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Original article

Physical, functional, body composition, quality of life, and biochemical characterization of patients who undergo hemodialysis in a Spanish hospital

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Abstract

Introduction: Patients who undergo hemodialysis experience progressive decay of their capacities and require an integral assessment to develop measures to counteract their typical disability.
Objective: The objective is to identify the characteristics of physical fitness, functional status, quality of life, body composition, and biochemical parameters in the study population, to be used as a baseline for prescribing an intradialytic physical exercise program.
Methods: This descriptive study was conducted with 38 ambulatory patients from the hemodialysis unit of the Consorci Sanitari de Terrassa hospital. The following test were applied: Static knee extension and handgrip dynamometry, 2-Minute Step Test (2MST), 6-Minute Walk Test

Keywords: Chronic kidney disease, hemodialysis, health evaluation, physical fitness, functional status, quality of life, body composition, biomarkers.

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(6MWT), Timed Up and Go (TUG), Short Physical Performance Battery (SPPB), Barthel Index, EuroQoL-5D, Beck Depression Inventory (BDI), multifrequency bioimpedance, and analysis of serum levels of nine biomarkers.
Results: Mean values obtained were 20.49 ± 7.74 kg in handgrip; 15.23 ± 9.17 kg in knee extension; 460.86 ± 143.48 mt in the 6MWT; 49.23 ± 18.02 steps in the 2MST; 18.25 ± 11.49 seconds in TUG; 6.11 ± 3.46 points in SPPB; 86.25 ± 20.98 points in the Barthel Index; 32.35 ± 9.40 % in body fat, and 7.15 ± 1.26 in MMI from body composition; 59.37 ± 19.65 points on the Euro-Qol-5D visual health scale, and 12.24 ± 7.47 points in the BDI.
Conclusion: Hemodialysis patients show low physical activity levels and reduced capacities associated with their deteriorating health status, especially in women. This study's test set is straightforward to implement, cost-effective, and accessible, making it a suitable baseline tool for assessing the effects of intradialytic physical exercise programs.

Caracterización física, funcional, de composición corporal, de calidad de vida y bioquímica de pacientes en hemodiálisis en un hospital español

Resumen
Introducción: los pacientes sometidos a hemodiálisis experimentan un deterioro progresivo de sus capacidades y requieren una evaluación integral para desarrollar medidas que contrarresten la discapacidad asociada.
Objetivo: el objetivo es identificar las características de la condición física, el estado funcional, la calidad de vida, la composición corporal y los parámetros bioquímicos en la población de estudio, para utilizarlos como base para la prescripción de un programa de ejercicio físico intradiálisis.
Métodos: este estudio descriptivo se realizó con 38 pacientes ambulatorios de la unidad de hemodiálisis del hospital Consorci Sanitari de Terrassa. Se aplicaron las siguientes pruebas: extensión estática de rodilla y dinamometría de prensión manual, prueba de marcha estacionaria de 2 minutos (2MST), prueba de marcha de 6 minutos (6MWT), prueba Timed Up and Go (TUG), batería corta de rendimiento físico (SPPB), índice de Barthel, EuroQoL-5D, Inventario de Depresión de Beck (BDI), bioimpedancia multifrecuencia y análisis de los niveles séricos de nueve biomarcadores.
Resultados: los valores promedio obtenidos fueron 20.49 ± 7,74 kg en prensión manual; 15.23 ± 9.17 kg en extensión de rodilla; 460.86 ± 143.48 mt en la prueba 6MWT; 49.23 ± 18.02 pasos en la prueba 2MST 18.25 ± 11.49 segundos en el TUG; 6.11 ± 3.46 puntos en la prueba SPPB; 86.25 ± 20.98 puntos en el Índice de Barthel; 32.35 ± 9.40 % en grasa corporal y 7.15 ± 1.26 en el Índice de Masa Musculoesquelética (MMI) de la composición corporal; 59.37 ± 19.65 puntos en la escala de salud visual EuroQol-5D, y 12.24 ± 7.47 puntos en el BDI.
Conclusión: los pacientes en hemodiálisis presentan bajos niveles de actividad física y capacidades asociadas con el deterioro de su salud, especialmente en mujeres. El conjunto de pruebas de este estudio es fácil de implementar, rentable y accesible para su uso como base para evaluar los efectos de los programas de ejercicio físico intradiálisis.
Palabras clave: enfermedad renal crónica, hemodiálisis, evaluación de la salud, aptitud física, estado funcional, calidad de vida, composición corporal, biomarcadores.

Introduction

Patients undergoing hemodialysis have been observed to have a higher prevalence of cardiovascular comorbidities and to develop various alterations such as loss of muscle mass [1], increased bone catabolism, insulin resistance, and decreased balance and body coordination [2], which are exacerbated by physical inactivity [3]. Specifically, during hemodialysis, patients must endure a period of forced inactivity commonly lasting 3 to 4 hours per session, three times a week, leading to generalized physical weakness and increased mortality [4], which directly impacts their functional independence and quality of life [1, 5].

Based on the above, this study aims to characterize physical capacity, functional status, quality of life, body composition, and biochemical parameters through a comprehensive assessment of the hemodialysis population. This study is part of a larger project that investigates physical exercise during the dialysis as a complementary and much-needed treatment to improve the quality of life of this population. For this reason, the characterization obtained from this article will serve as baseline data to adjust the intradialytic physical exercise program.

Methodology

Study design

The hypothesis of this study is that patients with chronic kidney disease undergoing hemodialysis experience a decline in physical capacity [6–8], functional status [2, 9–11], and quality of life [12, 13], along with alterations in body composition [1, 3, 14] and biochemical parameters [4, 15], relative to established standards for healthy, contemporaneous populations. This is a descriptive, cross-sectional, observational study with a non-randomized sample selection of hemodialysis patients from the Consorci Sanitari de Terrassa hospital in Barcelona, Spain. The study was conducted with the aim of using the information obtained from this population characterization to subsequently develop and implement a tailored intradialytic physical exercise program adjusted to their specific conditions.

Data collection

As part of an observational study, no sample size calculations were required. A total of 38 out of 64 patients attending the hemodialysis unit at the Consorci Sanitari de Terrassa were included. The inclusion criteria were as follows: being at least 18 years old, being on renal replacement therapy in the form of hemodialysis for at least three months as of February 13, 2023, with a frequency of three sessions per week, presenting chronic kidney disease at stage

G4 or G5 according to the KDIGO classification; and voluntarily agreeing to participate in the study by providing verbal consent. The exclusion criteria included: having any disorder that affects consciousness or cognitive function; hemodynamic instability; total functional dependence (Barthel Index score <20); musculoskeletal or respiratory disorders that would prevent the completion of the tests; and acute myocardial infarction or cerebrovascular disease within the last three months.

As part of the demographic data, the following variables were included: age, sex, duration of hemodialysis, use of mobility aids for short distances and enclosed spaces, level of physical activity, etiology of chronic kidney disease, type of vascular access, and existing comorbidities.

Physical capacity and functional status were assessed during a scheduled appointment through the nephrology service on days when the patient was not undergoing dialysis; quality of life was measured using self-report questionnaires; with regard to body composition, a bioimpedance test was conducted following the manufacturer's instructions (immediately after the completion of the dialysis session, using the obtained dry weight value); and finally, the last laboratory results from the first quarterly assessment of 2023, conducted by the nursing and nephrology services, were collected from the medical record to obtain biochemical parameters.

Analyzed variables

Physical fitness

Two subcategories were considered: maximum strength in the extremities and aerobic capacity. Maximum strength was assessed through upper extremity dynamometry (handgrip test) using the Camry© model EH101 electronic hand dynamometer on the non-access extremity, and lower extremity dynamometry was assessed through maximum knee extension from a seated position using the Kern & Sohn GmbH© model CH50K50 electronic scale adapted to an ankle boot. In each case, three attempts were made with one minute rest between each, and the best result was recorded in kilograms.

Aerobic capacity was evaluated with the 6-Minute Walk Test (6MWT) in patients younger than 60 years of age and the 2-Minute Step Test (2MST) in those older than 60 years, considering heart rate values, oxygen saturation levels, and perceived exertion according to the modified Borg scale, both before and after the tests, in addition to the number of meters walked or steps completed, according to the test administered.

Functional status

Two tests were administered: the Timed Up and Go (TUG) test, which measures the time in seconds it takes for the patient to stand up from a chair, walk 3 meters, return, and sit back down; and the Short Physical Performance Battery (SPPB), which comprises three components: walking speed over four meters; balance in a standing position with feet together, semi-tandem, and tandem; and the time it takes to stand up and sit down five times consecutively without using the upper limbs for support. Each test is scored from 0 to 4, for a maximum total of 12 points, reflecting the level of physical performance achieved, where a lower score is associated with worse functional and/or physical capacity.

To evaluate functionality regarding basic activities of daily living, the Barthel Index was utilized. This index assesses the level of functional independence in daily activities, specifically in the categories of eating, bathing, dressing, grooming, bowel control, urination, toilet use, transfers from chair to bed, ambulation, and stair climbing. This instrument assigns various weighted scores according to the patient's ability to perform these activities, resulting in a total score ranging from 0 (completely dependent) to 100 points (completely independent).

Body composition

Segmental multifrequency bioimpedance was performed using the Microcaya© InBody S10 bioimpedance analyzer [16], which was specifically designed for the field of nephrology. The dry weight obtained at the end of the hemodialysis session, along with age, height, and sex, was entered into the system. Four electrodes were placed, one on each wrist and ankle, after disinfecting the skin and removing metallic objects. The bioimpedance was measured in a supine position at six frequency levels (1, 5, 50, 250, 500, and 1000 kHz); however, only the values at 50 kHz were used for analysis, as this is the standard frequency.

This procedure yielded values for body weight (kg), height (m), body mass index (kg/m^2), total body water (L), intracellular water (L), extracellular water (L), body fat (%), fat mass (kg), soft lean mass (kg), skeletal muscle mass (kg), visceral fat area (cm^2), basal metabolic rate (kcal), and phase angle (°).

Quality of life

The EuroQol-5D questionnaire was administered, evaluating the domains of mobility, self-care, daily activities, pain/discomfort, and anxiety/depression, along with a visual health scale. The results from both the quality-of-life index score and the visual scale value were recorded.

Additionally, the level of depression was further assessed using the self-report questionnaire from the Beck Depression Inventory (BDI), which consists of 18 questions and yields a score between 0 and 63, where a higher score indicates greater depressive symptomatology.

Biochemical parameters

The following parameters were obtained from the laboratory blood analyses: calcium, ferritin, phosphorus, hemoglobin, transferrin saturation index, intact parathyroid hormone, albumin, total cholesterol, alkaline phosphatase, prealbumin, C-reactive protein, and potassium.

Statistical analysis

The analysis was conducted using the software Stata© IC 15.0 (17) (StataCorp LLC, College Station, TX, USA); all variables were organized and coded to generate tables and graphs. Statistical measures included proportions, sample means with corresponding standard deviations, and sample medians with interquartile ranges for variables with asymmetric distributions. Mean differences with their standard errors were analyzed using a two-sample t-test for equal variances, stratified by sex. Additionally, bar charts and scatter plots with trend lines were generated.

Results

Table 1 shows that, of the 38 patients evaluated, 57.89 % were men, with an average age of 71.84 ± 13.87 years for the overall group. Time on dialysis showed high variability ranging from three months to 21.8 years. Additionally, 55.26 % reported no use of any type of physical aids such as canes, wheelchairs, or walkers for mobility over short and medium distances; 52.63 % reported having a sedentary level of physical activity; the most common etiologies of chronic kidney disease were diabetic nephropathy and unknown origin; 90.48 % had a central venous catheter or an arteriovenous fistula as vascular access; and the most prevalent comorbidities were hypertension (86.84 %), cardiovascular diseases (78.95 %), and diabetes mellitus (47.37 %).

Table 1. General characterization of the analyzed sample

	Global	Min-Max	Women	Men
Age in years (Mean ± Std. Dev.)	71.84 ± 13.87	25 - 94	71.56 ± 12.13	72.04 ± 15.30
Time on hemodialysis in months (Median ± IQR)	29.5 ± 42	3 - 262	46.5 ± 47.5	38.5 ± 40
Sex			**Women**	**Men**
n (%)			16 (42.11)	22 (57.89)

Table 1. General characterization of the analyzed sample

	Global	Min-Max	Women	Men
Use of walking aids	**Total n**	**Total %**	**Women (%)**	**Men (%)**
Cane	8	21.05	12.50	87.50
Walker	5	13.16	60.00	40.00
Wheelchair	3	7.89	100.00	0.00
External prothesis	1	2.63	0.00	100.00
None	21	55.26	42.86	57.14
Physical activity level				
Sedentary	20	52.63	60.00	40.00
Low (<150 min/week)	14	36.84	28.57	71.43
Moderate (150 min/week)	3	7.89	0.00	100.00
Intense (>150 min/week)	1	2.63	0.00	100.00
Chronic kidney disease etiology				
Diabetic nephropathy	12	31.58	41.67	58.33
Nephroangiosclerosis	6	15.79	16.67	83.33
Glomerular nephropathy	5	13.16	40.00	60.00
Polycystic kidney disease	2	5.26	50.00	50.00
Other nephropathies	13	34.21	53.85	46.15
Vascular access				
Central venous catheter	17	44.74	52.94	47.06
Arteriovenous fistula	17	44.74	29.41	70.59
Polytetrafluoroethylene vascular prosthesis	4	10.53	50.00	50.00
Comorbidities				
Arterial hypertension	33	86.84	45.45	54.55
Cardiovascular diseases	30	78.95	43.33	56.67
Diabetes mellitus	18	47.37	38.89	61.11
Neurologic diseases	5	13.16	80.00	20.00
Other	37	97.37	43.24	56.76

Note. n: sample.
Source: Authors.

Physical fitness and functional status

As shown in table 2, better results were obtained by the male gender compared to the female in physical capacity and functional status tests, reflecting that, although both genders have very similar characteristics, their physical capabilities are not.

Men mobilized, on average, more weight in both dynamometry tests, with a significant difference of 9.89 ± 2.03 kg (P=0.000, t(35)= -4.8731) and 6.68 ± 2.85 kg (P=0,025, t(36)= -2.3460) in the upper and lower limbs, respectively. They also took more steps in the 2MST test (5.25 ± 7.33 steps, P=0.4810, t(24)= -0.7158), although the difference was not statistically significant. Additionally, men had a shorter average TUG time by 6.87 ± 3.93 seconds (P=0.0906, t(32)= 1.7451), indicating a high fall risk for women and a mild fall risk for men. Regarding the total SPPB score, men had a higher total score with a significant difference (2.66 ± 1.06 points, P=0.0170, t(36)= -2.5036), representing a mild functional limitation for men and a moderate functional limitation for women (figure 1).

Table 2. Physical fitness and functional status

Test	Global		Men		Women		P value
	Mean ± Std. Dev.	**n**	**Mean ± Std. Dev.**	**n**	**Mean ± Std. Dev.**	**n**	
Physical fitness							
Maximum strength							
Handgrip dynamometry (Kg)	20.49 ± 7.74	37	24.50 ± 6.66	22	14.61 ± 5.02	15	0.000
Knee extension dynamometry (Kg)	15,23 ± 9,17	38	18,04 ± 8,55	22	11,37 ± 8,82	16	0,025
Aerobic capacity							
6-Minute Walk Test (m)	460.86 ± 143.48	7	489.60 ± 163.66	5	389.00 ± 43.84	2	0.453
2-Minute Step Test (steps)	49.23 ± 18.02	26	51.25 ± 18.65	16	46.00 ± 17.40	10	0.481
Functional status							
Timed Up and Go test							
Execution time (s)	18.25 ± 11.49	34	15.62 ± 8.17	21	22.49 ± 14.84	13	0.091
Short physical performance battery							
Balance (score)	2.53 ± 1.52	38	3.05 ± 1.17	22	1.81 ± 1.68	16	0.012
Gait (score)	2.58 ± 1.33	38	3.00 ± 1.02	22	2.00 ± 1.51	16	0.020
Chair sit to stand 5-times (score)	1.00 ± 1.01	38	1.18 ± 1.05	22	0.75 ± 0.93	16	0.199
Gait speed (m/s)	0.69 ± 0.32	36	0.77 ± 0.31	22	0.57 ± 0.30	14	0.064
Chair sit to stand time (s)	14.83 ± 12.70	38	18.74 ± 12.86	22	9.45 ± 10.62	16	0.024
Total score	6.11 ± 3.46	38	7.23 ± 2.79	22	4.56 ± 3.78	16	0.010
Barthel index							
Feeding	9.82 ± 0.94	28	9.72 ± 1.18	18	10.00 ± 0.00	10	0.467
Bathing	3.21 ± 2.44	28	3.33 ± 2.43	18	3.00 ± 2.58	10	0.736
Dressing	8.39 ± 3.06	28	9.17 ± 1.92	18	7.00 ± 4.22	10	0.072
Grooming	3.93 ± 2.09	28	4.17 ± 1.92	18	3.50 ± 2.41	10	0.429
Bowel control	9.11 ± 2.38	28	9.72 ± 1.78	18	8.00 ± 3.50	10	0.065
Bladder control	9.64 ± 1.31	28	10.00 ± 0.00	18	9 .00 ± 2.11	10	0.051
Toilet use	8.93 ± 2.84	28	9.72 ± 1.18	18	7.50 ± 4.25	10	0.045

Table 2. Physical fitness and functional status

Test	Global		Men		Women		P value
	Mean ± Std. Dev.	n	Mean ± Std. Dev.	n	Mean ± Std. Dev.	n	
Transfers	13.39 ± 3.35	28	14.17 ± 2.57	18	12.00 ± 4.22	10	0.102
Ambulation	12.32 ± 4.61	28	13.33 ± 2.97	18	10.50 ± 6.43	10	0.121
Stairs	7.50 ± 3.73	28	7.78 ± 3.52	18	7.00 ± 4.22	10	0.606
Total score	86.25 ± 20.98	28	91.11 ± 12.67	18	77.50 ± 29.74	10	0.101

Source: Authors.

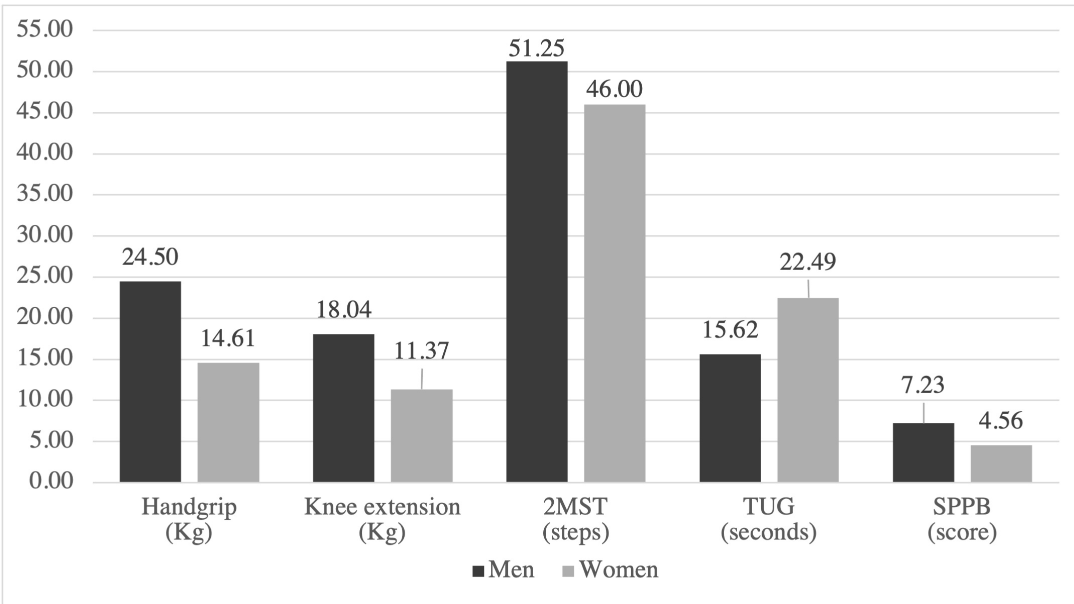

Figure 1. Physical fitness and functional status results by sex comparison

Source: Authors.

With respect to aerobic capacity, both sexes fell below the cutoff values for the 2MST test for ages between 60 and 94 years: the average for men was 51.25 ± 18.65 steps, against an expected range of 60-106 steps, and for women it was 46.00 ± 17.40 steps, with an expected range of 60-97 steps.

Considering that the analysis of aerobic capacity must weigh in various factors contributing to this physical quality, the respiratory, cardiovascular, and musculoskeletal systems were highlighted as the most relevant. Therefore, the data obtained from the 2MST test, which is representative of the aerobic capacity category, were cross-referenced with hemoglobin values (figure 2) and knee extension dynamometry values (figure 3). In the former, hemoglobin serves as an indicator of cardiovascular function due to the relationship between hemoglobin levels and the transport and delivery of oxygen to tissues; knee extension dynamometry, in turn, serves as an indicator of musculoskeletal function, reflecting the strength of the lower extremities and representing the capacity of the leg muscles to sustain the test.

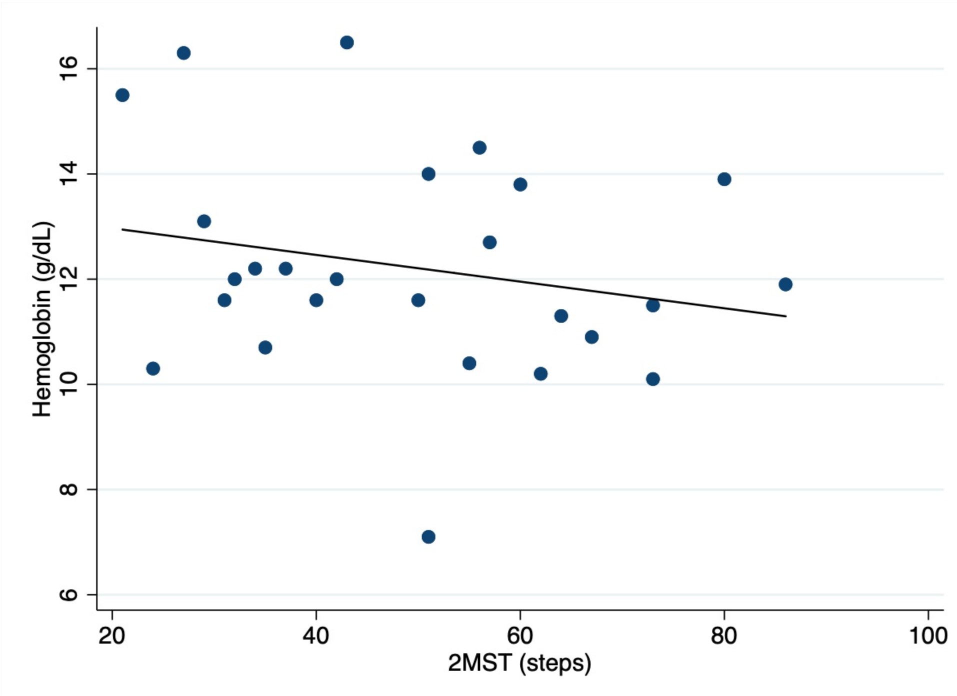

Figure 2. Relationship between aerobic capacity and hemoglobin levels

Source: Authors.

The data shows that as the number of steps in the 2MST test increases, the hemoglobin value decreases while knee extension dynamometry increases. This may suggest that, in these patients, aerobic capacity outcomes depend more on musculoskeletal function than on cardiovascular factors when there is no prior physical training.

This is corroborated by the data collected on initial heart rate, final heart rate, oxygen saturation percentage, and the Borg rating of perceived exertion at the end of the test. The average initial heart rate was 78.54 ± 15.75 bpm, the average final heart rate was 87.79 ± 18.61 bpm, the average oxygen saturation percentage was 94.97 ± 3.45 %, and the average Borg score of perceived exertion was 6.28 ± 1.41 out of 10, demonstrating a non-significant heart rate increase, with appropriate saturation values and moderate perceived exertion for the activity. Participants reported that the perceived exertion was more related to muscular fatigue in the lower limbs than to cardiorespiratory demands.

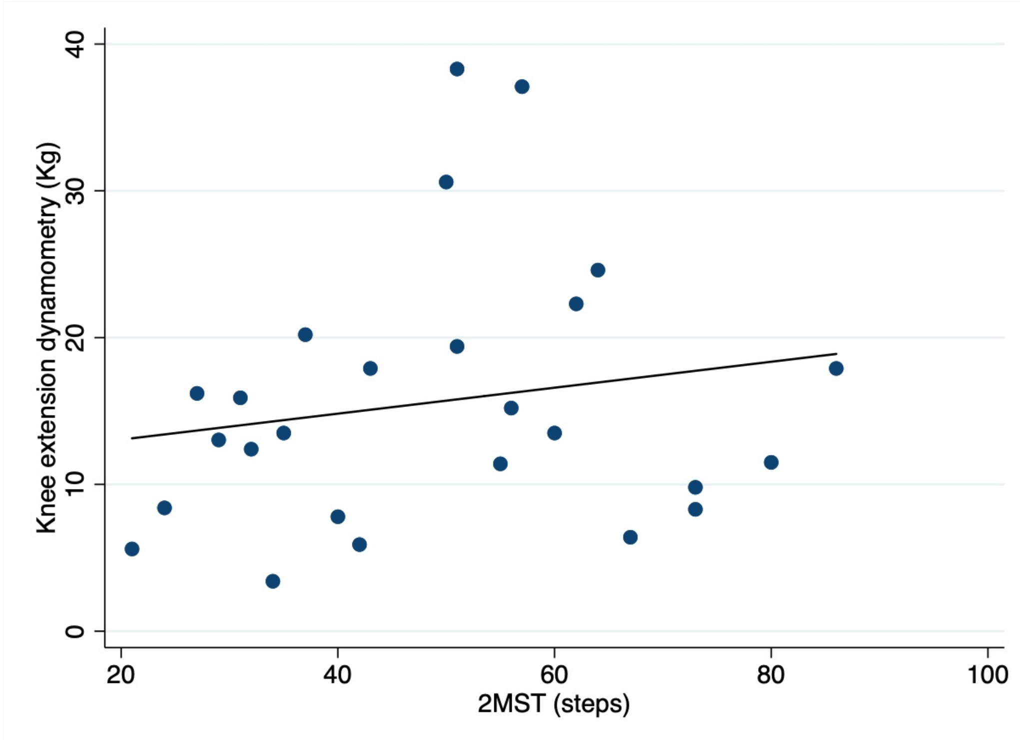

Figure 3. Relationship between aerobic capacity and lower limbs maximal strength

Source: Authors.

Regarding the level of functional dependence according to the Barthel Index scores, men had an average score of 91.11 ± 12.68 points, while women had an average score of 77.50 ± 29.74 points out of 100, indicating a mild functional dependence in both cases. However, consistent with the observations from the physical and functional capacity tests, the average score for women was lower than that reported for men (mean difference of 13.61 ± 8.00 points, P= 0.1007, t(26)= -1.7019).

Body composition

From the values obtained through bioimpedance (table 3), it can be observed that the percentage of body fat was above the expected range for age and sex [14], showing poorer conditions in male patients. For men, the normal range is between 11.0 % and 24.9 %, and the average obtained was 29.06 ± 7.79 %, while for women, the normal range is between 23.0 % and 35.9 %, and the average obtained was 36.29 ± 9.88 %.

Table 3. Body composition

Test	Global		Men		Women		P value
	Mean ± Std. Dev.	n	Mean ± Std. Dev.	n	Mean ± Std. Dev.	n	
Body weight (Kg)	70.01 ± 15.92	33	73.06 ± 14.71	18	66.35 ± 17.03	15	0.233
Height (m)	162.15 ± 8.28	33	167.72 ± 3.91	18	155.47 ± 7.11	15	0.000
Body Mass Index (Kg/m2)	26.58 ± 5.75	33	25.91 ± 4.87	18	27.40 ± 6.75	15	0.466
Total body water (L)	34.18 ± 6.35	33	37.54 ± 5.52	18	30.14 ± 4.82	15	0.000
Intracellular water (L)	20.68 ± 4.07	33	22.86 ± 3.65	18	18.07 ± 2.87	15	0.000
Extracellular water (L)	13.50 ± 2.43	33	14.69 ± 2.04	18	12.07 ± 2.10	15	0.001
Body fat (%)	32.35 ± 9.40	33	29.06 ± 7.79	18	36.29 ± 9.88	15	0.025
Body fat mass (Kg)	23.51 ± 10.93	33	22.01 ± 9.95	18	25.32 ± 12.10	15	0.394
Soft lean mass (Kg)	43.65 ± 8.19	33	48.02 ± 7.17	18	38.42 ± 6.10	15	0.000
Musculoskeletal mass (Kg)	24.96 ± 5.31	33	27.79 ± 4.76	18	21.55 ± 3.75	15	0.000
Musculoskeletal mass index (Kg/m2)	7.15 ± 1.26	33	7.53 ± 1.09	18	6.71 ± 1.35	15	0.062
Visceral fat area (cm2)	110.41 ± 53.18	33	101.87 ± 51.09	18	120.65 ± 55.57	15	0.320
Basal metabolic rate (kcal)	1374.49 ± 187.41	33	1472.89 ± 166.41	18	1256.40 ± 138.79	15	0.000
Phase angle (°)	4.58 ± 1.38	33	4.81 ± 1.43	18	4.32 ± 1.33	15	0.324

Source: Authors.

Regarding visceral fat area, the normal values range from 10 to 100 cm² for both men and women [14], with higher values associated with greater metabolic risk. Both means exceeded the expected values, indicating overweight and a metabolic risk across the entire sample, with a higher risk identified in the female sample (mean difference 18.78 ± 18.58 cm^2, P= 0.3201, t(31)= 1.0105).

Concerning the percentage of skeletal muscle mass, the expected range for women is between 24.1 % and 29.9 %, and for men between 33.1 % and 38.9 % [14]. The women assessed had an average of 33.36 ± 4.98 %, placing them above the expected range, while men were at the upper end of the expected range with an average of 38.53 ± 4.32 %.

The phase angle was also obtained, reflecting the resistance encountered by bioimpedance current in the tissues and serving as a reference for cellular integrity. The average for the sample was 4.58 ± 1.38°, with normal values considered to be between 4° and 7° in renal patients; values lower than 4° may indicate poor nutritional status, among other alterations in overall bodily health. No significant difference was found between sexes (-0.49 ± 0.48°, P=0.3237, t(31)= -1.0029).

Associated with nutritional status, the basal metabolic rate was obtained from the data provided by the bioimpedance data. Using this, the total energy expenditure was calculated using the following formula:

$$\text{Total energy expenditure} = [(\text{basal metabolic rate (BMR)} \times \text{physical activity factor}) +$$

$$\text{thermogenic effect of food}(10\,\%\text{of BMR})] \times (\text{lesion factor})$$

Additionally, the daily energy consumption was subtracted, which, according to recommendations for dialysis patients, is 35 kcal/kg/day [18]. The resultant value in kcal is the metabolic window, representing the amount of energy available for physical activity.

This last measurement refers to the amount of energy that the patient theoretically has available to perform light to moderate physical activity, as recommended by the World Health Organization (WHO). The average basal metabolic rate was 1374.49 ± 187.41 kcal, the total energy expenditure was on average 2116.71 ± 288.61 kcal, and the metabolic window results ranged from -267.96 kcal to 1352.40 kcal. A negative value indicates that the recommended dietary intake does not provide enough energy to perform other activities beyond those needed for basal metabolism, suggesting that the energy intake may be inadequate for physical activity. However, this does not represent an obstacle to engaging in such activities but rather serves as a warning to involve a nutritionist alongside the physiotherapist when prescribing physical activity.

Another important parameter provided by bioimpedance is the skeletal muscle mass index, which is currently used to confirm the diagnosis of sarcopenia by quantifying muscle mass [19]. Cut-off points have been established by sex, with <7.0 kg/m^2 for men and <5.5 kg/m^2 for women. In the analyzed sample, an average of 7.53 ± 1.09 kg/m^2 was obtained for men and 6.71 ± 1.35 kg/m^2 for women, with both genders being, on average, above the sarcopenia cut-off. However, 26.32 % of the sample fell below the cut-off level, with 60 % of those being men.

Considering that physical and functional performance are associated with body composition, walking speed, calculated from the SPPB walking test, and TUG test execution time were cross-referenced with skeletal muscle mass index values, yielding figures 4 and 5. These show that a higher index is associated with greater walking speed and shorter TUG test execution time, thus demonstrating that this index can serve as an indicator of functionality.

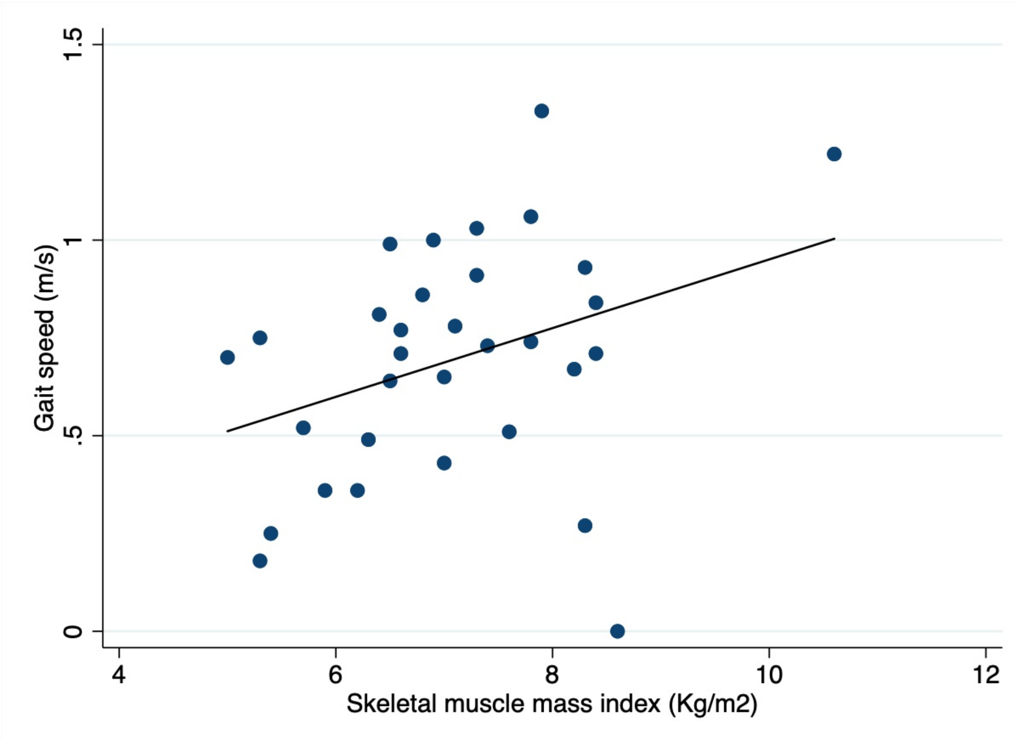

Figure 4. Relationship between body composition and gait speed

Source: Authors.

Quality of life

What was reported by women in the Euro-Qol-5D questionnaire demonstrates that they experience more problems than men in domains of self-care, daily activities, pain/discomfort, and anxiety/depression, which aligns with the findings on physical and functional capacity. However, no sex difference was observed in the mobility domain or the visual analog scale of perceived health status. No statistically significant mean differences between sexes were found in any of the Euro-Qol-5D categories.

Regarding depressive symptoms, a greater impact on health was again observed in women, with a mean difference of 6.55 ± 2.58 points out of 63. This classifies as mild depression for women (16.08 ± 7.97 points), while men fell into the category of minimal depression (9.53 ± 5.93 points) (table 4).

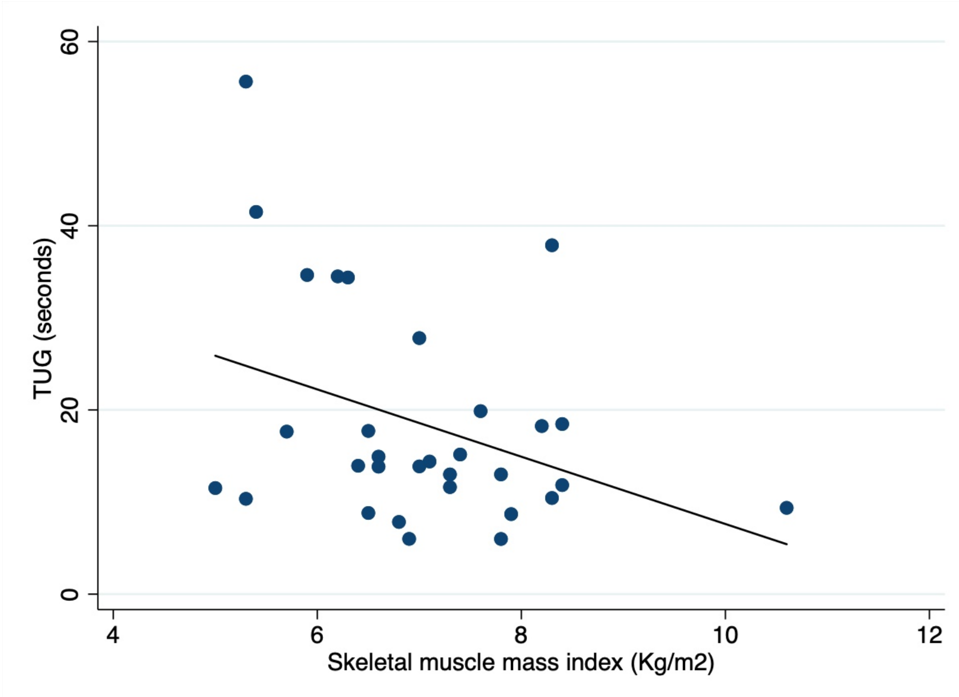

Figure 5. Relationship between body composition and time spend in Timed Up and Go test

Source: Authors.

Table 4. Quality of life

Test	Global		Men		Women		P value
	Mean ± Std. Dev.	n	Mean ± Std. Dev.	n	Mean ± Std. Dev.	n	
Euro Qol-5D							
Mobility	1.40 ± 0.50	35	1.40 ± 0.50	20	1.40 ± 0.51	15	1.000
Self-care	1.23 ± 0.43	35	1.20 ± 0.41	20	1.27 ± 0.46	15	0.506
Usual activities	1.29 ± 0.57	35	1.20 ± 0.41	20	1.40 ± 0.74	15	0.314
Pain/discomfort	1.54 ± 0.61	35	1.45 ± 0.51	20	1.67 ± 0.72	15	0.306
Anxiety/depression	1.31 ± 0.53	35	1.20 ± 0.41	20	1.47 ± 0.64	15	0.143
Health visual scale	59.37 ± 19.65	35	59.50 ± 16.70	20	59.20 ± 23.65	15	0.965
Beck Inventory							
Total score	12.24 ± 7.47	29	9.53 ± 5.93	17	16.08 ± 7.97	12	0.017

Source: Authors.

Biochemical parameters

It is worth mentioning the presence of three common metabolic characteristics of the chronic renal patient. First, persistent anemia, with 63.16 % of the sample having hemoglobin values below the normal range (72.73 % of the men and 50.00 % of the women). Second, a chronic inflammatory state, with 63.16 % and 47.37 % of the sample having ferritin and C-reactive protein levels above the expected values, respectively (for ferritin, 45.45 % of the men and 87.50 % of the women; for C-reactive protein, 50.00 % of the men and 43.75 % of the women). Finally, disrupted bone metabolism, with 42.11 % and 34.21 % of the sample having phosphorus and intact parathyroid hormone levels above the expected values, respectively (for phosphorus, 50.00 % of the men and 31.25 % of the women; for intact parathyroid hormone, 31.82 % of the men and 37.50 % of the women).

Table 5 presents the average values of the aforementioned parameters, providing a general vision of anemia, inflammation, and bone metabolism for both men and women. Together with the data from the metabolic window, these findings highlight the need to be cautious with the prescription of physical activity in these patients, given that they will require supervision to avoid exceeding their physiological capacities and to progressively adapt the physical load to their conditions in order to achieve optimal performance.

Table 5. Biochemical parameters

Test	Global		Men		Women		P value
	Mean ± Std. Dev.	n	Mean ± Std. Dev.	n	Mean ± Std. Dev.	n	
Calcium (mmol/L)	2.14 ± 0.16	38	2.13 ± 0.13	22	2.15 ± 0.19	16	0.664
Ferritin (ng/mL)	558.57 ± 412.68	37	476.95 ±372.58	22	678.27 ± 451.53	15	0.148
Phosphorus (mmol/L)	1.50 ± 0.51	38	1.56 ± 0.59	22	1.43 ± 0.36	16	0.449
Hemoglobin (g/dL)	11.93 ± 1.90	38	12.19 ± 1.84	22	11.57 ± 1.97	16	0.334
Transferrin saturation index (%)	26.28 ± 10.00	38	29.23 ± 10.99	22	22.22 ± 6.87	16	0.031
Intact parathyroid hormone (pg/mL)	263.56 ± 158.09	38	284.05 ± 170.18	22	235.37 ± 140.13	16	0.356
Albumin (g/L)	38.03 ± 4.63	38	37.52 ± 5.12	22	38.74 ± 3.92	16	0.432
Total cholesterol (mmol/L)	4.24 ± 1.29	38	4.19 ± 1.30	22	4.31 ± 1.32	16	0.775
Alkaline phosphatase (µkat/L)	2.23 ± 0.97	38	2.01 ± 0.70	22	2.52 ± 1.22	16	0.110
Prealbumin (mg/dL)	27.29 ± 7.74	38	27.08 ± 8.73	22	27.57 ± 6.38	16	0.848
C-reactive protein (mg/L)	13.00 ± 20.47	37	15.20 ± 25.04	22	9.78 ± 10.89	15	0.437
Potassium (mEq/L)	5.39 ± 0.95	38	5.20 ± 0.97	22	5.65 ± 0.87	16	0.144

Source: Authors.

Conclusion

The population is predominantly elderly, with a high percentage of incidence of arterial hypertension and other cardiovascular comorbidities concomitant with CKD, low levels of physical activity, and general conditions below age-expected norms, reflecting a progressive deterioration of their capabilities and quality of life. However, when comparing results by sex, a relevant pattern is observed, showing a greater impact across most categories in women.

Another noteworthy finding is the probable predominance of osteomuscular function over cardiovascular function when analyzing the results of aerobic capacity tests, as sarcopenia appears to be a dominant factor in these patients. Therefore, low values are likely related primarily to muscle fatigue due to the low musculoskeletal capacity to generate strength and movement, rather than to the capacity for oxygen and nutrient distribution and uptake in the tissues.

The potential relationship between the skeletal muscle mass index and functionality is also highlighted: as a general measure of muscle quantity, it could serve as an indicator of physical performance. Further research is needed to continue studying the relationship between the skeletal muscle mass index and other tests to better understand its function as a potential indicator of functionality.

Finally, this set of tests can be applied within a brief follow-up appointment with no increased costs (except for the body composition test), is easy to analyze, and proves helpful when measuring the behavior of this population's characteristics against other treatment alternatives, such as physical exercise, emphasizing the urgency to develop and implement such programs as part of routine care in hemodialysis centers. As other authors have described, physical exercise programs have positive effects in various areas that contribute to the perception of quality of life [20–23] , transforming the sedentary time during dialysis into active movement and helping foster and maintain healthier lifestyles.

Authors contribution

Yerith Eliana Zambrano Hendez: conceptualization, data curation, formal analysis, investigation, methodology, software, visualization, writing – original draft, writing – review and editing; Amanda Lucía Páez Rodríguez: conceptualization, data curation, formal analysis, investigation, methodology, visualization, writing – original draft, writing – review and editing; Vicent Esteve Simó: conceptualization, data curation, formal analysis, methodology, project administration, resources, software, supervision, validation, writing – review and editing; Edgar Cortés Reyes: conceptualization, project administration, supervision, validation, writing – review and editing.

Ethical statement

This work is part of a single-center prospective study, conducted in accordance with the study protocol, following the guidelines of the Declaration of Helsinki and the regulations of our institution. The Research Ethics Committee for Medicinal Products of the Terrassa Health Consortium approved the protocol with code CEIm 02-24-108-032.

Conflict of interest

The authors declare that they have no relevant or potential financial or personal conflicts of interest related to this study. This research was conducted without any external funding.

Use of artificial intelligence (AI)

The authors declare that they did not use artificial intelligence in the preparation or writing of this article.

Data statement

The authors declare that there are no open access data for this article. Any questions regarding this matter should be directed to the corresponding author.

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