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# The effects of dialysis modalities on sexual hormone levels in male patients

## *Erkek hastalarda diyaliz modalitelerinin cinsel hormon düzeyleri üzerine etkisi*

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**ABSTRACT**

**Introduction:** Low testosterone level is association with low quality of life and cardiovascular risk factors. The dialysis modality effects on testosterone levels remain unclear. To investigate the haemodialysis (HD) and peritoneal dialysis (PD) effects on male sexual hormones.

**Material and Method:** Serum total testosterone (TT), free testosterone (FT), follicle-stimulating hormone (FSH), luteinizing hormone (LH), prolactin (PRL) and sex hormone-binding globulin (SHBG) were investigated. Serum TT below 3 ng/ml was considered a low TT. Sociodemographic data and an Index of Independence in Activities of Daily Living were recorded.

**Results:** This study included adult male HD ($n$=71) and PD ($n$=24) patients. Age and dialysis duration were similar between groups. Serum TT and FT levels were significantly higher in the PD group ($p$=0.01 and $p$=0.05, respectively). There were no differences between the HD and PD groups with regard to SHBG, FSH, LH or PRL levels ($p$=0.353, $p$=0.858, $p$=0.410 and $p$=0.410, respectively). The number of patients who were capable of performing Index of Independence in Activities of Daily Living was higher in the PD group ($p$=0.033) and with normal TT levels ($p$=0.027). Binary regression analysis showed more favourable effects in the PD group on testosterone levels (OR=4.659; 1.477–14.704 95% CI Exp B).

**Conclusion:** PD has favourable effects on testosterone levels compared to HD. Mental and physical well-being resulting from PD and its technique affect TT levels.

**Keywords:** Chronic renal failure, haemodialysis, peritoneal dialysis, testosterone, index of independence in daily living activities

**ÖZ**

**Amaç:** Düşük testosteron düzeyi, kardiyovasküler risk faktörleri ve düşük yaşam kalitesi ile ilişkilidir. Diyalizin testosteron düzeyi üzerine etkisi halen net değildir. Amaç hemodiyaliz (HD) ve periton diyalizi (PD) tekniklerinin erkek cinsel hormonları üzerine etkisinin araştırmaktır.

**Gereç ve Yöntem:** Serum total testosteron (TT), serbest testosteron (ST), follikül stimulan hormon (FSH), luteinizan hormon (LH), prolaktin (PRL) and seks hormone bağlayıcı globulin (SHBG) incelendi. Serum TT, 3 ng/ml'nin altında ise düşük TT düzeyi kabul edildi. Sosyodemografik veriler ve günlük yaşam aktivitesinde bağımsız olabilme indeksi kaydedildi.

**Bulgular:** Çalışmaya erişkin erkek HD ($n$=71) ve PD ($n$=24) hastaları dahil edildi. Her iki grubun yaş ve diyaliz süreleri benzerdi. Serum TT ve ST düzeyleri anlamlı düzeyde PD grubunda yüksek idi ($p$=0.01 and $p$=0.05, respectively). PD ve HD grupları arasında SHBG, FSH, LH veya PRL düzeyleri açısından farklılık yoktu ($p$=0.353, $p$=0.858, $p$=0.410 and $p$=0.410, sırasıyla). Günlük yaşam aktivitesinde bağımsız olabilme indeksi aktivitelerini gerçekleştiren hasta sayısı PD grubu ($p$=0.033) ve normal TT düzeyli grupta ($p$=0.027) daha fazlaydı. Binary regresyon analizinde, PD grubunda testosteron düzeyine etkinin daha olumlu olduğu gösterilmiştir (OR=4.659; 1.477–14.704 95% CI Exp B).

**Sonuç:** Periton diyalizinin HD ile karşılaştırıldığında testosteron düzeyleri üzerine olumlu etkisi vardır. PD tekniğinin kendisi ve sağladığı fiziksel ve zihinsel iyilik hali testosteron düzeylerini etkilemektedir.

**Anahtar Kelimeler:** Kronik böbrek yetmezliği, hemodiyaliz, periton diyalizi, testosteron, günlük yaşam aktivitesinde bağımsız olabilme indeksi

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## INTRODUCTION

Chronic kidney disease (CKD) embodies several factors that affect an individual's quality of life, such as anaemia, bone mineral disorder, malnutrition, inflammation and hormonal imbalances. The incidence of these factors and their effects on quality of life may vary. An androgen deficiency resulting from disturbances in the hypothalamic-pituitary-gonadal axis together with the influence of a uremic environment is one of the major problems in dialysis patients (1). In addition, Handelsman reported that a uremic environment may cause primary hypogonadism with decreases in both testicular blood flow and testosterone production (2). Changes in hormone production and metabolism lead to a loss of libido, infertility, physical and mental problems as well as in increase in cardiovascular risk factors. Serum testosterone levels reaches normal range after the kidney transplantation. A recent study has reported a normalization of follicle-stimulating hormone (FSH), luteinizing hormone (LH) and testosterone levels during the early period following a renal transplantation, while a slower normalization was noted in Sertoli cell functions compared to that in Leydig cells (3). Another recent study demonstrated that a low testosterone level at time of transplantation is a risk factor for graft loss and mortality (4). All CKD patients who have not had the chance of pre-emptive transplantation must receive dialysis treatment. In our study, we aimed to investigate the differences between haemodialysis (HD) and peritoneal dialysis (PD) techniques in terms of hypogonadism.

## MATERIAL AND METHOD

### Ethical Declaration and Patients

This study was conducted with adult male patients, 71 of whom were receiving HD four hours a day, three days a week at the HD centre of our hospital, and 24 patients were under follow-up care at our PD unit. All participants gave written informed consent, and the study protocol was reviewed and approved by the **local ethics committee** (approval date and number: 15.05.2017 and 38/11). This study was carried out in compliance with the principles of the Declaration of Helsinki. With regard to the patients, those with a serum total testosterone (TT) level <3.0 ng/ml were considered to have low testosterone levels or hypogonadism (normal range for TT: 3–10.5 ng/ml). Sex hormone-binding globulin (SHBG), TT, free testosterone (FT), FSH, LH and prolactin (PRL) serum levels were tested in serum samples in line with the Society of Endocrinology and Metabolism guidelines (5). Blood samples were collected in the morning after fasting for 10–12 hours. The samples were centrifuged for 10 minutes at 3000 revolutions per minute. Serum samples were stored at -20 °C. FSH (mlU/ml), LH (mlU/ml), PRL (ng/ml) and TT (ng/ml) assays were run on a Unicel Dxl 800 (Beckman Coulter Inc., California, USA) device by means of a chemiluminescent immunoassay, while FT (pg/ml) and SHBG (nmol/L) were measured on a LB 2111 Gamma Counter (Berthold Technologies GmbH and Co., Bad Wildbad, Germany) via a radioimmunoassay. Other biochemical tests (urea, creatinine, sodium, potassium, calcium, phosphorus, albumin, total protein, uric acid, low density lipoprotein (LDL], high density lipoprotein (HDL], ferritin, intact parathormone, total cholesterol, triglyceride, C-reactive protein (CRP), glycosylated haemoglobin (HbA1c) and haemoglobin were performed during routine controls and the data were retrieved from the patients' files. Employment status, marital status, education level and comorbidities were retrieved from files or recorded via face-to-face interviews.

Katz's Index of Independence in Activities of Daily Living (Index of ADL) was used to determine activity scores (6). This is a survey where feeding, transfer, continence, toileting, bathing and dressing are assessed on a scale from 0 to 6 and each domain is scored as 1 or 0.

### Statistical Analysis

The Statistical Package for Social Sciences for Windows version 25.0 (SPSS Inc., Chicago, IL, USA) was used for the analyses. Descriptive analysis results are expressed as mean ± standard deviation, while variables with non-normal distributions are expressed as a median and interquartile range. To determine whether all variables were distributed normally, the Kolmogorov-Smirnov test was used. The *t*-test was used for variables with continuous normal distributions and the Mann-Whitney test was used for variables with non-normal distributions. Pearson's and Spearman's tests were employed to assess correlations. Statistical evaluations of categorical variables were performed with chi-square tests, while Pearson's or Fisher's exact tests were used for the assessment of the findings. In the present study, Index of Independence in Activities of Daily Living with a survey result of six full points were regarded as active or "1", and others (< 6 for a total score) were recorded as not active or "0". In this way, the index was adapted as a categorical variable for statistical evaluation. Binary logistic regression tests were used to determine the factors with an independent influence on testosterone levels. A $p$-value $\leq 0.05$ was considered statistically significant.

## RESULTS

The present study included 71 male patients undergoing HD and 24 male patients undergoing PD. While there were no differences between the HD and PD groups in terms of SHBG, LH or PRL ($p$=0.353, $p$=0.858, $p$=0.410 and $p$=0.410, respectively), TT and FT levels were significantly higher in the PD group ($p$=0.01 and $p$=0.05, respectively). Serum total cholesterol and LDL levels were also significantly higher in the PD group ($p$=0.031 and $p$=0.016, respectively). Serum intact parathormone levels, body mass index (BMI) and haemoglobin values, which have been associated with testosterone levels, were not significantly different between the HD and PD groups ($p$=0.543, $p$=0.577 and $p$=0.429, respectively). Education level, employment status and the Index of ADL scores were significantly different in the patients receiving PD ($p$=0.004, $p$=0.024 and $p$=0.033, respectively). Among the concomitant diseases (diabetes mellitus [DM], coronary artery disease, hypertension and cancer), only DM

**Table 1.** Demographics and clinical data of all participants

| Variables | | Haemodialysis paients | Peritoneal dialysis patients | P |
|---|---|---|---|---|
| Count (n) | | 71 | 24 | |
| Age (years) | | 53.59±15.17 | 47.67±17.12 | 0.113 |
| Smoke (n) | | | 0.774 | |
| | Smoking (n. %) | 24 (% 36.4) | 8 (% 34.8) | |
| | No smoking (n,%) | 18 (% 27.3) | 8 (% 34.3) | |
| | Smoking cessation (n,%) | 24 (% 36.4) | 7(% 30.4) | |
| Education | | | 0.004 | |
| | University (n,%) | 0 (% 0) | 4 (% 17.4) | |
| | High school (n,%) | 6 (% 9.0) | 3 (% 13.0) | |
| | Middle school (n,%) | 17 (% 25.4) | 2 (% 8.7) | |
| | Elementary school (n,%) | 35 (% 52.2) | 13 (% 56.5) | |
| | Illiterate (n) | 9 (% 13.3) | 1 (% 4.3) | |
| Marital status | | | 0.481 | |
| | Married (n,%) | 49 (% 73.1) | 17 (% 73.9) | |
| | Single (n,%) | 10 (% 14.9) | 5 (% 21.7) | |
| | Divorced /widow (n,%) | 8 (% 11.9) | 1 (% 4.3) | |
| Employment status | | | 0.024 | |
| | Employee (n,%) | 9 (% 13.4) | 6 (% 26.1) | |
| | Unemployed (n,%) | 36 (% 53.7) | 8 (% 34.8) | |
| | Retired (n,%) | 22 (% 32.8) | 9 (% 39.1) | |
| Active (n,%) | | 49 (% 70) | 22 (% 91.7) | 0.033 |
| Diabetes (n,%) | | 28 (% 40.6) | 3 (% 12.3) | 0.012 |
| Cancer (n,%) | | 5 (% 6.8) | 1 (% 4.2) | 0.537 |
| Hypertension (n,%) | | 45 (% 65.2)) | 16 (% 66.7) | 0.898 |
| Coronary artery disease (n,%) | | 22 (% 31.9) | 6 (% 25) | 0.527 |
| BMI (kg/m2) | | 23.99±4.24 | 24.57±4.74 | 0.577 |
| Dialysis duration (months) | | 52 (33-147) | 48 (5-156) | 0.156 |
| Haemoglobin (g/dl) | | 10.91±1.80 | 11.23±1.44 | 0.429 |
| HbA1C (%) | | 7.20 (5.30-8.40) | 5.40 (4.90-6.20) | 0.002 |
| CRP (mg/L) | | 17.51±23.42 | 8.36±9.06 | 0.021 |
| Albumin (g/L) | | 3.76±0.49 | 3.76±0.43 | 0.994 |
| Uric acid mg/dl) | | 6.56±1.35 | 6.78±0.97 | 0.404 |
| Calcium (mg/dl) | | 9.02 (6.30-9.20) | 9.17 (8.08-10.69) | 0.143 |
| Phosphorus (mg/dl) | | 5.38±1.31 | 5.01±1.15 | 0.224 |
| HDL (mg/dl) | | 38.36±9.24 | 39.75±9.95 | 0.536 |
| LDL (mg/dl) | | 105.06±35.07 | 125.83±38.011 | 0.016 |
| Total cholesterol (mg/dl) | | 156.59±42.99 | 179.42±46.49 | 0.031 |
| Triglyceride (mg/dl) | | 179.32±108.13 | 196.67±90.75 | 0.483 |
| Ferritin (mcg/L) | | 496.22±372.17 | 251.74±184.27 | 0.003 |
| iPTH (pg/ml) | | 366.30 (8.60-2536) | 368.40 (160.00-1019.00) | 0.543 |
| 25(OH) vitamin D (ng/ml) | | 15.08 (5.47-74.39) | 10.56 (4.29-37.16) | 0.160 |
| Total testosterone (ng/ml) | | 2.36 (0.41-6.22) | 3.67 (0.28-20.50) | 0.010 |
| Free testosterone (pg/ml) | | 19.44±16.63 | 28.59±22.60 | 0.050 |
| SHBG (nmol/L) | | 21.66±14.51 | 25.45±19.21 | 0.353 |
| FSH (mlU/ml) | | 7.08 (1.26-70.31) | 7.63 (1.70-26.03) | 0.858 |
| LH (mlU/ml) | | 7.68 (3.06-85.77) | 9.18 (2.63-25.28) | 0.410 |
| PRL (ng/ml) | | 13.70 (3.88-467.00) | 16.77 (6.11-73.62) | 0.410 |

BMI: Body mass index, CRP: C-reactive protein, iPTH: Intact parathormone, SHBG: Sex hormone-binding globulin, FSH: Follicle stimulating hormone, LH: Luteinizing hormone, PRL: Prolactin, Activity: Active=1 (Index of independence in activities of daily living index score=6), No active=0 (Index of independence in activities of daily living index score <6), $p<0.05$

had a significantly higher incidence in the HD group compared to the PD group (40.6% versus 12.3%, respectively, $p$=0.012). Age and dialysis vintage were similar between patients receiving HD and PD ($p$ >0.05 for both). Serum CRP and HbA1c values were significantly higher in the HD group than in the PD group ($p$=0.021 and $p$=0.002, respectively). Serum albumin levels were not different between the groups ($p$=0.994). Demographics and clinical data of all participants are presented in **Table 1**.

**Table 2.** Demographics and laboratory data of dialysis patients with serum testosterone deficiency (TT<3 ng/ml)

| Variables | Hemodialysis paients | Peritoneal dialysis patients | P |
|---|---|---|---|
| Age (years) | 55.55±15.51 | 38.51±11.41 | 0.016 |
| Count (n) | 31 (% 43.6) | 6 (% 25) | |
| Dialysis duration (months) | 55 (33-147) | 50 (13-151) | 0.844 |
| BMI (kg/m$^2$) | 24.92±4.76 | 25.78±5.30 | 0.696 |
| HbA1C (%) | 6.55 (4.20-8.80) | 5.20 (4.20-5.70) | 0.224 |
| CRP (mg/L) | 19.45±23.77 | 7.31±5.14 | 0.018 |
| Albumin (g/L) | 3.82±0.59 | 3.76±0.24 | 0.804 |
| Uric acid mg/dl) | 6.70±1.35 | 6.60±0.94 | 0.872 |
| Calcium (mg/dl) | 8.55±0.79 | 8.94±0.63 | 0.264 |
| Phosphorus (mg/dl) | 5.46±1.32 | 5.06±1.52 | 0.518 |
| iPTH (pg/ml) | 342.33±268.76 | 543.77±154.99 | 0.087 |
| LDL (mg/dl) | 116.89±39.68 | 121.83±21.72 | 0.771 |
| Total cholesterol (mg/dl) | 170.54±47.23 | 173.33±24.99 | 0.890 |
| Triglyceride (mg/dl) | 179.18±101.58 | 246.50±117.44 | 0.161 |
| Haemoglobin (g/dl) | 11.12±1.79 | 11.51±2.16 | 0.634 |
| Free testosterone (pg/ml) | 11.30 (2.62-65.77) | 9.39 (4.39-41.38) | 0.471 |
| SHBG (nmol/L) | 16.82±13.16 | 24.15±14.88 | 0.255 |
| FSH (mIU/ml) | 6.91 (1.26-70.31) | 3.77 (1.70-12.66) | 0.126 |
| LH (mIU/ml) | 7.91 (3.06-85.77) | 7.14 (2.63-13.94) | 0.340 |
| PRL (ng/ml) | 55.88±90.66 | 21.62±18.86 | 0.069 |
| Cancer (n) | 2 | 0 | 0.690 |
| Hypertension (n, %) | 19 (% 61) | 3 (% 50) | 0.351 |
| Diabetes (n, %) | 12 | 0 | 0.055 |
| Coronary artery disease (n, %) | 9 (% 29) | 1 (% 16.6) | 0.644 |
| Active (n, %) | 20 (% 64.5) | 5 (% 83.3) | 0.640 |

BMI: Body mass index, CRP: C-reactive protein, iPTH: Intact parathormone, SHBG: Sex hormone-binding globulin, FSH: Follicle stimulating hormone, LH: Luteinizing hormone, PRL: Prolactin, Activity: Active=1 (Index of independence in activities of daily living index score=6), No active=0 (Index of independence in activities of daily living index score <6 ), p<0.05

**Table 3.** Evaluation of dialysis patients with and without testosterone deficiency

| Variables | TT<3 ng/ml | TT ≥ 3 ng/ml | p |
|---|---|---|---|
| Age (years) | 52.63±16.09 | 51.85±16.67 | 0.835 |
| Count (n, %) | 37 (% 39) | 58 (% 61) | |
| Dialysis duration (months) | 55 (13-151) | 49 (5-156) | 0.460 |
| BMI (kg/m$^2$) | 24.88±4.85 | 23.79±3.83 | 0.301 |
| HbA1C (%) | 6.06±1.42 | 6.18±1.07 | 0.786 |
| CRP (mg/L) | 17.13±21.88 | 11.68±19.79 | 0.289 |
| Albumin (g/L) | 3.81±0.53 | 3.77±0.39 | 0.740 |
| Uric acid mg/dl) | 6.67±1.26 | 6.81±1.04 | 0.610 |
| Calcium (mg/dl) | 8.63±0.78 | 8.88±0.77 | 0.188 |
| Phosphorus (mg/dl) | 5.35±1.35 | 4.91±1.81 | 0.165 |
| iPTH (pg/ml) | 381.02±260.00 | 475.82±295.75 | 0.158 |
| LDL (mg/dl) | 116.26±37.45 | 111.21±40.58 | 0.596 |
| Total cholesterol (mg/dl) | 169.23±43.46 | 164.03±48.42 | 0.646 |
| Triglyceride (mg/dl) | 188.37±105.51 | 187.12±83.04 | 0.957 |
| Haemoglobin (g/dl) | 11.21±1.81 | 11.34±1.53 | 0.746 |
| Free testosterone (pg/ml) | 19.63±16.77 | 25.62±21.66 | 0.195 |
| SHBG (nmol/L) | 18.04±14.21 | 28.06±17.11 | 0.009 |
| FSH (mIU/ml) | 6.61 (1.26-70.31) | 7.52 (1.69-25.69) | 0.823 |
| LH (mIU/ml) | 7.95 (2.63-85.77) | 8.03 (4.12-25.28) | 0.764 |
| PRL (ng/ml) | 17.03 (6.11-467.00) | 14.04 (3.88-73.62) | 0.084 |
| Cancer (n, %) | 2 (% 33.3) | 4 (% 66.7) | 0.473 |
| Hypertension (n, %) | 22 (% 59.4) | 23 (% 39.6) | 0.676 |
| Diabetes (n, %) | 12 (% 38.7) | 19 (% 61.3) | 0.431 |
| Coronary artery disease (n, %) | 10 (% 35.7) | 18 (% 64.3) | 0.633 |
| Active (n, %) | 17 (% 43.1) | 33 (% 56.9) | 0.027 |

BMI: Body mass index, CRP: C-reactive protein, iPTH: Intact parathormone, SHBG: Sex hormone-binding globulin, FSH: Follicle stimulating hormone, LH: Luteinizing hormone, PRL: prolactin, Activity: Active=1 (Index of independence in activities of daily living index score=6), No active=0, (Index of independence in activities of daily living index score <6 ), p<0.05

Patients with serum TT levels <3.0 ng/ml were considered to have low testosterone levels or hypogonadism (normal range for TT: 3–10.5 ng/ml). There were 31 of 71 patients in the HD group (43.6%) and 6 of 24 patients in the PD group (25%) with serum TT levels<3 ng/ml. The patients receiving HD treatments with serum TT levels<3 ng/ml were older than those in the PD group ($p$ = 0.016). Serum CRP levels were significantly higher in the HD group ($p$=0.018). No significant differences were noted in dialysis vintage, BMI, haemoglobin or rate of comorbidities between the PD and HD groups with low testosterone levels ($p$ > 0.05 for all). There was also no significant difference in the Index of ADL for both groups with low TT levels ($p$=0.640). Furthermore, there were no differences between the HD and PD groups in terms of SHBG, FSH, LH and PRL results ($p$=0.255, $p$=0.126, $p$=0.340 and $p$=0.069, respectively). Data from patients with low TT levels undergoing HD and PD are shown in **Table 2**.

We evaluated all participants (71 HD patients and 24 PD patients) according to whether their serum testosterone levels were low (TT <3 ng/ml) or normal (TT ≥3 ng/ml). From this data, we determined the relationship between TT and both SHBG ($p$=0.009) and Index of ADL. The latter scores were statistically significant in favour of TT ≥3 ng/ml ($p$=0.027, $r$=0.267). No significant difference was noted in other parameters ($p$ >0.05 for all; **Table 3**).

We evaluated the associations of TT levels (TT below 3 ng/ml = 1 and TT ≥ 3 ng/ml = 2) with renal replacement therapy (PD=1 and HD=2) and DM (patients with DM=1 and patients without DM=2) by chi-square tests. These results

showed a statistically significant correlation was not observed for DM ($p$=0.431), while renal replacement therapy had both relationship ($p$=0.004) and correlation ($r$=0.341).

The effects of DM and renal replacement therapy were also assessed with binary regressions. These results showed that PD had an odd ratio=4.659 (1.477–14.704 95% CI Exp B) and $p$=0.009. For DM, the $p$=0.992.

## DISCUSSION

Hypogonadism in males refers to low TT and/or FT in the serum together with associated signs and symptoms. The Society of Endocrinology and Metabolism guidelines recommend routine screening for hypogonadism in healthy males of advanced age (7). This is based on the insidious onset of the clinical picture where tests and screenings may facilitate the diagnosis (8). The incidence has been reported from 25% to 66% in patients with CKD (9). However, the highest incidence may be observed in CKD patients undergoing dialysis.

Comorbidities render hypogonadism more severe. DM has been reported to be associated with lower testosterone levels in earlier stages. In the present study, only the incidence of DM was higher in the HD group among the comorbidities (**Tables 1** and **2**). When evaluated, for all patients receiving PD and HD with serum TT levels normal or below 3 ng/ml, the number of patients with DM was not significantly different (**Table 3**). Regarding TT levels, a binary regression analysis and chi square test revealed no influence of DM on TT levels in our study. Shi and colleagues, in their 5-year study, have shown that annualized TT changes are associated with obesity, being unmarried and smoking at baseline, but not with DM, hypertension or cardiovascular disease in the general population (10).

The number of male patients 65 years of age or older was 53 of 71 (74.6%) in the HD group and 19 of 24 (79.2%) in the PD group ($p$=0.665). Advanced age is an important factor in terms of low testosterone levels both in the general population and in patients with CKD. Although age was not different across the PD and HD groups in this study, serum TT and FT were lower in the HD group compared to the PD group (**Table 1**).

There was no statistically significant difference in terms of dialysis duration between the PD and HD groups in the present study (48 (5–156) months, and 52 (33-147) months, respectively, $p$=0.156). Moreover, the dialysis durations were similar between patients with low and normal TT levels (55 (13–151) months and 49 (5–156) months, respectively, $p$=0.460). Cigarran's study reported that dialysis durations were significantly different between patients with low and normal TT levels, while the differences in testosterone levels between the two dialysis techniques cannot be justified by the time on renal replacement therapy (11). This is consistent with the results of the present study.

The adequacy of dialysis was assessed in the HD group and on a weekly basis in the PD group. A normal value for adequacy of dialysis was accepted as Kt/V ≥1.4 for the HD group and Kt/V >1.7/week for the PD group. There was no inadequacy of dialysis in either the PD or HD groups. A study evaluating the effect of HD adequacy on testosterone levels by Kim and colleagues demonstrated no significant difference in terms of testosterone levels between the groups with and without HD adequacy (12). As in the study of Kim et al, this study was demonstrated that dialysis adequacy was not associated with serum testosterone levels. Although urea and creatinine values of PD patients scratch the plateau, TT and FT levels are better, which indicates that the situation cannot be explained only by the uremic environment. This shows that we should investigate the causes other than uremia.

About 50–60% of testosterone is bound to SHBG, while 40–50% is albumin-bound and 1–2% is in free form. In our study, no difference was noted in serum albumin and SHBG values in the HD and PD groups ($p$=0.994 and $p$=0.353, respectively). In CKD, it appears that SHBG levels are unaffected by a decline in glomerular filtration rate (GFR) (13).

One of the two studies investigating the superiority between HD and PD reported that testosterone levels were higher in patients undergoing PD (11). The second study demonstrated the benefit of a nightly nocturnal home HD to conventional HD (14). Our study is important in that it confirms the findings of these studies (11,14).

Patients who choose PD are often those who are able to perform personal activities and prefer not spending four hours on HD three times a week. Furthermore, male patients receiving PD treatments are usually married and able to obtain full support from their family. A study that followed men aged 35 years and older for 5 years in Australia reported that being unmarried predicted a decrease in testosterone, whereas men who were married were more likely to have an increase in testosterone (10). When adequately informed, improved treatment satisfaction and compliance to treatment have been observed in patients receiving PD compared to those receiving HD (15,16).

Heiman highlights that the rate of sexual dysfunction is 10–52% in the general population and he reported that adequate sexual functioning also appears to be associated with personal well-being and relationship stability, although this may be more accurate for men than women (17). Additionally, Azevedo stated that sexual dysfunction is strongly associated with an impaired quality of life (18).

Clinical outcomes of low TT and FT levels are muscle wasting, frailty, loss of physical performance and sexual dysfunction (19). There is no opinion suggesting the opposite association in the literature. A study conducted in Singapore reported favourable effects of exercise on testosterone and sexual function in obese individuals (20). The PD group in our study exhibited superiority compared with the HD group in terms of the Index of ADL scores ($p$=0.033; **Table 1**).

As stated in both a previous study (11) and in our study, higher testosterone levels in patients receiving PD compared to HD has a positive effect on physical performance on testosterone levels. Additionally, in their study evaluating quality of life parameters among patients receiving PD or HD treatments, Russo and colleagues reported better psychophysical well-being in the PD group. They also reported patients receiving HD treatments are associated with a greater tendency of having depression (21).

We believe that taking an active part in the treatment of patients receiving PD by applying the treatment themselves may contribute to improving testosterone levels. Russo et al. suggested that PD appears to have clear advantages in terms of quality of life thanks to the possibility of performing treatments independently at the patient's home (21).

The limitations of this study are as follows: 1) We had a low number of patients, especially those on PD. 2) There was a lack of testosterone assays performed with dialysate fluids. A study involving male patients on HD and healthy participants who received transdermal testosterone replacement reported that the amount of testosterone removed via dialysis was very low (22). No such study has been conducted for PD.

Considering the associations between testosterone and mortality, quality of life and graft loss, further studies with multi-centre designs involving a greater number of patients would be useful.

## CONCLUSION

The effect of dialysis techniques on TT has not been fully clarified. However, the benefits of PD versus HD have been confirmed with the present study. We believe that PD, and the technique itself, offer enhanced mental and physical well-being with positive benefits on TT levels.

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