OPEN ACCESS

ISSN: 2835-9496

Piñon-Ruiz MJ, et al. (2024): 388
DOI: 10.47991/2835-9496/AJCMR-119

Research Article

American Journal of Clinical and Medical Research

Assessment of Physical Capacity, And Quality of Life in Patients with Renal Transplantation, On Hemodialysis and A Control Group of Healthy Subjects

Piñon-Ruiz M. J[1*], Huerta-Franco M. R[2], Apolinar-Jiménez E[3], Vargas-Luna F.M[4]

[1]*Master's degree in clinical research, Division of Health Sciences, University of Guanajuato- Campus Leon.*
[2]*Department of Sciences Applied to Work, Division of Health Sciences, University of Guanajuato –Campus Leon.*
[3]*Metabolism and Nutrition Unit, Research Department, Bajío High Specialty Regional Hospital.*
[4]*Department of Physical Engineering, Division of Sciences and Engineering, University of Guanajuato –Campus Leon.*

[*]***Corresponding author:*** *Piñon-Ruiz M. J, Master's degree in clinical research, Division of Health Sciences, University of Guanajuato- Campus Leon. Email: jocelynepinon.r@hotmail.com*

Citation: *Piñon-Ruiz MJ, Huerta-Franco MR, Apolinar-Jiménez E, Vargas-Luna FM (2024) Assessment of Physical Capacity, And Quality of Life in Patients with Renal Transplantation, On Hemodialysis and A Control Group of Healthy Subjects. Ameri J Clin Med Re: AJCMR-119.*

Received Date: *09 February, 2024;* ***Accepted Date:*** *19 February, 2024;* ***Published Date:*** *23 February, 2024*

Abstract

Chronic kidney disease (CKD) and its replacement treatments such as hemodialysis (HD) and kidney transplantation (KT) directly affect the physical capacity, independence, and quality of life (QoL) of patients who suffer from them. The objective of this study was to compare the physical capacity and QoL of patients undergoing HD and KT versus a healthy control group (HCG). In the present cross-sectional study, we included 125 patients classified into the following groups: 1) 46 KT recipients (mean ± standard deviation age of 27.39 ± 5.04 years); 2) 47 HD patients (28.89 ± 5.76 year); and 3) 32 HCG (29.63 ± 6.34 years). Physical capacity was assessed using dynamometry, Queen's College Step test, and sit and reach test. QoL was assessed with SF36 questionnaire. One-way ANOVA or Kruskal-Wallis H tests, and the chi-square test were used for data analysis. No significant differences were observed when comparing the three groups in the Queen's College Step test (p=0.47), nor in the sit and reach test (p=0.13); however, in the test of strength there were differences being the median values and interquartile ranges: 31.65 (24.77-33.40 kg) for HCG, 24.9 (19.90-30.80 kg) for HD, and 22.7 (18.18-30.10 kg) for KT group respectively (p=0.003). The SF-36 scores in these last two groups showed a worse state of health compared to HCG, mainly in physical dimension. The results of this study demonstrated that HD and KT patients had reduced physical capacity and QoL compared to HCG. KT patients have similar physical capacity than HD patients, despite former have a new organ that reverses the uremic process.

Keywords: *health-related quality of life, physical capacity, hemodialysis, kidney transplantation.*

1. Introduction

Currently, chronic diseases, particularly kidney disease, have a significant prevalence worldwide. In Latin America, and in Mexico it is a relevant problem due to its high incidence and mortality. That is why vigilance is important to avoid irreparable con-sequences. [1,2]. Patients with chronic kidney disease achieve greater survival due to the use of renal replacement therapies. The renal replacement therapy of choice is a successful kidney transplant; however, hemodialysis has similar results and represents the most used treatment [3]. Despite all these forms of therapy, chronic kidney disease continues to have a high impact on the quality of life of patients; since it affects their physical capacity, modifies their lifestyle and family dynamics. Due to the need to reorient the personal and work projections of these patients, many of them present emotional problems such as stress, anxiety, and depression.

Very few previous studies have demonstrated differences between patients on HD and TR and even of this group versus a control group, however, physical capacity and quality of life continue to be lower than that of healthy individuals of the same age [4–7]. Only in some studies, carried out in Europe, it has been concluded that kidney transplant recipients presented lower values in all parameters of muscular structure, strength and power [8,9]. All of the above are frequently associated with worse clinical outcomes, a greater probability of hospitalization and decreased survival [10-15]. However, some others highlight that physical capacity and body composition show no differences between hemodialysis patients, kidney transplant recipients, and healthy people [16]. From all of the above, it can be inferred that the results of previous studies in this field were not all in the same direction, and in the insight of available evidence, in Mexico there are no studies in this regard, still more surveys are necessary. Therefore, this study aims to compare the physical capacity and quality of life of patients on hemodialysis and kidney transplant with a group of healthy people.

2. Materials and Methods

This research, with an observational, cross-sectional, and analytical design, was approved by the Research and Research Ethics Committees of the Hospital Regional de Alta Especialidad del Bajío, with registration number CI/HRAEB/018/2022. Furthermore, all participants gave their written informed consent to participate in the study.

The sample size was calculated using a statistical program with the one-way ANOVA formula, with a confidence level of 95%, and a power of 80%, with a medium effect size of 0.30.

The study included 47 adult CKD patients undergoing regular hemodialysis, 46 kidney transplant patients, and 32 healthy control subjects. Regarding the patients with HD and KT, were of both sexes, over 18 years of age and under 50 years of age,

with a minimum of three months and a maximum of 60 months from the start of HD or the performance of KT, in addition to being clinically stable and with medical authorization that would allow physical tests to be carried out. The study did not include KT patients who had a history of acute rejection of the renal transplant proven by a biopsy performed in the last three months prior to inclusion; if they had any musculoskeletal problem that prevented independent ambulation; if they presented cognitive deficit; limb amputation; history of hospitalizations in the last month; previous history of coronary artery disease, or hemodynamically unstable (heart rate, and blood pressure, with values outside the normal range); and if patients had a diagnosis of systemic lupus erythematosus or diabetes mellitus. The above is due to the fact that the conditions or pathologies mentioned could modify the results in terms of musculoskeletal consequences directly related to CKD, for example the common presence of diabetic neuropathy.

In the inclusion criteria for the control group participants, adults between 18- and 50-year-old, it was considered that they should not present any disease that would affect the study variables; and to consider the same socioeconomic level and culture of the patients, they should be relatives of the CKD patients included in this research. This way, selection biases due to socioeconomic level and lifestyle among the three groups of participants were avoided. This was an advantage compared to the reference values of the national general population.

Assessment protocol

The evaluation of the three groups of participants was collected through a complete medical history, which included pathological and non-pathological personal history, and physical examination. All participants underwent an anthropometric evaluation, upper limb muscle strength, cardiorespiratory capacity, hamstring flexibility were measured, and quality of life was evaluated as described below:

Anthropometric assessment

All patients underwent an anthropometric assessment that included body weight [kg], height [cm], and body mass index (BMI) using the standard procedure [17]. Weight and height were measured with a digital scale which had an integrated stadiometer (Seca® brand, model 763). In the case of HD patients, weight was recorded within the first hours after the dialysis session. In addition to recording the level of physical activity of these patients, they were questioned about their comorbidities such as hypertension, and adherence and monitoring of a diet aimed at patients with CKD.

Laboratory data

Serum levels of hemoglobin, creatinine, albumin, urea, blood urea nitrogen, and electrolytes sodium, potassium, calcium, magnesium, and phosphorus were determined. Renal function was reported for all patients as the Glomerular Filtration Rate (GFR), using the formula according to the CKD-EPI [18].

Hand muscle strength

Handgrip strength was evaluated using a CAMRY MODEL EH10 dynamometer. This test is considered a reliable indicator of health and well-being; in addition, a strong predictor of mortality and expectation in patients with CKD [12,19–21]. The position was executed according to the instructions of the American Society of Hand Therapists, the participants exerted the greatest grip strength possible by maximally flexing the fingers of the hand. Three evaluations were carried out considering a minute of rest between each one of them and the one in which the participant managed to make the greatest grip was taken an account [22,23].

Queen's College Step test

Cardiorespiratory fitness was indirectly assessed using the Queen's College Step Test, which is recommended by the American College of Sports Medicine. It consists of going up and down a step at a height of 15 inches for three minutes, at a set speed of 22 steps/min for women and 24 steps/min for men. After completing the three minutes, the participant must remain standing for five seconds and after this the heart rate must be taken for one minute. The above was used to estimate the maximum oxygen consumption by means of a formula [24].

Sit and reach test

This test was used to estimate the flexibility of the hamstring and lower back muscles, it has excellent validity, reliability and response capacity; consists of measuring the distance between the tips of the fingers of the hand to the tangent to the soles of the feet represented with a ruler fixed to the top of a wooden box of 30.5 cm x 30, 5 cm x 30.5 cm, when performing maximum active trunk flexion with the knees extended, for 2-3 seconds. The furthest distance reached was recorded as cm [25].

Quality of life

To measure quality of life, the Spanish version of the 36-item Medical Outcomes Study-Short Form (SF-36) questionnaire was used. This questionnaire is a generic tool that is used to evaluate quality of life exhaustively and comprehensively. It consists of 36 items that cover the following eight dimensions: 1) functional capacity; 2) physical aspects; 3) emotional aspects; 4) pain, 5) general health; 6) vitality; 7) social aspects; and 8) mental health. The scale also includes one more question that compares the current health status and that of a year ago. This instrument evaluates both the negative aspects (illness) and the positive aspects (well-being); returns a final score from 0 to 100 points; where 0 corresponds to the worst state of health in general, and 100 points represents the best state of health [23, 30].

Statistic analysis

Statistical analysis of the data was performed using SPSS 25.0 software (SPSS Inc., Chicago Illinois). The qualitative variables (sociodemographic and clinical variables) are presented as tables of frequencies and percentages; these variables were compared between the groups with X^2 tests. The distribution probability for all quantitative variables was calculated using the Shapiro-Wilk test; variables with normal distribution were expressed as mean ± standard deviation ($X \pm SD$). The variables that did not present a normal distribution are presented as medians and interquartile ranges. Differences in continuous and normally distributed variables were compared between the three groups using one-way analysis of variance (ANOVA) and post-hoc range tests. To compare the variables without normal distribution between groups, the non-parametric Kruskal-Wallis H test was used, and the pairwise test of medians was performed with the Mann-Whitney U test. In all statistical analyses, a value was considered significant when $p < 0.05$.

3. Results

General characteristics:

The study population consisted of 125 patients, 47 in the HD group, 46 in the KT group, and 32 in the HCG. The three study groups were mostly made up of men: 25 (53.2%) in the HD group, 25 (54.3%) in the RT group, and 19 (59.4%) in the control group; the results of the X^2 tests did not show significant differences when comparing these proportions between the three groups.

When comparing the age average of the three groups, no significant differences were observed, being 28.89 ± 5.76 years for the HD group, 27.39 ± 5.04 years for the RT group, and 29.63 ± 6.34 years for the HCG (Table I). The results in terms of frequency of physical activity and job occupation are shown in Table I.

Table I: Differences in sociodemographic characteristics between HD patients, KT patients, and the control group of healthy subjects

	Hemodialysis (HD) n=47	Kidney transplant (KT) n=46	Healthy control group (HCG) n=32	p
Age (years)	28.89 ± 5.76	27.39 ± 5.04	29.63 ±6.34	0.20
Sex -Men -Women	 25 (53.2%) 22 (46.8%)	 25 (54.3%) 21 (45.7%)	 19 (59.4%) 13 (40.6%)	 0.85
Job occupation	19 (40.4%)	28 (60.90%)	29 (90.6%) [a]	<0.001
Physical activity (active lifestyle)	3 (6.4 %)	3 (6.5%)	14 (43.8%)[b,c]	<0.001
Scholarship -Elementary school -High school -College -University	 7 (14.9%) 24 (51.1%) 12 (25.5%) 4 (8.5%)	 8 (17.4%) 22 (47.8%) 9 (19.6%) 7 (15.2%)	 1 (3.1%) 13 (40.6%) 13 (40.6%) 5 (15.6%)	 0.24
Dietary regimen	5 (10.6%)	8 (17.4%)	1 (3.1%)	0.14
Weight (kg)	63.23 ± 13.94	63.52 ± 13.54	71.4 ±14.32 [a,b]	0.02
Height (cm)	161.67± 8.40	159.54 ± 9.04	163.5 ± 10.8	0.17
BMI (kg/m^2)	22.9 (21.25-26.5)	23.1 (21.25-23.1)	26.49 (23.7-29.05) [c]	0.02

Note: Bonferroni post hoc analysis for pair of data [a],p=0.001 vs HD; [b],p=0.001 vs KT, [c], p=0.001 vs HD.

The time from the diagnosis of CKD and the start of dialysis sessions in the HD group was shorter compared to the time from surgery in the group with KT (p=<0.001). Weight and BMI were significantly higher in the HCG (p=0.02); the latter being significantly higher only in the HD group (p=<0.001) (Table II).

Table II: Differences in the clinical characteristics of patients with HD and KT

	Hemodialysis (HD) n=47	Kidney transplant (KT) n=46	p
Hypertension	39 (83.0%)	24 (52.25%)	0.002
CKD etiology -Idiopathic -Other	 39 (82.9%) 8 (17.1%)	 40 (87%) 6 (13%)	 0.12
Time since CKD diagnosis (months)	30 (16-60)	72 (69-107.25)	<0.001
Time with TR or HD (months)	19 (14-35)	41 (15.75-49.75)	0.01
Donor type -Deceased -Alive	 -	 18 (39.13%) 28 (60.87%)	 -
Vascular access (HD) -AVF -Niagara catheter -Mahurkar catheter -Permacath	 15 (31.9%) 5 (10.6%) 7 (14.9%) 20 (42.6%)	 -	 -
Medication -Cyclosporine -Tacrolimus -Mycophenolic acid -Prednisone -Beta-blockers	 - - - - 39 (83.0%)	 32 (70%) 14 (30%) 46 (100%) 46 (100%) 24 (52.25%)	 0.002

Note: AVF = arteriovenous fistula, qualitative variable reported as frequency and percentage; quantitative variable with normal distribution, presented as mean and standard deviation; quantitative variable without normal distribution, are presented as median and interquartile ranges.

Results of laboratory data between HD patients and KT patients.

KT patients had significantly lower levels of serum creatinine (p<0.0001), urea (p<0.0001), blood urea nitrogen (p <0.0001), magnesium (p<0.0001), phosphorus (p<0.0001), and potassium (p<0.0001). Regarding GFR, it was higher in this group (p<0.0001), as well as hemoglobin concentration (p<0.0001), and calcium (p<0.0001) compared to HD patients; however, albumin levels were similar in both groups (p=0.88) (Table III).

Table III: Comparison of laboratory data (biochemical results) in patients with HD and KT

	Hemodialysis (HD) n=47	Kidney transplant (KT) n=46	p
Urea Nitrogen (BUN) (mg/dL)	63 (51.0-77.0)	22 (18.0-31.0)	<0.0001
Urea (mg/dL)	134.80 (109.10-159.45)	47.10 (38.50-62.10)	<0.0001
Creatinine (mg/dL)	12.40 (9.30-16.50)	1.6 (1.20-1.90)	<0.0001
Hemoglobin (g/dL)	10.53 ± 1.85	13.35 ± 3.04	<0.0001
Albumin (g/dL)	4.3 (3.95-4.50)	4.30 (4.20-4.60)	0.87
Magnesium (mg/dL)	2.4 (2.10-2.85)	2 (1.70-2.20)	<0.0001
Phosphorus (mg/dL)	5.9 (5.05-7.50)	3.90 (3.40-4.20)	<0.0001
Potassium (mmol/L)	5.60 (4.70-6.10)	4.5 (4.30-4.80)	<0.0001
Calcium (mg/dL)	8.7 (7.80-9.30)	9.5 (9.2-10.10)	<0.0001
GFR (ml/min/1.73 m^2)	4.07 (3.27-5.40)	61.88 (49.98-72.36)	<0.0001
Note: GFR=glomerular filtration rate, qualitative variable reported as frequency and percentage; quantitative variable with normal distribution, are presented as mean and standard deviation; quantitative variable without normal distribution, are presented as median and interquartile ranges.			

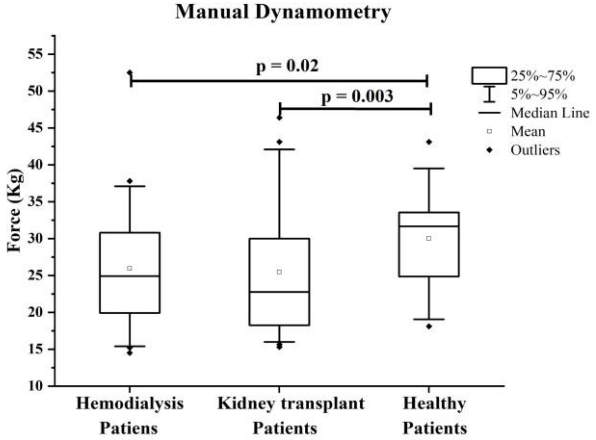
Results of physical capacity.

Differences between groups were for dynamometry, obtaining significantly lower values of strength deterioration in both HD and KT groups compared to the HCG (p=0.003), with strength deterioration being clinically more notable in the KT group (Table IV) (Figure I).

Table IV: Physical capacity results, when comparing patients with HD, KT and the control group of healthy subjects.

	Hemodialysis (HD) N= (47)	Kidney transplant (KT) N= (46)	Healthy control group (HCG) N=32	p
Upper limb strength (kg).	24.9 (19.90-30.80)	22.7 (18.18-30.1)	31.65 (24.77-33.40) [a,b]	0.003
Hamstring flexibility (cm).	-11(-15.0,-1.0)	-6.5 (-14.0,-0.50)	-6 (-9.75, 1.0)	0.129
Queens College step test.	48.44 (41.42-59.25)	44.49 (40.82-55.57)	47.54 (40.96-57.25)	0.474
Vo^2max level -Acceptable -Average -Well -High	N (%) 0 (0) 3(6.4) 21 (44.7) 23 (48.9)	N (%) 1 (2.2) 5(10.9) 23(50) 16 (34.8)	N (%) 0 (0) 1(3.1) 14(43.8) 17 (53.1)	 0.538
Note: Bonferroni post-hoc analysis between pairs of data [a],p=0.020 vs HD; [b],p=0.003 vs KT.				

Figure I: Handgrip test values among the different groups of patients and healthy subjects.



Quality of life results

The quality of life of HD and KT patients was found to be significantly ($p < 0.05$) impaired compared to the quality of life of HCG, particularly with regard to physical domains of the QoL scale, and the psychological and social domains.

The HCG presented significantly higher values ($p < 0,05$) in the dimensions of physical function (Figure IIA), vitality, mental health, social function and bodily pain, compared to patients with HD and KT (Table V). Regarding the physical role, the values of the HCG were only significantly higher ($p < 0,05$) compared to the HD group (Figure IIB). In the general health domain of the QoL scale presented differences between the three study groups: being the HD patients those who perceived worse general health status. However, in turn, the HCG had a higher perception of general health status than the KT group (Figure IIC). Finally, changes in health status were only significantly greater in the KT group compared to the HD group.

Figure IIA: Differences in the domain of physical function in the SF36 in the different groups of patients and healthy subjects.

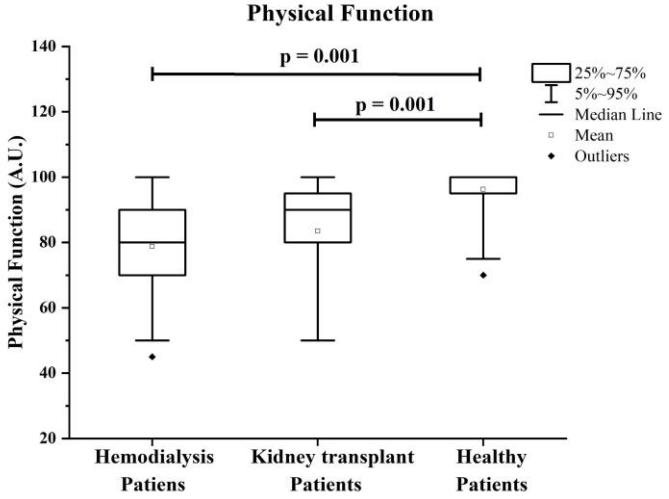


Figure IIB: Differences in the domain of physical role in the SF36 in the different groups of patients and healthy subjects.

Table V: Results of the Quality-of-Life Questionnaire (SF 36), when comparing patients with CKD and the control group of healthy subjects

	Hemodialysis (HD) N= (47)	Kidney transplant (KT) N= (46)	Healthy control group (HCG) N=32	p
Physical function	80 (70-90)	90 (78.75-95)	100 (95-100) [a,b]	<0.001
Physical role	100 (50-100)	100 (75-100)	100 (100-100) [c]	<0.007
Emotional role	100 (66.7-100)	100 (66.7-100)	100 (100-100)	0.116
Vitality	65 (55-75)	70 (55-80)	90 (67.5-100) [d,e]	<0.001
Mental health	80 (64-96)	76 (64-88)	94 (84-100) [f,g]	<0.001
Social function	75 (75-100)	87.5 (62.50-100)	100 (87.5-100) [h,i]	<0.001
Body ache	90 (67.50-100)	90 (67.50-100)	100 (82.50-100) [j,k]	0.018
General health	50 (35-60) [l,m]	65 (50-75)	75 (50-100) [n]	<0.001
Health changes	75 (50-75) [o]	75 (50-100)	75 (50-100)	0.017

Note: Post hoc Bonferroni analysis, comparison between pairs of data: [a],p=0.001 vs. KT; [b],p=0.001 vs. HD; [c],p=0.005 vs. HD; [d],p=0.001 vs. HD; [e],p=0.003 vs. KT; [f],p=0.001 vs. KT; [g],p=0.06 vs. HD; [h],p=0.001 vs. HD; [i],p=0.005 vs. KT; [j],P=0.026 v.s HD; [k],p=0.046 vs. HC; [l],p=0,012 vs KT; [m],p=0.001 vs. HC; [n], p=0.023 vs. HC; [o],p=0.028 vs. KT.

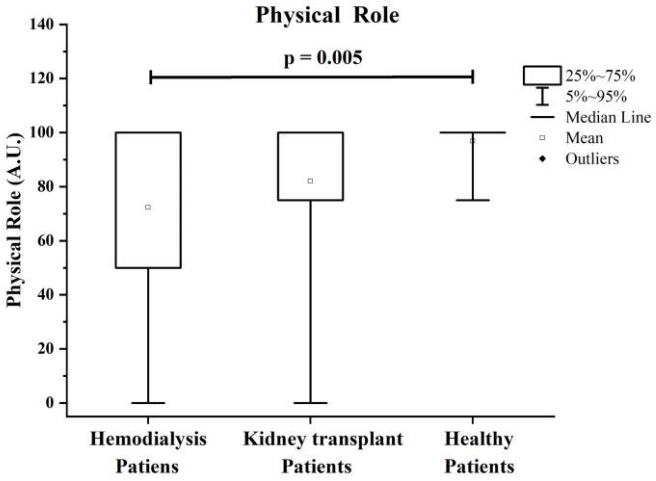
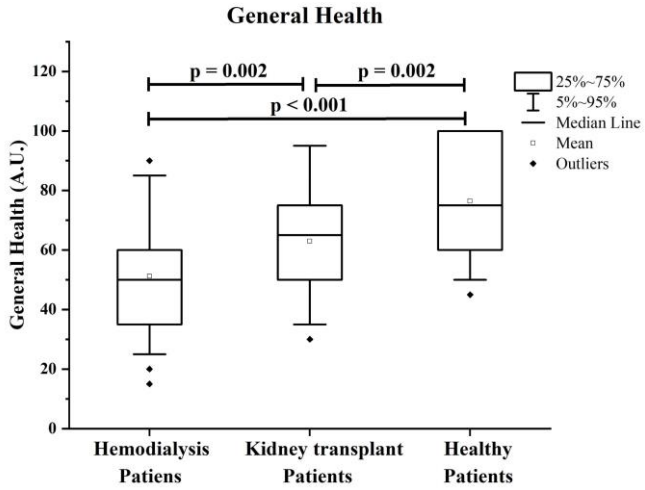


Figure IIC: Differences in the general health in the SF36 in the different groups of patients and healthy subjects.



Finally, an analysis was carried out to find statistical associations between manual muscle strength and the results of the physical dimensions evaluated in the questionnaire (physical role, physical function, vitality), finding only a significant association ($p < 0.05$) between manual dynamometry and physical function; However, this association was very low ($r=0.19$).

Additionally, the correlations between the study variables and the time since the start of hemodialysis and kidney transplant were analyzed, resulting in no statistical significance.

4. Discussion

The results showed that patients with HD and KT presented less strength in the upper limb evaluated with dynamometry compared with the HCG, in turn the results were lower in patients with KT. Regarding cardiorespiratory fitness and flexibility, there were no differences between the three groups.

Regarding quality of life, most of the dimensions evaluated were significantly lower in the two groups of patients with CKD. However, this was similar between HD patients and the KT group, mainly in physical dimensions. The healthy control group showed significantly higher values in five of the following eight dimensions of the SF36 scale: i) physical, ii) social, iii) vitality, iv) mental health and v) pain. Patients in the KT group presented better results compared to the HD group, in terms of changes in their health status. Only the group of HD patients presented significantly lower scores in physical role and general health status, compared to patients with KT and HC.

A relevant finding was to demonstrate that the CKD patients evaluated in this investigation belong to a much younger age group compared to CKD patients from other parts of the world [26–28]. The mean and SD age for HD and KT patients was of 28.89 ± 5.76 and 27.39 ± 5.04, respectively; however, the average age reported of the mentioned studies was 50 years. The low physical capacity of the patients studied in Europe and Asia could be attributed to the advanced age of the patients with CKD [26–28]. These findings demonstrate that Mexican CKD patients present with the disease much earlier and therefore have a poor QoL at earliest ages.

In our studyit is of interest that the CKD patients (on HD or on KT) were young adult patients, in who their physical capacity would be expected to be at its maximum level; despite this, the CKD patients showed inferior results, even when compared to the older CKD population from Europe and Asia [9,29,30].

KT patients had lower levels of serum creatinine, urea nitrogen, urea, phosphate, potassium, and higher levels of GFR, calcium, and hemoglobin concentrations compared with HD patients,

coinciding with the results of previous literature [5,8,31]. However, albumin levels were similar for both groups, which could indicate no change in post-transplant nutritional status and persistence of a microinflammatory state.

The results of the physical fitness tests of the patients with CKD, and of the volunteers in the control group, demonstrated that the grip strength was significantly lower in the groups with CKD when compared to those in the HCG. The group with KT being the one that obtained the lowest clinical This result corroborates the findings found in other studies that confirmed 30% to 40% reduction in muscle strength in patients undergoing replacement treatment, compared to individuals who did not receive it [32–35].

In a study carried out in kidney transplant recipients in Paraguay, a result in the grip test was reported, on average 15.02 ± 8.03 kg (in the dominant hand); if we compare these results with those of our study we observe an average of 22.7 (18.18-30.1 kg), evidently our results were superior to those of the aforementioned study; the explanation could be due to the fact that the average age of the patients in the Paraguayan study was almost double that of our study group; therefore, the mature age of these patients may be related to the natural decrease in their muscle strength. We were also able to observe that the results of the serum urea and creatinine levels of the Paraguayan patients were higher, and the hemoglobin levels were lower, compared to those observed in the patients in our study [36].

In another study carried out with three groups of subjects: 1) patients on dialysis, 2) patients without dialysis waiting for KT, and 3) patients with KT (more than 5 years after surgery), it was found that patients with KT presented similar results in muscle strength to those of patients with CKD on the waiting list for KT and to those of healthy subjects of the same age reported in the literature [5] . The patients with KT in our study had an average of three years of kidney transplantation, which could have influenced the lower muscle strength values, so there could be a relationship between muscle strength and the time elapsed since surgery [5].

The results we observed in HD patients with low muscle strength when comparing them with KT patients, and the control group subjects, were similar to the results found in another study with HD patients and compared with the control group [37].

In the evaluation of muscular flexibility of the hamstring muscles and the posterior part of the trunk; we did not find differences between the KCD and the control group; all three groups presented moderate muscle shortening [39]. In patients with CKD, it may be due to a high amount of fat, muscle hypotonia, and the sedentary life [38], [43].

In the present study, the evaluation of cardiorespiratory capacity was evaluated with the indirect test of submaximal exercise (the Queen's College Step Test, the American College of Sports Medicine); In this test, heart rate is measured immediately upon completion of the test and the result is interpreted using tables to indirectly determine VO2-max. However, this trial had some biases because 83% of the HD patients and 52.5% of the KT population were being treated with beta blockers, which could have modified the heart rate response at the end of the trial [40 ,41]. This made it difficult to compare our results with those of other studies [39,40], [44,45].

The results of the literature demonstrate that VO2-max determined with a cycle ergometer test in patients on HD is less than 10% to 50% of the maximum capacity of healthy un-trained individuals [42]. In our study the results indicated a 6.5% decrease in patients with KT compared to healthy controls; however, these differences were not statistically significant. Results that coincide with those of other studies in which no differences were found in VO2-max between patients on HD and KT, including pediatric patients with peritoneal dialysis [43,44]. Our results and those of the studies could be due to the following reasons: 1) the high percentage of body fat of the three groups evaluated, 2) the low lean mass that negatively affected muscle strength, 3) the sedentary lifestyle of the groups evaluated [41–43].

However, other studies show that patients with KT had a significantly higher VO2-max compared to people on hemodialysis, and like that of healthy controls [7,44,45]. Clinical-ly, our results were lower in KT patients than in HD patients. This may be related, in addition to the reasons mentioned above, to the lower amount of lean mass in the lower limbs, to muscle atrophy, the decrease in muscle oxidative capacity, to the greater amount of fat; and because patients in other studies carry out rehabilitation programs to improve physical capacity in general. In Mexico, until now, it is not a common practice to treat patients with CKD (on HD and with KT) with physical exercise and rehabilitation programs, be-because there is no infrastructure, trained professional staff, and in general the poor budget offered for these patients [46]. Despite this, it is clear to us that valid conclusions cannot be obtained from the Queen's College Step Test, in a CKD patient that consumes be-ta-blockers. Probably an alternative would be to evaluate the patient’s aerobic capacity using perceived exertion tests, which is not affected by the intake of beta-blockers [47,48].

Recent reports in the literature on the QoL of patients with CKD show that these patients have reduced functional capacity, which makes it difficult to perform basic activities, rest time, work and occupation, and social life; thus, reducing their overall QoL. In our study, it was evident to demonstrate that patients on HD and those with KT presented a deterioration in health status demonstrated by low scores in most dimensions of the QoL test [51,52]. In another study, it was shown that QoL was very low in HD patients and was even lower compared to that of KT patients. In both groups their QoL was comparable to that of patients with hematological malignancies in remission or in patients receiving chemotherapy [53]. The results of these researchers coincide with those obtained in the present study, in which we demonstrated that the group of patients with KT were only better in two dimensions of QoL compared to patients on HD, but in no dimensions of the QoL scale was better when compared to the scores obtained by HCG [49-51].

This study demonstrated a significant decrease in the QoL of CKD patients on HD and KT, especially in the physical dimensions, vitality, social function, mental health, and bodily pain; results similar to those of other studies in which the same measurement instrument (SF-36) was used; these studies demonstrated better results in the mental component dimension and low scores in the physical dimension in patients with CKD undergoing periodic HD [12,51-54]. Our results on the evaluation of QoL and those of other researchers can be

explained by the following reasons: 1) by the immobilization of patients with CKD associated with dialysis, 2) by the chronic fatigue experienced by patients, 3) by the uremic syndrome, 4) due to the high burden of comorbidities, 5) due to the general lack of physi-cal activity, and 6) due to symptoms of depression. Although we would think that after a successful kidney transplant, all physical and emotional alterations would be reversed; in this investigation we demonstrated that this is not the case. Patients with KT are afraid of losing the kidney graft; because the vast majority do not have a physical, nutritional, and psychological training plan appropriate to their conditions [55-57].

The result of the physical role dimension was the only one of the QoL scale that turned out to be better in the control group compared to HD patients. The explanation is because this dimension evaluates problems at work, or activities of daily living related to physical ca-pacity. However, HD patients usually require an average of 12 hours in HD therapies, which forces them to modify their occupational and work dynamics; this could also be a barrier for them to perform scheduled physical exercise. KT patients reported a positive change in their health status, demonstrated by a higher score on the SF36 scale, during the last year, compared to HD patients; however, the score in this dimension did not reach the score of the control group. In previous studies it has been documented that there is a relationship between better renal function and better QoL; however, in the present investigation, it was shown that despite the improvements in renal function in patients with KT, their QoL in most dimensions was like that observed in patients on HD [51,58,59].

The results of this research illustrate how the physical, psychological, social functioning and general health of patients with CKD were affected; therefore, the evaluation of QoL is important after the start of renal replacement therapies. The main therapeutic goal is to improve these patients' ability to function so that they can enjoy life to the fullest. In this research it was shown that only 40.4% of HD patients and 60.9% of KT patients were economically active, since they had a job. The explanation for this result could be due to the poor state of health, and the time required for treatment by HD patients. In this study it was shown that patients with TR had a better state of health than patients on HD, but 39.1% did not have a job, a figure that is much higher when compared to the percentage of unemployed people in the control group 9.4%. Unemployment of patients with TR is higher than that of the general Mexican population, affecting their family and social role.

Low levels of physical activity, increased weight and body fat, poor QoL after kidney transplant; and the subsequent increase in cardiovascular risk should be a cause of concern for the medical community that cares for this group of patients. Therefore, it is necessary to make greater efforts to optimize education, advice and encourage the practice of regular physical activity with programs and strategies focused on patients with CKD.

In the K/DOQI clinical practices for cardiovascular diseases [60,61], and in the section on patients treated with dialysis, it is described that nephrologists and health personnel involved in dialysis should promote and raise awareness among CKD patients about the practice of physical exercise to increase the levels of physical condition. This is because physical exercise has been shown to have an anti-inflammatory effect, since it reduces visceral fat, and decreases the prevalence of sarcopenia, thus achieving successful rehabilitation leading to a better prognosis for KT and HD patients [60,61]. For this reason, different physical activity programs have been implemented in many countries; however, these health strategies represent high costs for the health system, which makes it difficult to implement physical exercise for this population, which requires the help of professional staff prepared in this area [62]. Despite this, there are proposals for home physical exercise programs that have shown favourable results for the benefit of physical capacity in this type of population.

In Mexico, only one study has been carried out in which a group of patients with KT is intervened with physical exercise [63]. However, to the best of our knowledge, this is the first study in which the physical health status of KT patients, HD patients, is comprehensively evaluated and compared with a control group of healthy subjects. Therefore, it is imperative that more research be carried out in patients with CKD, in which nutritional status, type of regular diet, physical fitness status, strength, flexibility, and anthropometric variables such as body composition are evaluated; since they are non-invasive clinical methods, widely available, portable, low-cost and quick to apply and interpret [66], [70]. There are some limitations in this study, such as susceptibility to selection bias, since we only included ambulatory patients without severe physical disabilities, previous graft loss, previous hospitalizations, or significant comorbidities, so the representativeness of the sample of the Mexican population of patients with CKD could be compromised. The lack of random sampling and multicentre participation is also a problem resulting in the inability to generalize the results to this population.

Another limitation of this research is its cross-sectional design since it does not show the dynamics of changes at different times after kidney transplantation. For this reason, it is advisable to carry out more research in which longitudinal measurements are carried out at different times, in various populations of patients with CKD, to better define the effects of transplantation on the development of alterations in physical, psychological, and functional capacity. nutritional status of these patients and in this way be able to evaluate the effects of a rehabilitation program precisely and accurately with physical exercise and physiotherapy interventions could improve the variables of physical capacity and body composition.

Finally, this investigation did not include assessment of dietary intake, lifestyle habits, or energy expenditure of patients and controls. Therefore, it is not possible to determine the etiology of the increase in fat mass, and only inferences can be made about the possible causes.

Conclusions

Surprisingly, manual muscle strength and the quality of life of KT patients are closer to that of hemodialysis patients than the values of healthy volunteers, contrary to what would be thought due to the reversal of uremia due to the presence of the new organ. In addition to this, both the HD and KT groups have lower manual muscle strength and lower quality of life compared to healthy control group. Therefore, these results demonstrate the need to carry out further research in relation to

the evaluation of the state of comprehensive physical capacity of patients with CKD, in order to design novel health strategies in which physical exercise programs are designed for the population of patients with CKD, with the idea of preventing the appearance of musculoskeletal problems, sarcopenia, and excess body fat; all of these problems go unnoticed by general practitioners, family doctors, and even nephrology specialists. Therefore, the multidisciplinary work of medical doctors, physical therapists, physical education teachers, nutritionists and psychologists is necessary for the comprehensive treatment of these patients.

Author Contributions: Conceptualization, M.J.-P. and M.R.-H.; methodology, M.J.-P., M.R.-H, E.A.-J and F.M.-V.; formal analysis, M.J.-P., M.R.-H, E.A.-J and F.M.-V., resources, M.J.-P.; writing—original draft preparation, M.J.-P., M.R.-H, E.A.-J and F.M.-V.; writing—review and editing, M.J.-P., M.R.-H, supervision, M.J.-P.; project administration, M.J.-P..; funding acquisition, M.J.-P. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the National College of Humanities, Sciences and Technologies (CONAHCYT)

Institutional Review Board Statement: This research was approved by the Research and Research Ethics Committees of the Hospital Regional de Alta Especialidad del Bajío, with the following registration number: CI/HRAEB/018/2022. It is declared that the procedures followed were carried out in accordance with the ethical standards of the Responsible Research and Ethics Committee, and in accordance with the provisions of the World Medical Association in the Declaration of Helsinki; that the protocols of the work center on confidentiality and the publication of patient data have been followed, and that the informed consent of the patients referred to in the article has been obtained.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The original contributions presented in the study are included in the article; further inquiries can be directed to the corresponding author.

Acknowledgments: To Hospital Regional de Alta Especialidad del Bajío for allowing us to use the facilities, instruments, and patients to carry out this research

Conflicts of Interest: The authors declare no conflict of interest.

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