH and HOMA index or testosterone levels in the PCOS group.

Conclusions: Endothelial dysfunction may be an early sign of cardiovascular system abnormalities in young PCOS women. It is possible that increased DHEA-S levels may offer a cardioprotective advantage that attenuates the effects of cardiovascular risk factors that accompany PCOS.
agging (15). Furthermore, forearm endothelial dysfunction appears to have a prognostic significance for future cardiovascular events in hypertensive patients (16). Interestingly, lower post-ischemic forearm reactive hyperemia is associated with all-cause mortality in end-stage renal disease patients independently of the presence of end-organ damage such as left ventricular hypertrophy or arteriosclerosis (17).

In this study, young women with PCOS were evaluated for possible endothelial dysfunction in comparison with healthy age-matched women and a group of young women with IH. Relationships of endothelial function with metabolic and hormonal indices were also examined.

Subjects and methods

Subjects recruited were grouped as follows: Group A: 27 women with PCOS (mean age 25.6 years), group B: 16 women with IH (mean age 27.8 years) and group C: 13 healthy women (mean age 25.7 years) who served as controls. The sex-hormone-binding globulin (SHBG) and free androgen index had been calculated in the controls. The sex-hormone-binding globulin (SHBG) and free androgen index had been calculated in the

PCOS was defined as (i) menstrual irregularity due to oligomenorrhea (fewer than nine menstrual periods per year) or amenorrhea (no menstrual periods for at least three months), (ii) clinical (hirsutism, acne or male pattern balding) and/or biochemical evidence of hyperandrogenism. Although they were not included as a criterion for diagnosis, ovarian morphological changes detected by ultrasound (eight or more subcapsular follicular cysts ≤10 mm (18) and in some cases increased ovarian stroma) were present in all patients in this group.

Idiopathic hirsutism (IH) was defined as (i) presence of terminal hairs in a male-like pattern quantified by Ferriman-Gallwey score of ≥8 (19), (ii) no biochemical evidence of hyperandrogenism, (iii) no menstrual cycle abnormalities and (iv) normal ovarian ultrasonographic appearance. Controls had normal ovulatory cycles and no clinical or laboratory findings of androgen excess and normal ovarian morphology on ultrasound. None of the participants received oral contraceptives, antihypertensive drugs or any other medication for the 6 months preceding the study. None of the participants was a former or current smoker. Non-ovarian causes of hyperandrogenism were excluded. All measurements were performed during the follicular phase of the menstrual cycle in those with menstrual cyclicity and at any time in the PCOS women. Recent ovulation of the amenorrheic women was excluded by measurements of progesterone levels (< 5 nmol/l).

Exclusion criteria were (i) arterial hypertension, (ii) diabetes mellitus, (iii) hyperlipidemia, and (iv) coronary artery disease. All participants gave informed consent and the scientific committee of our institution approved the study protocol.

Study protocol

Measurements began approximately at 20:30 h. Subjects were fasted for 12 h. An ovarian ultrasonogram was performed in every participant during the previous day. A fasting serum sample was obtained for determination of total cholesterol, high-density lipoprotein cholesterol, triglycerides, creatinine, glucose, insulin, thyroid, steroid and pituitary hormones. Basal insulin resistance index (HOMA) was calculated according to the formula (20):

\[
\text{Insulin resistance} = \frac{F1 \times G}{22.5}, \quad \text{where } F1 = \text{fasting insulin (}\mu\text{U/ml)} \text{ and } G = \text{fasting glucose (mmol/l)}.
\]

The body mass index (BMI) was calculated by the formula:

\[
\text{BMI} = \frac{\text{weight (kg)}}{\text{[height (m)]}^2}.
\]

The waist to hip ratio was measured as the ratio between the circumferences of the waist at the level midway between the lowest rib margin and the iliac crest and the hip at the widest trochanters.

Serum total testosterone and estradiol were measured using a chemiluminescence assay (ACS-180, Bayer). Serum insulin immunoreactivity was measured by ELISA (Boehringer Biochemicals, Mannheim Germany). Dehydroepiandrosterone-sulfate (DHEA-S) was measured by RIA (Radim Spa Italia, Rome, Italy). Standard methods were used for glucose, cholesterol and triglyceride determinations.

Venous occlusion strain-gauge plethysmography

Subjects were kept in a supine position in a quiet, dark, air-conditioned room (constant temperature, 22 °C to 25 °C) throughout the study. After 10 min in a supine position, endothelial function of resistance arteries was assessed by measuring forearm blood flow response (FBF) during reactive hyperemia (RH) as previously described (21). FBF was measured using a mercury-filled silastic strain-gauge plethysmograph (EC-5R, D.E Hokanson Inc.). A wrist cuff was inflated to a pressure of 50 mmHg above the systolic blood pressure of each subject 4 min before each measurement (occluded FBF), as this is the proposed duration of arterial occlusion to produce close to maximal vasodilatation of the blood vessels and maximal peak RH FBF. Furthermore, an upper arm cuff was inflated to 50 mmHg for 7 s during each 15 s cycle using a rapid cuff inflator (EC-20, D.E Hokanson, Inc.) to occlude venous outflow from the arm. FBF output signal was transmitted to a recorder (U-228 advance Co, Nagoya, Japan). FBF was expressed as millilitres per minute per 100 ml of forearm tissue.

Four plethysmographic measurements were averaged to yield values for FBF at baseline. After releasing the wrist-occluded cuff, FBF was measured every 15 s for 3 min. The forearm vascular response to RH was then

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evaluated. Blood pressure was measured in the left arm at baseline and during RH every 1 min starting from time point 0 after release of the arterial occlusion.

**Derived parameters**

Percentage change of flow (dfl %) during hyperemia was calculated as \( \{[\text{reactive hyperemia FBF}-(\text{basal flow})]/(\text{basal flow})\} \times 100 \). Maximal percentage change of flow (max dfl %) corresponds to dfl % during peak RH FBF observed immediately after arterial occlusion release.

Duration of reactive hyperemia (durRH) was calculated separately for each individual by calculating the time needed for hyperemic flow to return to baseline levels as previously described (21). Baseline level for each subject was defined as the subject’s basal flow ± s.d. plus the difference of the group’s lower hyperemic blood flow minus the group’s basal flow.

**Statistical analysis**

All variables of the continuous plethysmographic parameters were expressed as mean ± standard deviation. The normality of distribution of our data was checked using the Shapiro Wilk W test. No variable was found to have a normal distribution according to the above test. The non-parametric Mann–Whitney U test was used for comparison of continuous data with non-normal distribution. The non-parametric Spearman correlation coefficient was calculated and evaluated to identify significant associations between flow parameters and demographic traits and the lipid profiles of patients that were not normally distributed. Median regression (least absolute traits and the lipid profiles of patients that were not normally distributed. Median regression (least absolute value) analysis was also used in order to investigate potential linear relationship between the dependent variable (durRH) and other candidate independent variables. The results were considered statistically significant if the two-tailed \( P \)-value was less than 0.05.

Data were analyzed using STATA (Version 8.0, Stata Corporation, College Station, TX 77845, USA).

**Results**

The characteristics of the study groups are shown in Table 1.

The durRH was shorter in PCOS group when compared with normal controls (63.75 ± 13.33 s vs 113.18 ± 20.92 s, \( P = 0.036 \)). A similar finding was observed when PCOS were compared with IH group (63.75 ± 13.33 s vs 105 ± 17.20 s, \( P = 0.05 \)). The durRH did not differ between IH and controls (105 ± 17.20 s vs 113.18 ± 20.92 s, ns) (Fig. 1).

A statistically significant positive linear correlation was found between the durRH and DHEA-S levels (\( r = +0.48, P = 0.04 \)) in the PCOS group.

When the group of PCOS was divided according to BMI levels in BMI ≤ 25 and BMI > 25 subgroups, this association was only marginally significant (\( P = 0.07 \) and \( P = 0.08 \) respectively). No significant association of DHEA-S with durRH was found when the whole population was examined as one group.

The HOMA index of basal insulin resistance, was significantly different between PCOS and control group (2.45 ± 0.77 vs 0.36 ± 0.14, \( P < 0.0001 \)) as well between the PCOS and IH groups (2.45 ± 0.77 vs 0.50 ± 0.17, \( P = 0.002 \)). The HOMA index did not differ significantly between IH and the control group (0.50 ± 0.17 vs 0.36 ± 0.14, \( P = 0.09 \)). There was no significant correlation between durRH and HOMA index or testosterone levels in the PCOS group (Table 2). The FBF at rest and the peak RH FBF did not differ significantly between controls and PCOS or IH groups (Table 3). Maximum % increase of FBF (max dfl %) did

### Table 1 Baseline characteristics of the study population.

<table>
<thead>
<tr>
<th>Variable</th>
<th>PCOS (n=27)</th>
<th>IH (n=16)</th>
<th>Controls (n=13)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (year)</td>
<td>25.6±5.8</td>
<td>27.8±6.5</td>
<td>25.7±5.6</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>28.4±6.6a</td>
<td>25±3.3</td>
<td>23.2±2.7</td>
</tr>
<tr>
<td>Waist/hip ratio</td>
<td>0.8±0.09</td>
<td>0.76±0.05</td>
<td>0.76±0.04</td>
</tr>
<tr>
<td>SBP (mmHg)</td>
<td>115±20</td>
<td>113±19</td>
<td>109±12</td>
</tr>
<tr>
<td>DBP (mmHg)</td>
<td>75±13</td>
<td>75±16</td>
<td>72±9</td>
</tr>
<tr>
<td>Cholesterol (mg/dl)</td>
<td>183.9±28.7</td>
<td>176.4±28.1</td>
<td>173.6±28.8</td>
</tr>
<tr>
<td>HDL (mg/dl)</td>
<td>54±13.5</td>
<td>59.6±16.4</td>
<td>51±6.5</td>
</tr>
<tr>
<td>LDL (mg/dl)</td>
<td>105±8.6</td>
<td>103±10.1</td>
<td>101±9.8</td>
</tr>
<tr>
<td>Triglycerides (mg/dl)</td>
<td>108±78.6a,b</td>
<td>56±28.06</td>
<td>52±19.9</td>
</tr>
<tr>
<td>Insulin (µU/ml)</td>
<td>11.4±18.2a</td>
<td>2.1±0.25</td>
<td>1.65±0.22</td>
</tr>
<tr>
<td>17α-estradiol (nmol/l)</td>
<td>0.18±0.09</td>
<td>0.28±0.2</td>
<td>0.33±0.2</td>
</tr>
<tr>
<td>Glucose (mg/dl)</td>
<td>89.3±11</td>
<td>91±8.5</td>
<td>86±5.4</td>
</tr>
<tr>
<td>Testosterone (nmol/l)</td>
<td>2.2±0.9a</td>
<td>1.92±0.7c</td>
<td>1.3±0.4</td>
</tr>
<tr>
<td>DHEA-S (µmol/l)</td>
<td>8.97±5.5a</td>
<td>9.06±5.3</td>
<td>6.27±3.5</td>
</tr>
<tr>
<td>HOMA index</td>
<td>2.45±3.9a,b</td>
<td>0.5±0.6</td>
<td>0.36±0.5</td>
</tr>
</tbody>
</table>

DHEA-S: dehydroepiandrosterone-sulfate; BMI: body mass index; SBP: systolic blood pressure; DBP: diastolic blood pressure; HDL: high density lipoprotein; LDL: low density lipoprotein. Values are mean±s.d.

*aP < 0.05, PCOS vs controls, *P < 0.05, PCOS vs IH, *P < 0.05, IH vs controls.

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not differ significantly between the three groups of our study (Table 3).

In order to exclude a potential effect of the group on the durRH, the variables which were found to differ significantly between controls, PCOS and IH groups (Table 1) were selected for median regression (least absolute value) modeling, including those variables for which the \( t \) test had a \( P \)-value less than 0.05. Thus we concluded that the group that the patients belonged to and insulin levels predicted linearly and significantly the durRH (Table 4) whereas we found no such associations for the other candidate variables.

**Discussion**

Metabolic and hormonal alterations have long been recognized as possible contributing factors to the pathophysiology of CVD and have thus been studied extensively. Relevant to this issue, in this clinical observational study, we have found impaired endothelial function expressed as impaired durRH in young women with PCOS. We have also shown that durRH is associated positively with DHEA-S levels, which is the most abundant androgen produced by the adrenals (22). To the best of our knowledge, this is the first time that a beneficial role of the androgen DHEA-S in endothelial function is reported in women with PCOS.

Endothelial dysfunction has previously been reported in PCOS either by estimation of flow-mediated dilatation (FMD) in the brachial artery of lean, obese and normal weight PCOS women (23, 24), or by studying leg blood-flow with an invasive technique in a small number of obese women with PCOS (25).

RH, an adaptive mechanism of vascular endothelium to hypoxia stimulus, is affected by nitric oxide (NO) production from intact endothelial cells (10, 26, 27). It is believed that the early phase of RH (peak RH FBF, and maxdl %) is related to vessel wall structure abnormalities and not to endothelial function (28). Tagawa \textit{et al.} (26) have reported that NO mainly contributes to the mid and late phase of FBF response after peak vasodilatation and thus augments the durRH whereas it plays a minor role in the peak FBF that represents the early phase of RH. In our study no differences were observed in the early phase of RH between the study groups. On the contrary we found that durRH is significantly shorter in the study group of young PCOS women when compared both with healthy, age-matched females and a group of subjects with IH. A reduction of durRH has already been reported in hypercholesterolemic patients, while administration of an antioxidant ameliorates the durRH (21), suggesting that increased oxidative stress has causal relationship with impaired durRH in these patients. Increased oxidative stress has been observed in women with PCOS (29), so this might be the pathophysiological mechanism underlying these differences.

**Table 2** Simple correlations of various metabolic and hormonal parameters with duration of reactive hyperemia (durRH) in the study groups.

<table>
<thead>
<tr>
<th>Correlation of durRH with:</th>
<th>PCO</th>
<th>IH</th>
<th>Controls</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>-0.08</td>
<td>0.69</td>
<td>0.32</td>
</tr>
<tr>
<td>Weight</td>
<td>-0.10</td>
<td>0.62</td>
<td>-0.30</td>
</tr>
<tr>
<td>Testosterone</td>
<td>0.06</td>
<td>0.76</td>
<td>-0.52</td>
</tr>
<tr>
<td>Waist/hip ratio</td>
<td>-0.043</td>
<td>0.84</td>
<td>0.05</td>
</tr>
<tr>
<td>Glucose</td>
<td>-0.15</td>
<td>0.46</td>
<td>-0.06</td>
</tr>
<tr>
<td>BMI</td>
<td>-0.004</td>
<td>0.98</td>
<td>-0.11</td>
</tr>
<tr>
<td>Prolactin</td>
<td>0.15</td>
<td>0.51</td>
<td>0.15</td>
</tr>
<tr>
<td>Insulin</td>
<td>0.19</td>
<td>0.35</td>
<td>-0.50</td>
</tr>
<tr>
<td>HOMA index</td>
<td>0.16</td>
<td>0.45</td>
<td>0.50</td>
</tr>
<tr>
<td>17(\alpha)-estradiol</td>
<td>0.46</td>
<td>0.06</td>
<td>-0.13</td>
</tr>
<tr>
<td>Progesterone</td>
<td>0.06</td>
<td>0.77</td>
<td>0.22</td>
</tr>
<tr>
<td>DHEA-S</td>
<td>0.48</td>
<td>0.04</td>
<td>0.40</td>
</tr>
<tr>
<td>Cholesterol</td>
<td>-0.17</td>
<td>0.49</td>
<td>0.66</td>
</tr>
<tr>
<td>Triglycerides</td>
<td>0.17</td>
<td>0.54</td>
<td>-0.24</td>
</tr>
<tr>
<td>HDL-cholesterol</td>
<td>0.26</td>
<td>0.33</td>
<td>0.40</td>
</tr>
<tr>
<td>LDL-cholesterol</td>
<td>-0.33</td>
<td>0.40</td>
<td>-0.32</td>
</tr>
</tbody>
</table>
The most interesting finding of our study is that in the group of PCOS, the durRH is positively correlated with DHEA-S levels, possibly showing a protective effect of DHEA-S on vascular function. Previous studies have reported that DHEA-S directly induces endothelial NO synthesis through genomic and non-genomic mechanisms characterizing human endothelial cells as primary targets for DHEA-S (30). Furthermore, DHEA-S supplementation improves endothelial function and insulin sensitivity in men (31).

Accordingly, DHEA-S levels have been reported to correlate inversely with the intima-media thickness of carotid arteries in young PCOS women (32, 33). Another possible explanation for the vascular protective effect of DHEA-S may be by means of prevention of platelet aggregation (34), reduction of cholesterol uptake (35, 36) and decrease of vascular smooth muscle cells proliferation (37). A favorable effect through conversion of DHEA-S to estradiol (38) may also contribute to the improvement of endothelial function. Interestingly, a negative relationship between DHEA-S, coronary artery disease (CAD) and atherosclerosis has been documented in cross sectional studies in young women (39, 40, 41).

However, it is important to note that other investigators have not found associations of DHEA-S levels with cardiovascular function parameters (42, 43, 44).

Additionally, a number of studies were designed to examine the possible association of endothelial function with DHEA-S, with negative results (24, 25, 33, 45). The discrepancy between our results and those of the previously mentioned studies could be explained by the DHEA-S much lower levels that could have obscured any effect of the hormone on endothelial function. Accordingly, no correlations were found between DHEA-S levels and durRH in the groups having lower levels of DHEA-S in our study (Table 2). Additionally, when the whole population of our study was analyzed as one group (results not shown) the association between DHEA-S and the endothelial function index could no longer be depicted, obviously because the effect is diluted and can thus only be revealed in the case of elevated DHEA-S and/or abnormal endothelial function.

Although we have no data on free androgen index, total testosterone levels did not correlate significantly with durRH in the PCOS group in this study. Indeed the various published studies, which have examined the possible role of testosterone on vascular endothelium function and cardiovascular disease in the female population, have reported conflicting results (46, 47).

Studies performed in young obese PCOS women have shown correlations of testosterone and insulin levels with endothelial dysfunction and increased arterial stiffness (25, 48). However, Mather et al. have recently reported normal endothelial function despite insulin resistance in healthy obese PCOS women (49) and additionally a lack of negative effect of androgen levels in endothelial function. It is important to note that in the study by Mather et al. levels of DHEA-S were not estimated and thus any evaluation of the potential role of DHEA-S in endothelial function was not possible.

Although the PCOS group in our study had increased HOMA insulin resistance index compared to IH group and controls, the index itself did not correlate with parameters of endothelial dysfunction. Insulin resistance has been proposed as the key factor linking hypertension, impaired glucose tolerance, obesity and lipid abnormalities with CAD in young women with PCOS (50). Indeed, several lines of evidence support the presence of a strong association between insulin resistance and endothelial dysfunction (51–54). However, a recent study designed to examine the relationship between metabolic and hormonal indices and markers of early cardiovascular disease in PCOS, showed no relationship between endothelial dysfunction and insulin resistance. Insulin resistance in this study seems to exert its effect on the peripheral vascular system through the arterial media layer and not the endothelium, as evidenced by its association with arterial stiffness and pulse wave velocity (33).

### Table 3 Plethysmographic parameters in the three study groups.

<table>
<thead>
<tr>
<th></th>
<th>PCOS (n=27)</th>
<th>IH (n=16)</th>
<th>Controls (n=13)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FBF at rest (ml/min/100 ml)</td>
<td>4.96±2.8</td>
<td>4.12±2.1</td>
<td>5.4±3.2</td>
</tr>
<tr>
<td>Peak RH FBF (ml/min/100 ml)</td>
<td>9.8±6.1</td>
<td>7.49±4.9</td>
<td>9.9±5.3</td>
</tr>
<tr>
<td>Max (dfl%)</td>
<td>102.6±81.9</td>
<td>101.4±98.1</td>
<td>96.4±49.9</td>
</tr>
</tbody>
</table>

### Table 4 Median regression for durRH.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coef.</th>
<th>Standard error</th>
<th>t</th>
<th>P &gt; t</th>
<th>(95% Confidence interval)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group (categories vs controls (reference))</td>
<td>PCOS group</td>
<td>−113.781</td>
<td>45.63711</td>
<td>2.49</td>
<td>0.016</td>
</tr>
<tr>
<td></td>
<td>IH Group</td>
<td>−30</td>
<td>49.33685</td>
<td>0.61</td>
<td>0.546</td>
</tr>
<tr>
<td>Insulin</td>
<td>1.567944</td>
<td>0.636955</td>
<td>2.46</td>
<td>0.018</td>
<td>0.284247 2.851642</td>
</tr>
<tr>
<td>Intercept</td>
<td>133.7456</td>
<td>36.19222</td>
<td>3.7</td>
<td>0.001</td>
<td>60.80502 206.6863</td>
</tr>
</tbody>
</table>

(Number of obs = 48, Min sum of deviations = 2477.352, Pseudo $R^2 = 0.1659$)
IH may represent a condition possibly related to PCOS; however, we did not find any differences in dHR between this group and controls. This suggests that if IH is indeed related to PCOS, it probably represents a very mild variant and supports the view of a large heterogeneity in the PCOS syndrome.

The findings of our study may offer some explanation for the observed discrepancy between the calculated risk level for cardiovascular events and the fact that the number of deaths due to CVD was not increased in the two published studies of mortality in women with PCOS (55, 56). This observation leads to the speculation that PCOS women are probably of “intermediate phenotype” regarding cardiovascular risk. It is possible that increased DHEA-S levels, frequently encountered in PCOS, and their putative protective effect on the endothelium may partly explain this complex association. It is thus possible that anti-androgen treatment might not be very suitable at least for the preservation of vascular health in PCOS, while the favorable effect of insulin sensitizers in the vasculature may only be mediated through their effect on insulin resistance and not through the resulting amelioration in androgen levels. It seems that the lifestyle modifications need to be the focus of advice in these women to improve endothelial dysfunction and possibly reduce cardiovascular risk.

The limitations of our study include the small number of subjects in each group and its observational character. However, we studied a population covering considerable part of the spectrum of conditions associated with hirsutism and putative hyperandrogenism. Diagnostic criteria utilized in clinical trials of such conditions may pose a further limitation since they are not absolutely sufficient for clinical diagnosis and grouping of the population studied (8). Our findings are not confounded by obesity, which has several relevant influences on its own. Endothelial-independent vasodilatation was not estimated in our study, so we cannot exclude an effect of DHEA-S on smooth muscle cell function of resistance arteries in PCOS women. One further limitation is the lack of data on SHBG and consequently on free androgen index (FAI) during the vascular studies which may obscure the potential impact of testosterone in endothelial function but we support the idea that this limitation does not alter the main message of our study: i.e. the possible protective role of DHEA-S in endothelial function in women with PCOS.

In conclusion, endothelial dysfunction may be the early sign for complications of cardiovascular system in young PCOS women. These preliminary findings indicate that increased DHEA-S levels may offer a cardioprotective advantage that attenuates the effects of the cardiovascular risk factors that accompany the PCOS. It should be pointed out that these findings do not support the therapeutic use of DHEA-S and that larger cohort studies with longitudinal follow up are needed to determine the possible role of androgens in women with PCOS.

References


50 Dunaf A. Insulin resistance and the polycystic ovary syndrome: mechanisms and implications for pathogenesis. *Endocrine Reviews* 1997 **18** 774–800.


53 Paradisi G, Steinberg H, Marguette K, Hook G & Baron A. Troglitazone therapy improves endothelial function to near normal levels in women with polycystic ovary syndrome. *Journal of Clinical Endocrinology and Metabolism* 2003 **88** 576–580.


56 Wild SH, Pierpoint T, McKeigue PM & Jacobs HS. Cardiovascular disease in women with polycystic ovary syndrome at long-term follow-up: a retrospective cohort study. *Clinical Endocrinology* 2000 **52** 595–600.

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