Does polycystic ovary syndrome with phenotype D affect the cardiovascular endurance, core endurance, body awareness, and the quality of life? A prospective, controlled study

Fenotip D’li polikistik over sendromu kardiyovasküler enduransı, kor enduransı, vücut farkındalığını ve yaşam kalitesini etkiler mi? Prospektif, kontrollü çalışma

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Abstract

Objective: This study evaluates cardiovascular endurance, core endurance, body awareness, and the quality of life in normal-weight women with polycystic ovary syndrome.

Materials and Methods: This study included a total of 101 normal-weight women (51 with and 50 without polycystic ovary syndrome). Cardiovascular endurance was evaluated with the 20-meter Shuttle Run test, and maximum oxygen consumption was calculated. Core endurance was evaluated with core stability tests, body awareness with the body awareness questionnaire, and the quality of life with short form-36. Blood lipids, glucose, insulin, homeostatic model assessment for insulin resistance (HOMA-IR), hormonal profile, and high-density and low-density lipoprotein cholesterol were measured.

Results: Maximum oxygen consumption, core endurance, body awareness questionnaire, and short form-36 results were lower in women with polycystic ovary syndrome than healthy women (p<0.05). There was a significant correlation between core endurance tests, high-density lipoprotein cholesterol, maximum oxygen consumption, and homeostatic model assessment for insulin resistance scores (p<0.05).

Conclusion: When normal-weight women with polycystic ovary syndrome and control groups with similar androgen levels and body mass index profiles were compared, women with polycystic ovary syndrome had lower aerobic capacity and muscle endurance. This suggests that the adverse metabolic profile of polycystic ovary syndrome can limit physical function.

Keywords: Polycystic ovary syndrome, exercise tolerance, core stability, body image

ÖZ

Amaç: Bu çalışmada, normal kilolu polikistik over sendromlu kadınların kardiyovasküler enduransının, kor enduransının, vücut farkındalığının ve yaşam kalitesinin değerlendirilmesi amaçlanırdı.

Gereç ve Yöntemler: Bu çalışmaya toplam 101 normal kilolu kadın (51 polikistik over sendromlu ve 50 polikistik over sendromsuz) dahil edildi. Kardiyovasküler endurans, 20 metreklik Shuttle Run testi ile değerlendirildi ve maksimum oksijen tüketimi hesaplandı. Kor enduransları kor stabilite testleri ile, vücut farkındalığı vücut farkındalığı anketi ile, yaşam kaliteleri kısa form-36 ile değerlendirildi. Kan lipitleri, glukoz, insulin, homeostatik model değerlendirmesi (HOMA-IR), hormon profilleri ve yüksek yoğunluklu ve düşük yoğunluklu lipoprotein kolesterol ölçüldü.

Bulgular: Polikistik over sendromlu kadınlarda maksimum oksijen tüketimi, kor endurans, vücut farkındalık anketi ve kısa form-36 sonuçları sağlıklı kadınlara göre daha düşüktü (p<0.05). Kor endurans testleri ile yüksek yoğunluklu, lipoprotein kolesterol, maksimum oksijen tüketimi ve homeostatik model değerlendirilmesi insulin direnci skorları arasında anlamlı bir ilişki vardı (p<0.05).

Conclusions: When normal-weight women with polycystic ovary syndrome and control groups with similar androgen levels and body mass index profiles were compared, women with polycystic ovary syndrome had lower aerobic capacity and muscle endurance. This suggests that the adverse metabolic profile of polycystic ovary syndrome can limit physical function.

Keywords: Polycystic ovary syndrome, exercise tolerance, core stability, body image

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Received/Geliş Tarihi: 30.05.2021 Accepted/Kabul Tarihi: 20.06.2021

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Turkish Journal of Obstetrics and Gynecology published by Galenos Publishing House.
Introduction

Polycystic ovary syndrome (PCOS) affects 6–10% of reproductive-aged women. PCOS is a common endocrinological disease that can have progressive metabolic effects. Hyperandrogenism, ovulatory dysfunction, dyslipidemia, and insulin resistance (IR) are the principal features of this syndrome. Also, women with PCOS have more cardiovascular risk factors, such as dyslipidemia, hypertension, glucose intolerance, and diabetes, compared with women without PCOS.

The maximal oxygen consumption (VO₂max) is the highest amount of oxygen used by the body during maximal exercise, and the risk of cardiovascular disease increases when VO₂max is reduced. Studies are contradictory about whether PCOS affects VO₂max. One study stated that VO₂max values of women with and without PCOS were similar. A second study found that VO₂max values of women with PCOS were lower than those without PCOS.

In addition to the change in VO₂max, muscle function may also be affected by biochemical results in PCOS. Insulin is the primary regulator of muscle proteins. It can stimulate mitochondrial protein synthesis. Androgens can increase muscle strength or endurance and may promote free-fat muscle growth. When the amount of high-density lipoprotein cholesterol (HDL) decreases, it can decrease muscular function by increasing the release of proinflammatory cytokines. Core endurance is a muscle function (abdominal, paraspinal, gluteal, diaphragm, and pelvic floor muscles) PCOS can affect core muscles due to impaired biochemical profiles.

The endurance of the core muscles and the cardiorespiratory system are among the parameters of physical function. Body awareness informs the individual of the relationship between physical function and mental activity and explains how these factors affect the body. Alexander stated that the change in muscular functions decreases physical awareness and information from the body. Based on studies showing changes in these factors, PCOS may also affect the body awareness. In addition, the change in the appearance of women with PCOS, infertility, decrease in performance, and cardiovascular disease risk may affect their quality of life (QOL).

To the best of our knowledge, there are no studies comparing women with and without PCOS regarding VO₂max, core endurance, QOL, and body awareness. Studies on PCOS have mainly been conducted on obese women. We wanted to exclude the obesity factor to examine the effect of PCOS. The present study evaluates VO₂max, core endurance, body awareness, and QOL in normal-weight women with and without PCOS and investigate the effect of PCOS on these parameters.

Materials and Methods

Study Design and Participants

This case-control study was conducted prospectively in the gynecology department of a tertiary hospital. Also, permission was granted from the Clinical Research Ethics Committee of the University before the study (decision no: 2017-KAEK-189_2020.01.08_04). All participants were informed about the study based on the 1975 Helsinki Declaration. All participants also signed informed consent that they agreed to participate in the study.

Inclusion criteria were weight stability (<2.0 kg weight changes) for the last 3 months, 18-40 years of age, willingness to participate in the study, and having normal weight [body mass index (BMI): 18.5-24.99 kg/m²]. The exclusion criteria for both groups included smoking, volunteers who performed regular exercise, cardiovascular and chronic diseases, androgen-secreting tumors, late-onset 21-hydroxylase deficiency, drugs (such as hormones, anti-diabetic agents, and oral contraceptives), and pregnancy. Participants with a history of angina or any other cardiopulmonary or physical symptoms that could affect exercise performance were also excluded.

The diagnosis of PCOS was made according to the Rotterdam criteria: those with two of the three criteria were diagnosed as PCOS: oligo and/or anovulation (>35 days or <8 spontaneous menstruation/year), biochemical and/or clinical (Ferriman-Gallwey score >8) hyperandrogenism, and polycystic ovary (12 or more follicles 2-9 mm in diameter in each ovary and/or ovarian volume >10 mL). We included only phenotype D-PCOS women in our study, as hyperandrogenism may affect muscle strength. In our study, the women in the PCOS group were identified according to the specific European Society for Human Reproduction and Embryology and the American Society for Reproductive Medicine phenotypes as type D: oligo and/or anovulation (35 days or <8 spontaneous menstruation/year), biochemical and/or clinical (Ferriman-Gallwey score >8) hyperandrogenism, and polycystic ovary (12 or more follicles 2-9 mm in diameter in each ovary and/or ovarian volume >10 mL). We included only phenotype D-PCOS women in our study, as hyperandrogenism may affect muscle strength. In our study, the women in the PCOS group were identified according to the specific European Society for Human Reproduction and Embryology and the American Society for Reproductive Medicine phenotypes as type D: oligo and/or anovulation (35 days or <8 spontaneous menstruation/year), biochemical and/or clinical (Ferriman-Gallwey score >8) hyperandrogenism, and polycystic ovary (12 or more follicles 2-9 mm in diameter in each ovary and/or ovarian volume >10 mL).

According to the reference study results, they had a large effect size (d=0.71). Assuming we could achieve a lower effect size level (d=0.5), a power analysis was performed before the study. Accordingly, when at least 100 participants 50 from the PCOS group and 50 from the control group) were included in the study, which would result in 80% power with a 95% confidence level (5% type 1 error rate).
Evaluations

Demographic characteristics [age (years), education (primary school, high school, or university), and employment status (yes or no)] were questioned, and waist-hip ratio (WHR) was calculated.

Ultrasonography: Morphological features of the ovaries of all participants were examined by transabdominal/transvaginal ultrasonography (GE Voluson E8, USA)(4,12)

Biochemical analysis: Blood samples were collected on the second or third days of the menstrual cycle. Serum insulin, luteinizing hormone, follicle-stimulating hormone, and total testosterone levels were measured via electrochemiluminescence immunoassay on a Roche COBAS 6000 e601 (Roche Diagnostics, Mannheim, Germany) autoanalyzer. Fasting glucose, total cholesterol (TC), high-density lipoprotein cholesterol (HDLC), and triglyceride (TG) levels were analyzed on a Roche COBAS 6000 c501 (Roche Diagnostics) autoanalyzer. Low-density lipoprotein cholesterol (LDL-C) was calculated using the Friedewald formula when the TG level was less than 400 mg/dL. Homeostatic model assessment for insulin resistance (HOMA-IR) was used to calculate IR. HOMA-IR (fasting blood glucose mg/dL x fasting insulin mIU/L/405) value ≥2.5 was accepted as the presence of IR(3,4,10).

Cardiorespiratory endurance: The cardiovascular endurance level (VO2max) of all participants was evaluated with the 20-meter shuttle run test (20mSRT)(8,21). This test was developed in accordance with the Eurofit test Battery (1988) directives. In the 20mSRT, the participants ran continuously on a 20-m-track at an initial speed of 8 km/h, which increased 0.5 km/h per one minute. The running pace was adjusted using a timer and signal generator. The women who took the test were asked to complete the 20-m-course at each signal. The test was terminated for women unable to reach the lines one meter before the lines that determined the 20 meters when the signal was received. The running pace in accordance with the test protocol was provided by the signals obtained from the Pro Tmr Esc 1000 sport test timer(21,22). VO2max levels in mL/kg/min were calculated using Leger's formula(23):

\[ \text{VO2 peak}=31.025+3.238*S - 3.248*A + 0.1536*S*A \]

\[ S=\text{final speed (kmh}-1); A=\text{age (years)}. \]

Core endurance: A protocol developed by McGill was used to assess the endurance of the core muscles. Core endurance was evaluated with a core stability test (trunk flexion, extension, and lateral right/left bridge tests). In the trunk flexion test (TFT), the participants were seated on the treatment table with a wedge that provided a 45° flexion on their back. The knees were brought to 90° flexion. The test was ended when the upper body could not maintain the 45° angle (Figure 1a). In the trunk extensor endurance test (TEET), the participants were asked to lie on the treatment table in the prone position. In the prone position, the spina iliaca anterior superior part of the participant was placed on the edge of the table. The body was suspended from the table (Figure 1b). The lateral bridge test (RBT/LBT): Participants were asked to build a side bridge by standing on the forearms with the elbow flexed at 90° in the side-lying position. They were also instructed to lift the hip off the table with the other arm and hand. The test was terminated when the straight body position could not be maintained. This test was repeated for both the right and left sides separately. The time to maintain these positions was recorded (Figure 1c) (10,24,25).

Body awareness: Participants’ body awareness was evaluated using the body awareness questionnaire (BAQ) developed by Shields et al.(26) Turkish validity and reliability of the questionnaire were carried out by Karaca and Bayar(27) Participants’ body awareness was evaluated using the BAQ(13). BAQ aims to evaluate cases with sensitivity to body cycles and rhythms, the ability to perceive minor changes in normal functioning, and the ability to predict bodily responses. BAQ consists of 18 items and 4 subdimensions. The four subdimensions are as follows: body reactions estimation (BAQ-I), sleep-wake cycle (BAQ-II), prediction at the onset of the disease (BAQ-III), and paying attention to the changes in body processes and reactions (BAQ-IV). Each of the 18 expressions is scored between 1 and 7 (1=Not at all true about me, 7=Very true about me)(26). The higher the score obtained from the questionnaire, the higher the level of body awareness.

QOL: Participants’ QOL was evaluated using the short form-36 (SF-36) scale(28). Turkish validity and reliability of the scale were conducted by Kocyigit et al.(28) in 1994. The SF-36 consists of 36 items and eight subdimensions. Physical function, role restriction due to physical problems, role restriction due to emotional problems, mental health perception, social function, general health perception, body pain, and vitality comprised the subdimensions. The scoring of each section was between 0 and 100. Zero indicated the lowest QOL, whereas 100 indicated the highest QOL(14).

Figure 1a. Trunk flexor bridge test, b. Trunk extensor bridge test, c. Left/right side bridge test
Statistical Analysis

All statistical analyses were performed using SPSS 25.0 software. Continuous variables were defined by the mean ± standard deviation, median (minimum-maximum values), and categorical variables were defined by number and percent. The Kolmogorov-Smirnov test was used for the determination of normal distribution. For independent group comparisons, an independent samples t-test was used when parametric test assumptions were not provided. A Spearman correlation analysis was performed to analyze the relationships between continuous variables. The effect of PCOS on continuous variables was determined by linear regression analysis models using dummy variables. Statistical significance was determined as p<0.05.

Results

In the present study, 101 women [control group (50 women) and PCOS group (51 women)] were included in the study. Their demographic information is provided in Table 1. There was no significant difference in women’s age, education, BMI, and occupation status between the groups (p>0.05).

The comparison of the biochemical results, VO2max, core endurance tests, body awareness, and the quality of life of participants is shown in Table 2. WHR and HOMA-IR index variables were higher in the PCOS group compared with the control group (p<0.05). HDL-C, VO2max, and mean ± standard deviation, *Mann-Whitney U test (z), ***Independent Samples t-test (t)

Table 1. Demographic characteristics of participants

|                        | Control (n=50) | PCOS (n=51) | P  |
|------------------------|---------------|-------------|----|
| Age (y)*               | 25 (18-34)    | 24 (18-38)  | 0.27 (z=-1.10) |
| BMI (kg/m²)**          | 22.7±1.33     | 23.0±1.12   | 0.317 (t=3.568) |
| Total                  |               |             |    |
| Education status**     | 0.88 (χ² 0.24) |            |    |
| Primary education      | 1 (2%)        | 1 (2%)      | 2 (2%) |
| High school            | 19 (38%)      | 17 (33.3%)  | 36 (35.6%) |
| University             | 30 (60%)      | 33 (63.7%)  | 63 (62.4%) |
| Occupation**           | 0.622 (χ² 0.24) |            |    |
| Worker                 | 25 (50%)      | 23 (45.1%)  | 48 (47.9%) |
| Housewife              | 25 (50%)      | 28 (54.9%)  | 53 (52.5%) |

BMI: Body mass index; y: Years; M: Meter
Data is shown as median (min-max) and mean ± standard deviation
*Mann-Whitney U test (z), **chi square test (χ²), ***Independent samples t-test (t)

Table 2. Biochemical analyses, core endurance tests, body awareness, and the quality of life of participants

|                        | Control (n=50) | PCOS (n=51) | p     |
|------------------------|---------------|-------------|-------|
| WHR                    | 0.8 (0.64-1.07)| 0.85 (0.69-1.37)| 0.0001* (z=-4.748) |
| HDL-C (mg/dL)          | 61.55±15.43   | 49.17±9.37  | 0.0001* (t=4.882) |
| LDL-C (mg/dL)          | 90 (20.98-159)| 88.42 (35-214.4)| 0.555 (z=0.591) |
| HOMA-IR (mg/dL)        | 1.79          | 2.81        | 0.0001* (z=4.790) |
| Triglycerides (mmol/L) | 67.45         | 75          | 0.055 (z=3.277) |
| Total cholesterol (mmol/L) | 148.45 (84.5-259) | 153 (102.4-269) | 0.257 (z=1.134) |
| VO2max (ml/kg/minute)  | 24.7 (19-27.5)| 23.2       | 0.02* (z=-2.332) |
| Total testosterone (ng/mL) | 0.31         | 0.32        | 0.691 (z=-0.398) |
| SF-36                   |              |             |       |
| Physical function      | 87.5 (60-100) | 75 (60-100) | 0.0001* (t=10.360) |
| Physical role difficulty| 100 (0-100)  | 75 (50-100) | 0.0001* (z=7.326) |
| Emotional role difficulty| 66 (0-100)   | 66 (0-100)  | 0.745 (z=0.326) |
| Vitality               | 60 (30-85)    | 55 (40-80)  | 0.001* (z=-3.269) |
| Mental health          | 68.98±12.91   | 54.47±10.62 | 0.0001* (t=6.173) |
| Social function        | 75 (37.5-100) | 75 (25-100) | 0.136 (z=1.491) |
| Pain                   | 77.5 (50-100) | 75 (45-100) | 0.0001* (z=-3.502) |
| General health         | 67.5 (50-100) | 60 (40-85)  | 0.002* (z=-3.061) |

WHR: Waist-hip ratio; HOMA-IR: Homeostatic model assessment for insulin resistance; SF: Short-form; BAQ: Body awareness questionnaire; BAQ-I (anticipation of bodily reactions); BAQ-II (sleep/wake cycle); BAQ-III (anticipation at the onset of the disease); BAQ-IV (changes in body process); BAQ-II (sleep-wake cycle); BAQ-III (anticipation at the onset of the disease); BAQ-IV (changes in body process); TFT: Trunk flexion test; TEET: Trunk extensor endurance test; LBT: Lateral left bridge test; RBT: Lateral right bridge test; mL: Milligram; dL: Deciliter; mL: Milliliter; HDL-C: High-density lipoprotein cholesterol, LDL-C: Low-density lipoprotein cholesterol, PCOS: Polycystic ovary syndrome, Data is shown as median (minimum-maximum) and mean ± standard deviation, *Mann-Whitney U test (z), ***Independent Samples t-test (t)
was found between HDL-C and VO2max, TFT, TEET, RBT, and LBT scores (p<0.001). There was a negative correlation between VO2max and HOMA-IR, WHR, and triglyceride values (p<0.05). A negative correlation was found between TFT and WHR, HOMA-IR, and triglyceride values (p<0.05). A negative correlation was found between TEET and WHR and HOMA-IR values (p<0.001). A negative correlation was found between RBT and WHR, LDL-C, HOMA-IR, and TC values (p<0.05).

Correlations of VO2max, core endurance, body awareness, and QOL scores are shown in Table 4. A moderate negative correlation was found between BAQ-III and VO2max (p<0.05). A weak positive correlation was found between TEET and vitality and BAQ-II results (p<0.05). A moderate positive correlation was found between mental function and VO2max (p<0.05).

Considering these differences, the factors that affected the PCOS factor were investigated. PCOS decreased HDL-C, HOMA-IR, TFT, TEET, RBT, LBT, BAQ-total, BAQ-I, BAQ-II, BAQ-IV, physical function, physical role limitation, vitality, mental, pain, and general score variables (standard beta values, from -0.910 to -276). Also, PCOS had an increasing effect on the HOMA-IR index and BAQ-III variables (Table 5).

### Discussion

This study showed that normal-weight PCOS women with phenotype D had a lower cardiovascular endurance, core endurance, body awareness, and QOL than the women in the control group. To the best of our knowledge, this is the first study investigating the effect of normal weight in PCOS on these factors.

Many studies in the literature compare cardiovascular performance and QOL in PCOS\(^ {1,10,16}\). However, these studies were primarily conducted on obese women\(^ {1,16,20}\). In one of these studies\(^ {10}\), the mean BMI was 39.9±6.1 kg/m\(^2\), while in another study, the mean BMI values were 34.1±5.5 in PCOS and 35.5±4.9 kg/m\(^2\) in the control group\(^ {10}\). In the present study, the BMI of women with and without PCOS were 23.4±0.97 and 22.6±1.10 kg/m\(^2\), respectively. This study was the first study planned within normal BMI limits.

In one study\(^ {4}\), VO2max was evaluated, and its relationship with hormonal and metabolic factors was investigated. Another study\(^ {12}\) compared metabolic heart rate and VO2max factors in women with and without PCOS. In the present study, many factors that might affect the lifestyle in PCOS were investigated more comprehensively than studies reported in the literature.

In PCOS, proinflammatory cytokines can damage the endothelial tissue with the emergence of the inflammatory process. As a result of this tissue damage, the number of mitochondria and the amount of VO2max might decrease\(^ {1,3,4,17,28}\). VO2max is the maximum amount of oxygen the body can use during activity and is known as the best indicator of cardiovascular endurance. Only a few small studies are evaluated VO2max values in women with PCOS\(^ {3,4}\). Thomson et al.\(^ {4}\) found no difference in VO2max of women with and without PCOS who were overweight. Orio et al.\(^ {3}\) assessed VO2max in overweight women with PCOS and found that overweight women with PCOS had lower VO2max values than overweight women without PCOS\(^ {3,15}\). In our study, normal-weight women with PCOS had lower VO2max capacities than healthy women. We also found that the PCOS factor affects HDL-C and HOMA-IR values a relationship between HDL-C and VO2max. This result might indicate that IR and HDL-C factors affected myocardial and skeletal muscle metabolism. So, HOMA-IR and HDL-C should be regularly examined in PCOS, even at a normal weight.

### Table 3. Correlations between VO2max, core stability, and biochemical analyses variables

|                     | All patients |
|---------------------|--------------|
|                     | WHR          | HDL-C        | HOMA-IR      | Triglyceride |
|                     | (mg/dL)      | (mg/dL X μU/mL) | (mmol/L)    |
| VO2max (mL/kg/minute) | r -0.351     | 0.455        | -0.444       | -0.207       |
|                     | p 0.000      | 0.000        | 0.000        | 0.038        |
| TFT (s)             | r -0.459     | 0.525        | -0.505       | -0.277       |
|                     | p 0.000      | 0.000        | 0.000        | 0.005        |
| TEET (s)            | r -0.498     | 0.472        | -0.425       | -0.172       |
|                     | p 0.000      | 0.000        | 0.000        | 0.086        |
| RBT (s)             | r -0.480     | 0.462        | -0.457       | -0.192       |
|                     | p 0.000      | 0.000        | 0.000        | 0.055        |
| LBT (s)             | r -0.422     | 0.432        | -0.489       | -0.213       |
|                     | p 0.000      | 0.000        | 0.000        | 0.032        |

WHR: Waist-hip ratio, HOMA-IR: Homeostatic model assessment for insulin resistance, s: Second, TFT: Trunk flexion test, TEET: Trunk extensor endurance test, LBT: Lateral left bridge test, RBT: Lateral right bridge test, mg: Milligram, dL: Deciliter, mL: Milliliter, HDL-C: High-density lipoprotein cholesterol, r: Spearman correlation
In addition to VO2max, muscle strength and endurance have also been shown to affect the risk of morbidity and mortality. PCOS can alter muscle function through different metabolic and hormonal factors (such as hyperandrogenism, obesity, IR, HDL-C). Only two studies in the literature evaluated muscle strength in PCOS (4,5). One study (4) found no difference in the muscle strength of women with and without PCOS who were overweight and ignored the effect of hyperandrogenism on muscle function. Another study (5) found that women with PCOS had higher muscle strength than the control group. They stated that hyperandrogenism is effective in muscle strength in the study and attributed it to androgen hormones. Based on these studies, we included women with phenotype D-PCOS. So, we excluded women with hyperandrogenism. Our study found that normal-weight women with PCOS (phenotype D) had lower muscle endurance than control group women. This may indicate that WHR and IR are more important than other factors in damaging muscle function by slowing protein synthesis.

Body awareness is related to the perception of physical, psychosomatic, and autonomic changes in the body. Alexander stated that while working on body awareness, 

| Table 4. Correlations between BAQ, SF-36, VO2max, and core stability test variables |
|---------------------------------------|-------------------------------------|-------------------------------------|
| VO2max                                | PCOS                                | Control                            |
|                                       | TFT                                 | TEET                                | RBT                                | LBT | TFT | TEET | RBT | LBT |
| BAQ-total                             | r -0.079                            | -0.131                              | -0.223                              | -0.035                          | -0.092                         | -0.084                          | -0.144                         | -0.009                         | 0.032                         | -0.162                          |
|                                       | p 0.581                             | 0.359                               | 0.115                               | 0.808                           | 0.520                           | 0.563                           | 0.317                           | 0.949                           | 0.828                         | 0.260                           |
| BAQ-I                                 | r -0.074                            | -0.076                              | -0.158                              | 0.016                          | -0.110                          | -0.151                          | -0.170                          | -0.030                          | -0.010                         | -0.123                          |
|                                       | p 0.605                             | 0.597                               | 0.269                               | 0.910                           | 0.443                           | 0.295                           | 0.238                           | 0.836                           | 0.948                         | 0.396                           |
| BAQ-II                                | r 0.268                             | 0.241                               | 0.286*                              | -0.018                         | -0.223                          | -0.207                          | -0.262                          | -0.018                          | -0.063                         | -0.277                          |
|                                       | p 0.057                             | 0.089                               | 0.042                               | 0.902                           | 0.117                           | 0.149                           | 0.066                           | 0.900                           | 0.661                         | 0.051                           |
| BAQ-III                               | r -0.286*                           | -0.089                              | -0.015                              | -0.151                         | -0.078                          | 0.113                           | -0.071                          | 0.012                           | -0.118                         | -0.159                          |
|                                       | p 0.042                             | 0.535                               | 0.091                               | 0.289                           | 0.084                           | 0.436                           | 0.623                           | 0.933                           | 0.413                         | 0.269                           |
| BAQ-IV                                | r -0.275                            | -0.098                              | -0.239                              | -0.195                         | -0.179                          | 0.051                           | -0.027                          | 0.013                           | 0.114                         | -0.050                          |
|                                       | p 0.051                             | 0.494                               | 0.109                               | 0.211                           | 0.724                           | 0.853                           | 0.929                           | 0.432                           | 0.729                         |
| Physical function                     | r -0.006                            | -0.178                              | 0.085                               | -0.169                         | -0.087                          | 0.105                           | -0.337**                        | 0.100                           | 0.239                         | 0.387**                         |
|                                       | p 0.967                             | 0.212                               | 0.533                               | 0.236                           | 0.544                           | 0.469                           | 0.017                           | 0.492                           | 0.095                         | 0.006                           |
| Physical role difficulty              | r 0.111                             | -0.096                              | 0.040                               | 0.088                          | 0.200                           | 0.246                           | 0.249                           | 0.152                           | 0.157                         | 0.324*                          |
|                                       | p 0.438                             | 0.504                               | 0.778                               | 0.540                           | 0.160                           | 0.084                           | 0.081                           | 0.293                           | 0.276                         | 0.022                           |
| Emotional role difficulty             | r -0.060                            | 0.054                               | 0.079                               | -0.052                         | 0.088                           | -0.162                          | 0.000                           | -0.204                          | 0.018                         | -0.170                          |
|                                       | p 0.674                             | 0.705                               | 0.583                               | 0.716                           | 0.539                           | 0.262                           | 1.000                           | 0.155                           | 0.904                         | 0.237                           |
| Vitality                              | r 0.152                             | 0.239                               | 0.387**                             | 0.190                          | 0.260                           | 0.008                           | 0.114                           | 0.008                           | 0.002                         | -0.037                          |
|                                       | p 0.288                             | 0.091                               | 0.005                               | 0.182                           | 0.065                           | 0.957                           | 0.430                           | 0.954                           | 0.990                         | 0.801                           |
| Mental health                         | r 0.286*                            | 0.270                               | -0.015                              | -0.166                         | -0.113                          | 0.115                           | 0.018                           | -0.091                          | 0.232                         | 0.198                           |
|                                       | p 0.042                             | 0.055                               | 0.915                               | 0.245                           | 0.431                           | 0.428                           | 0.904                           | 0.529                           | 0.105                         | 0.167                           |
| Social function                       | r -0.008                            | 0.112                               | 0.003                               | -0.122                         | -0.101                          | 0.098                           | -0.004                          | 0.179                           | 0.129                         | 0.133                           |
|                                       | p 0.956                             | 0.432                               | 0.981                               | 0.394                           | 0.479                           | 0.497                           | 0.980                           | 0.213                           | 0.374                         | 0.355                           |
| Pain                                  | r 0.254                             | 0.177                               | 0.214                               | 0.098                           | 0.237                           | -0.054                          | 0.176                           | 0.140                           | 0.086                         | -0.048                          |
|                                       | p 0.072                             | 0.214                               | 0.131                               | 0.492                           | 0.094                           | 0.709                           | 0.220                           | 0.333                           | 0.553                         | 0.738                           |
| General health                        | r 0.218                             | 0.037                               | 0.226                               | 0.273                           | 0.058                           | 0.018                           | -0.184                          | 0.049                           | 0.239                         | -0.030                          |
|                                       | p 0.124                             | 0.798                               | 0.110                               | 0.053                           | 0.688                           | 0.903                           | 0.202                           | 0.736                           | 0.095                         | 0.838                           |

PCOS: Polycystic ovary syndrome, TFT: Trunk flexion test, TEET: Trunk extensor endurance test, LBT: Lateral left bridge test, RBT: Lateral right bridge test, BAQ: Body awareness questionnaire, BAQ-I (anticipation of bodily reactions); BAQ-II (sleep-wake cycle); BAQ-III (anticipation at the onset of the disease); and BAQ-IV (changes in body process); r: Spearman correlation
Muscular changes can decrease the ability to receive information from the body\(^3\). To the best of our knowledge, there is no study in the literature evaluating body awareness in PCOS. In the present study, the body awareness of women with PCOS was lower than women without PCOS. VO\(_{2}\text{max}\) and core endurance were also associated with body awareness parameters. These results may indicate that muscular and cardiovascular performance can be affected by changes in body awareness. This might suggest that providing body awareness training to women with PCOS in advanced studies might positively affect these parameters.

Body image deterioration and infertility can lead to self-confidence and psychological problems, reducing the QOL\(^2\). The number of studies examining the effects of PCOS on QOL and its subscales is limited. Most studies found lower physical role function, pain, vitality, social function, emotional function, and mental health values in PCOS\(^3\). However, the cause-effect relationship remains unclear. Our results were similar to those reported in the literature. In other studies, the sole effect of PCOS on QOL could not be evaluated due to the obesity factor. Obesity itself is a concept that affects the QOL.

Physical function and physical role limitation subscales of SF-36 in the present study also showed physical performance\(^3\). Core endurance and cardiovascular endurance are already indicators of physical performance. These subscales showed physical performance because cardiovascular endurance and core endurance are associated with these subscales. Also, there was a relationship between the psychological subparameter of SF-36 and VO\(_{2}\) max in PCOS. This may indicate that mental well-being can positively affect aerobic performance.

The strength of the present study was that it was the first study to present a comprehensive summary of the parameters affected by PCOS. Further studies with a larger sample size may provide additional insights into the relationship between PCOS and body awareness, muscle function, and QOL.

### Table 5. Effects of PCOS factor on biochemical parameters, VO\(_{2}\text{max}\), core endurance, BAQ, and SF-36 in the linear regression model

| Dependent variable | Std. beta | t  | p     | 95% CI Lower bound | 95% CI Upper bound |
|--------------------|-----------|----|-------|--------------------|--------------------|
| HDL-C (mg/dL)      | -0.441    | -4.882 | 0.0001* | -17.408 | -7.347 |
| LDL-C (mg/dL)      | 0.132     | 1.322 | 0.189 | -4.345 | 21.714 |
| HOMA-IR (mg/dL x µU/mL) | 0.469 | 5.284 | 0.0001* | 0.730 | 1.608 |
| Triglyceride (mmol/L) | 0.161 | 1.620 | 0.108 | -4.074 | 40.346 |
| Total cholesterol (mmol/L) | 0.097 | 0.968 | 0.335 | -6.769 | 19.667 |
| VO\(_{2}\text{max}\) (mL/kg/minute) | -0.174 | -1.760 | 0.082 | -1.482 | 0.089 |
| TFT (s)            | -0.689    | -9.471 | 0.0001* | -32.745 | -21.401 |
| TEET (s)           | -0.910    | -21.777 | 0.0001* | -65.090 | -54.219 |
| RBT (s)            | -0.624    | -7.954 | 0.0001* | -29.033 | -17.440 |
| LBT (s)            | -0.659    | -8.725 | 0.0001* | -36.803 | -23.166 |
| BAQ-total          | -0.721    | -10.360 | 0.0001* | -20.711 | -14.053 |
| BAQ-I              | -0.718    | -10.261 | 0.0001* | -9.985 | -6.749 |
| BAQ-II             | -0.606    | -7.576 | 0.0001* | -6.553 | -3.833 |
| BAQ-III            | 0.219     | 2.229 | 0.028* | 0.109 | 1.881 |
| BAQ-IV             | -0.497    | -5.704 | 0.0001* | -5.491 | -2.657 |
| Physical function  | -0.451    | -5.029 | 0.0001* | -13.981 | -6.070 |
| Physical role difficulty | -0.486 | -5.539 | 0.0001* | -27.758 | -13.117 |
| Emotional role difficulty | -0.011 | -0.114 | 0.910 | -14.421 | 12.855 |
| Vitality           | -0.276    | -2.860 | 0.005* | -9.691 | -1.752 |
| Mental health      | -0.527    | -6.173 | 0.0001* | -19.173 | -9.846 |
| Social function    | -0.146    | -1.468 | 0.145 | -13.916 | 2.083 |
| Pain               | -0.367    | -3.930 | 0.0001* | -18.015 | -5.926 |
| General health     | -0.320    | -3.361 | 0.001* | -11.364 | -2.927 |

Std. beta: Standardized coefficients beta, CI: Confidence interval; univariate linear regression analysis
TFT: Trunk flexion test, TEET: Trunk extensor endurance test, LBT: Lateral left bridge test, RBT: Lateral right bridge test, WHR: Waist-hip ratio, HOMA-IR: Homeostatic model assessment for insulin resistance, s: Second, cm: centimeter, BAQ: Body awareness questionnaire, SF: Short-form, BAQ-I (anticipation of bodily reactions); BAQ-II (sleep-wake cycle); BAQ-III (anticipation at the onset of the disease) and ^#BAQ-IV (changes in body process)
by PCOS in women of normal weight. Other strengths of the study were its adequate sample size, practical evaluation of the factors, and cost advantage. Also, another strength is the inclusion of only PCOS women with phenotype D for the study group.

**Study Limitations**

The present study had some limitations. One study limitation was that it did not analyze habitual physical activity levels for work and leisure. Also, nutritional habits and psychological problems could not be evaluated in detail. However, more detailed methods require more time. Also, long-term study protocols can reduce women’ adaptability.

**Conclusion**

PCOS is among the most common endocrine disorders in the world. It is an important health problem that can significantly affect many factors. PCOS treatment and evaluation parameters have gained importance because of the chronic course of PCOS. In PCOS, the evaluation of parameters, such as aerobic capacity, muscular endurance, and QOL, can prevent potential negative problems. Also, determining the factors affected by PCOS may indicate that different approaches can be used as treatment options. According to phenotypes, future studies should investigate the effect of different exercise approaches on these parameters (muscle endurance, VO2max, body awareness, others).

**Ethics**

**Ethics Committee Approval:** Permission was granted from the Clinical Research Ethics Committee of the University before the study (decision no: 2017-KAEK-189_2020.01.08_04). All participants were informed about the study based on the 1975 Helsinki Declaration.

**Informed Consent:** All participants also signed informed consent that they agreed to participate in the study.

**Peer-review:** Internally peer-reviewed.

**Authorship Contributions**

Concept: H.D., M.M.C., Design: H.D., Data Collection or Processing: H.D., M.M.C., Analysis or Interpretation: M.M.C., Writing: H.D.

**Conflict of Interest:** The authors report no conflict of interest.

**Financial Disclosure:** The authors have no financial interests about the research.

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