Al-Farouk journal of sciences
Volume (2), Issue (5) (Nov, 2026)
ISSN: 3135-2359

مجلة الفاروق للعلوم
المجلد (2) العدد 5 نوفمبر 2026
عدد خاص بالمؤتمر العلمي الرابع للعلوم والتقنية
28-29 نوفمبر 2026 مصراتة – ليبيا
إدارة المعاهد العليا – وزارة التعليم التقني

One-Year Longitudinal changes in Body Composition and Nutritional Markers Among Maintenance Hemodialysis Patients: A Retrospective Longitudinal Study

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Received: 29/7/2026 Revised: 20/8/2026 Accepted: 28/8/2026 Publication: 28/11/2026

الملخص "باللغة العربية"

المقدمة: يتعرض مرضى الفشل الكلوي المزمن الخاضعون للغسيل الكلوي لاضطرابات في الحالة التغذوية وتغيرات في تركيب الجسم، مما يستدعي المتابعة الدورية باستخدام مؤشرات تركيب الجسم والمؤشرات البيوكيميائية. هدفت هذه الدراسة إلى تقييم التغيرات الطولية في تركيب الجسم وبعض المؤشرات البيوكيميائية المرتبطة بالحالة التغذوية لدى هؤلاء المرضى خلال عام واحد.

المنهجية: أُجريت دراسة استرجاعية طولية شملت 66 مريضاً يخضعون للغسيل الكلوي المنتظم، بمتوسط عمر 46.1 ± 15.1 سنة (53.0% من النساء). جُمعت البيانات من السجلات الطبية عند ثلاث نقاط زمنية خلال عام واحد (التقييم الأول، وبعد ستة أشهر، وبعد اثني عشر شهراً). وشمل التقييم مؤشرات تركيب الجسم (الوزن الجاف، والكتلة العضلية، ونسبة الدهون في الجسم)، إلى جانب المؤشرات البيوكيميائية (الهيموجلوبين، متوسط حجم الكرية[MCV] ، الألبومين، المغنيسيوم، فيتامين د، الكوليسترول الكلي، والدهون الثلاثية) .استُخدم اختبار فريدمان للقياسات المتكررة، تلاه اختبار ويلكوكسون مع تصحيح بونفيروني للمقارنات الثنائية، بالإضافة إلى اختباري ارتباط سبيرمان ومان-ويتني للتحليلات الثانوية.

النتائج: أظهرت مؤشرات تركيب الجسم استقراراً دون وجود فروق ذات دلالة إحصائية خلال فترة المتابعة ($P > 0.05$)في المقابل، سُجلت تغيرات طولية معنوية في مستويات الهيموجلوبين($P < 0.001$) ، الألبومين ($P = 0.049$)، متوسط حجم الكرية($P < 0.001$) ، المغنيسيوم($P = 0.027$) ، والكوليسترول الكلي .($P = 0.028$) وأظهر كل من الهيموجلوبين والألبومين اتجاهاً تصاعدياً، في حين انخفضت مستويات المغنيسيوم، والكوليسترول الكلي، ومتوسط حجم الكرية بمرور الوقت. كما ارتبط الوزن الجاف في التقييم الأول طردياً مع نسبة الدهون في الجسم ($r = 0.495$, $P < 0.001$)وعكسياً مع الكوليسترول الكلي .($r = -0.370$, $P = 0.004$) بالإضافة إلى ذلك، كان الانخفاض في مستويات المغنيسيوم أكثر وضوحاً لدى المرضى المصابين بارتفاع ضغط الدم مقارنة بغير المصابين ($P = 0.027$).

الخلاصة: حافظ مرضى الغسيل الكلوي المزمن على استقرار مؤشرات تركيب الجسم خلال عام واحد من المتابعة، على الرغم من حدوث تغيرات معنوية في بعض المؤشرات البيوكيميائية ذات الأهمية السريرية. وتؤكد هذه النتائج أهمية المراقبة التغذوية الدورية التي تجمع بين قياسات تركيب الجسم والمؤشرات المخبرية، مع التركيز على المتابعة المستمرة لمستويات المغنيسيوم، خاصة لدى المرضى المصابين بارتفاع ضغط الدم.

الكلمات الافتتاحية :الغسيل الكلوي المزمن؛ الحالة التغذوية؛ تركيب الجسم؛ التحاليل البيوكيميائية؛ الدراسة الطولية؛ الدراسة الاسترجاعية.

Background: Malnutrition and protein–energy wasting are common clinical complications in maintenance hemodialysis (HD) patients and are associated with high morbidity and mortality. Longitudinal data showing how body composition and laboratory parameters change over time remain limited in routine clinical practice.

Objective: This retrospective study evaluated one-year changes in body composition (dry weight, skeletal muscle mass, and body fat percentage) and laboratory parameters (serum albumin, vitamin D, hemoglobin, mean corpuscular volume [MCV], serum magnesium, total cholesterol, and triglycerides) in chronic HD patients.

Methods: Clinical data were collected from the medical records of 66 maintenance HD patients (mean age 46.1 ± 15.1 years; 53.0% female) across three time points over one year. The Friedman

test was used to evaluate changes over time, followed by post-hoc Wilcoxon signed-rank tests with Bonferroni correction. Spearman's correlation and Mann-Whitney U tests were used for secondary analyses.

Results: Over the one-year study period, no statistically significant longitudinal changes were detected in body composition markers (all $P > 0.05$). Significant changes occurred in hemoglobin ($P = 0.001$), serum albumin ($P = 0.049$), MCV ($P < 0.001$), serum magnesium ($P = 0.027$), and total cholesterol ($P = 0.028$). Hemoglobin and albumin levels increased, while MCV, magnesium, and total cholesterol declined. At baseline, dry weight was positively correlated with body fat percentage ($r = 0.495$, $P < 0.001$) and negatively correlated with total cholesterol ($r = -0.370$, $P = 0.004$). The decline in serum magnesium was greater in hypertensive patients compared to non-hypertensive patients ($P = 0.027$).

Conclusion: Although hemodialysis patients maintained stable body composition over one year, significant changes in laboratory indices highlight the importance of regular biochemical monitoring. Hypertensive patients may benefit from closer magnesium monitoring, and incorporating magnesium and MCV into routine testing may provide a more complete picture of nutritional status in this population.

Keywords: Maintenance hemodialysis; Nutritional status; Anthropometric markers; Biochemical parameters; Longitudinal assessment; Retrospective study.

1. Introduction

Malnutrition and protein-energy wasting (PEW) are common in patients on maintenance hemodialysis (HD), and both raise the risk of illness and death. A large meta-analysis found that PEW affects between 28% and 54% of dialysis patients worldwide [1]. Inflammation is a major contributing factor; it tends to accompany malnutrition and atherosclerosis in this population, a combination known as the malnutrition-inflammation-atherosclerosis (MIA) syndrome, and together these factors worsen cardiovascular outcomes [2]. Although serum albumin is a traditional nutritional marker, systemic inflammation and fluid status limit its accuracy as a single indicator [2,3]. Measures such as dry weight, muscle mass, and body fat percentage remain necessary to assess body composition more accurately. Dialysis patients typically show reduced muscle mass and altered tissue distribution compared with healthy individuals of the same age [4]. Bioimpedance devices are increasingly used alongside these measures, as they allow fluid status and body composition to be assessed quickly and at repeated intervals [5].

While the link between nutrition and clinical outcomes is clear, longitudinal data remain limited. Available research is mainly cross-sectional, making it difficult to assess how patient status changes over time [6]. The few prospective studies that exist tend to involve small samples evaluated over a one-year period [7]. Locally, published evidence on these parameters in maintenance dialysis patients remains limited. This retrospective longitudinal study examines one-year changes in body composition, alongside biochemical and hematological parameters, using medical records from a single dialysis center. These parameters include serum albumin, vitamin D, hemoglobin, mean corpuscular volume (MCV), total cholesterol, and triglycerides, measured at three time points over one year. The study describes these changes over time and examines how laboratory values relate to changes in body composition, which may help guide nutritional monitoring in hemodialysis care.

2. Methods:

2.1. Study Design and Patient Population

This retrospective longitudinal study was conducted at the Misrata Hemodialysis Center – Main Unit, using medical records of patients on maintenance hemodialysis between January and December 2025. The study was approved by the center's administration. Patient consent was not required, as data were collected retrospectively from existing records. The study population included adult patients (≥ 18 years) who had been on chronic hemodialysis for at least 6 months and had complete records across three evaluation points. Patients were excluded if they had acute kidney injury, active malignancy, acute infection, or recent hospitalization for acute complications. In total, 66 patients met the criteria and were included in the final analysis.

2.2. Clinical and Laboratory Data Collection

Data were collected at three time points: baseline (T1: January–February 2025), 6-month follow-up (T2: June–July 2025), and 12-month follow-up (T3: December 2025). Baseline variables included age, sex, dialysis duration, and history of diabetes and hypertension. Anthropometric and body composition parameters were recorded post-dialysis. Dry weight (kg) was measured using a calibrated medical scale. Skeletal muscle mass (kg) and body fat percentage (%) were assessed using multi-frequency bioelectrical impedance analysis (InBody 770, Biospace, Seoul, Korea) [8]. Blood samples were analyzed at the center's central laboratory using standard automated analyzers. Biochemical and hematological markers included serum albumin (g/L), vitamin D, intact parathyroid hormone (PTH), hemoglobin (g/dL), mean corpuscular volume (MCV, fL), serum magnesium (mg/dL), total cholesterol (mg/dL), and triglycerides (mg/dL). Because the study was retrospective, some non-routine tests were not ordered for every patient at every visit, resulting in a small amount of missing data. Sample sizes therefore differ slightly across parameters; each was analyzed using all available data to preserve statistical power.

2.3. Statistical Analysis

Analyses were performed using IBM SPSS Statistics version 26. Continuous variables were tested for normality with the Shapiro–Wilk test. Since most parameters were non-normally distributed, non-parametric methods were used throughout. Changes across the three time points were assessed using the Friedman test. Variables showing significant change were followed by pairwise comparisons using the Wilcoxon signed-rank test with Bonferroni correction (significance threshold $P < 0.0167$). Spearman's rank correlation examined baseline relationships between continuous variables. The Mann–Whitney U test compared changes ($\Delta = T3-T1$) between subgroups based on diabetes or hypertension status. For all other analyses, a two-tailed $P < 0.05$ was considered significant.

3. Results:

3.1. Baseline Demographic and Clinical Characteristics

Table 1 shows baseline data for the 66 hemodialysis patients. Mean age was 46.1 ± 15.1 years, and 53.0% were female. Hypertension was the most common comorbidity (71.2%), followed by diabetes (22.7%). Mean dialysis duration was 6.1 ± 4.5 years, and mean dry weight was 67.8 ± 16.8 kg. Average BMI was 25.4 ± 5.3 kg/m², placing the group in the overweight range. InBody data, however, showed that skeletal muscle mass averaged only 24.5 ± 6.0 kg, while body fat percentage was high at 31.8 ± 10.2%. This suggests that the elevated BMI may be driven more by fat mass than muscle mass, a pattern that has been associated with chronic uremia [9].

Table 1. Baseline Characteristics of the Study Population (N = 66)

Characteristic	Value
Demographic and Clinical Variables	
Age (years), Mean ± SD	46.1 ± 15.1
Sex, n (%)	
Male	31(47.0)
Female	35(53.0)
Comorbidities, n (%)	
Diabetes Mellitus	15(22.7)
Hypertension	47(71.2)
Dialysis Duration (years), Mean ± SD	6.1 ± 4.5
Anthropometric and Body Composition Parameters, Mean ± SD	

Body Mass Index (kg/m²)	25.4 ± 5.3
Dry Weight (kg)	67.8 ± 16.8
Muscle Mass (kg)	24.5 ± 6.0
Fat Percentage (%)	31.8 ± 10.2
Laboratory Parameters, Mean ± SD	
Albumin (g/L)	41.3 ± 5.5
Hemoglobin (g/dL)	9.5 ± 1.9
MCV (fL)	91.5 ± 6.0
Calcium (mg/dL)	9.0 ± 1.0
Phosphorus (mg/dL)	5.5 ± 1.8
Magnesium (mg/dL)	2.6 ± 1.0
PTH (pg/mL)	827 ± 914
Vitamin D (ng/mL)	35.6 ± 30.7
Total Cholesterol (mg/dL)	169 ± 49
Triglycerides (mg/dL)	158 ± 92

Note: Data are presented as mean ± standard deviation (SD) for continuous variables and as frequency (percentage) for categorical variables.

3.2. Longitudinal Changes in Anthropometric and Laboratory Parameters:

3.2.1. Anthropometric and Body Composition Changes

Over the one−year follow−up, dry weight, muscle mass, and body fat percentage showed no significant changes across the three time points (all $P > 0.05$; Table 2), indicating that body composition remained stable throughout the study.

Table 2. Friedman Test Results for Longitudinal Changes in Body Composition and Laboratory Parameters Over One Year

Parameter	N	Chi-Square (χ^2)	P-value
Anthropometric and Body Composition			
Dry Weight (kg)	58	0.236	0.889
Muscle Mass (kg)	58	3.556	0.169
Fat Percentage (%)	58	0.724	0.696
Laboratory Parameters			
Albumin (g/L)	58	6.034	0.049*
MCV (fL)	58	26.114	<0.001*
Hemoglobin (g/dL)	58	14.009	0.001*
Calcium (mg/dL)	52	0.883	0.643
Phosphorus (mg/dL)	57	4.246	0.120
Magnesium (mg/dL)	55	7.226	0.027*
Total Cholesterol (mg/dL)	39	7.128	0.028*

Triglycerides (mg/dL)	41	1.317	0.518

Note: *The sample size for each Friedman test varies based on the availability of complete, repeated data across all three time points for that specific parameter.*

This finding is clinically relevant. Hemodialysis patients are usually expected to lose muscle and fat progressively due to inflammation and uremic catabolism—a condition known as protein-energy wasting (PEW) [9]. The stability observed here may reflect the nutritional monitoring and counseling provided at the center, which has been associated with better preservation of muscle status in HD patients with PEW [11]. Still, the retrospective design means dietary intake and physical activity were not directly assessed, so this cannot be attributed to nutritional intervention with certainty. An alternative explanation is that this patient group may have had a relatively stable uremic condition or lower inflammatory burden over the study period.

3.2.2. Hematological Indices: Hemoglobin and MCV

Changes in nutritional and hematological parameters across the three time points are shown in Figure 1. Hemoglobin levels changed significantly over the 12 months ($\chi^2 = 14.009$, $P = 0.001$; Table 2), with the increase reaching significance only between T1 and T3 ($P = 0.002$; Table 3), suggesting a gradual improvement rather than an early shift. This pattern is consistent with ongoing anemia management protocols at the center, which typically involve adjustments to erythropoiesis-stimulating agents (ESAs) and iron supplementation [12]. However, the retrospective design means specific ESA dose changes or protocol adherence could not be verified directly. In contrast, mean corpuscular volume (MCV) decreased significantly over the same period ($\chi^2 = 26.114$, $P < 0.001$; all post-hoc comparisons $P < 0.0167$), indicating a shift toward microcytosis. The combination of rising hemoglobin with falling MCV may point to a functional iron deficit or an altered marrow response to erythropoietin [10]. This would suggest that despite the hemoglobin improvement, iron availability for red cell synthesis may not have kept pace. One possible mechanism is that inflammation raises hepcidin levels, which can restrict iron transport even when iron stores appear adequate [10].

3.2.3. Serum Albumin

Serum albumin varied significantly over the study period ($\chi^2 = 6.034$, $P = 0.049$), with the difference reaching significance only between T2 and T3 ($P = 0.014$). This later-stage increase may be related to ongoing dietary counseling or periods of lower systemic inflammation [2,11]. Without CRP data, however, it is not possible to determine whether this reflects improved nutritional intake, a reduction in inflammatory activity, or both.

3.2.4. Magnesium and Total Cholesterol

Serum magnesium decreased significantly over the 12 months ($\chi^2 = 7.226$, $P = 0.027$), with the change reaching significance only between T1 and T3 ($P = 0.013$). This decline may be related to ongoing magnesium losses through the dialysate combined with limited dietary intake [13]. Total cholesterol also decreased significantly ($\chi^2 = 7.128$, $P = 0.028$), particularly between T1 and T3 ($P = 0.008$). In hemodialysis patients, lower cholesterol has been associated with several factors, including statin use, dietary fat restriction, and declining nutritional status, since low lipid levels are often linked to protein-energy wasting [9]. Given the lack of data on medication changes and dietary adherence, these declines likely reflect a combination of metabolic factors rather than any single cause.

Figure 1. Longitudinal changes in serum biochemistry and hematological indices over the three follow-up time points.

Table 3. Pairwise Comparisons of Parameters with Significant Longitudinal Changes (Bonferroni-Corrected)

Parameter	Time Comparison	Wilcoxon Z-value	P-value
Albumin (g/L)	T1 vs T2	-1.456	0.145
	T1 vs T3	-0.163	0.870

	T2 vs T3	-2.454	0.014*
MCV (fL)	T1 vs T2	-3.785	<0.001*
	T1 vs T3	-4.328	<0.001*
	T2 vs T3	-2.895	0.004*
Hemoglobin (g/dL)	T1 vs T2	-1.799	0.072
	T1 vs T3	-3.114	0.002*
	T2 vs T3	-1.832	0.067
Magnesium (mg/dL)	T1 vs T2	-0.869	0.385
	T1 vs T3	-2.486	0.013*
	T2 vs T3	-0.987	0.324
Total Cholesterol (mg/dL)	T1 vs T2	-1.564	0.118
	T1 vs T3	-2.654	0.008*
	T2 vs T3	-1.956	0.050

Note: Bonferroni correction was applied for three pairwise comparisons per variable, establishing an adjusted statistical significance threshold at $P < 0.0167$. T1: baseline; T2: six months; T3: 12 months.

3.3. Baseline Correlation Analysis

Spearman's correlation analysis (Table 4) identified two significant relationships at baseline. Dry weight was positively associated with body fat percentage ($r = 0.495$, $P < 0.001$), a pattern commonly reported in chronic kidney disease populations [4]. Dry weight was also negatively correlated with total cholesterol ($r = -0.370$, $P = 0.004$); in hemodialysis patients, lower cholesterol has been linked more to protein–energy wasting than to reduced cardiovascular risk [9]. No significant baseline correlations were found between serum albumin and other anthropometric or laboratory parameters, consistent with the view that albumin is a multifactorial marker shaped by systemic inflammation and general health status rather than diet or body measurements alone [2,3].

Table 4. Spearman's Correlation Coefficients Between Key Anthropometric and Laboratory Parameters at Baseline (T1)

Parameter	Albumin	MCV	Dry Weight
Albumin	1.000		
MCV	-0.023	1.000	
Dry Weight	0.023	0.084	1.000
Fat %	-0.093	0.139	0.495*
Hemoglobin	0.226	0.061	0.100
Magnesium	-0.052	0.045	0.169
Total Cholesterol	-0.015	-0.230	-0.370*

Note: Values represent Spearman's correlation coefficients (r) between each row variable and the three baseline parameters selected for correlation analysis (albumin, MCV, and dry weight). Correlations among the remaining row variables (fat %, hemoglobin, magnesium, total cholesterol) were not computed, as these three parameters were the primary variables of interest. *Correlation is significant at the 0.01 level (2-tailed). Sample sizes vary across parameters due to missing values in retrospective records

3.4. Longitudinal Changes Across Comorbidity Subgroups

Subgroup analysis using Mann-Whitney U tests (Table 5) showed a significant difference in magnesium change (Δ = T3 - T1) between hypertensive and non-hypertensive patients (P = 0.027), with hypertensive patients showing a smaller change (mean rank 24.68 vs. 34.83). Lower magnesium levels in dialysis patients have been associated with cardiovascular parameters and blood pressure management [13], though this difference may also reflect other factors such as dietary habits, antihypertensive medications, or fluid balance between groups. No significant associations were found between diabetes status and longitudinal changes in any parameter (all P > 0.05); given the small subgroup size (n = 14-15), larger studies would be needed to confirm this.

Table 5. Subgroup Comparison of Longitudinal Changes (Δ = T3 - T1) by Diabetes Mellitus and Hypertension Status (Mann-Whitney U Test).

PARAMETER	COMORBIDITY GROUP	N	MEAN RANK	P-VALUE
Δ ALBUMIN (G/L)	Non-diabetic	44	30.14	0.611
	Diabetic	14	27.50	
	Non-hypertensive	18	28.89	0.853
	Hypertensive	40	29.78	
Δ HEMOGLOBIN (G/DL)	Non-hypertensive	18	30.56	0.749
	Hypertensive	40	29.03	
	Non-diabetic	44	28.28	0.330
	Diabetic	14	33.32	
Δ MCV (FL)	Non-diabetic	44	28.82	0.586
	Diabetic	14	31.64	
	Non-hypertensive	18	32.61	0.347
	Hypertensive	40	28.10	
Δ MAGNESIUM (MG/DL)	Non-hypertensive	18	34.83	0.027*
	Hypertensive	37	24.68	
	Non-diabetic	42	28.27	0.820
	Diabetic	13	27.12	
Δ TOTAL CHOLESTEROL (MG/DL)	Non-diabetic	31	18.94	0.251
	Diabetic	8	24.13	
	Non-hypertensive	15	19.33	0.773
	Hypertensive	24	20.42	

4. Strengths and Limitations

Assessing patients at three time points over one year offers an advantage over the cross-sectional designs that dominate this field [6,7]. Using official medical records also reduced recall and self-reporting bias, and non-parametric methods were used throughout given the non-normal distribution of the data. Still, several limitations apply. As a retrospective study, it cannot establish cause-and-effect relationships—only statistical associations. The single-center design and modest sample size (n = 66) limit how far these results can be generalized, and the small comorbidity subgroups reduced power to detect smaller differences. Several relevant variables were not available in the records, including dietary intake, Subjective Global Assessment (SGA) scores, C-reactive protein (CRP), and specific medication details (e.g., phosphate binders, vitamin D, statins). Missing data across some parameters is a common limitation of retrospective chart reviews.

5. Clinical Implications

The stability of dry weight, muscle mass, and body fat percentage over one year suggests that body composition was maintained in this group—a favorable finding given how common protein-energy wasting is in hemodialysis patients [1]. The parallel rise in hemoglobin and albumin points to stable clinical management overall, but the declines in MCV and magnesium warrant closer attention. A falling MCV alongside stable-to-rising hemoglobin may reflect iron deficiency or restricted iron availability, often linked to underlying inflammation [10], and supports monitoring iron stores alongside routine hemoglobin testing during anemia management. The progressive decline in magnesium, more pronounced among hypertensive patients, suggests this electrolyte may be worth monitoring routinely, particularly given its associations with cardiovascular risk in dialysis populations [13]. A standardized nutritional protocol—incorporating validated tools such as the Malnutrition-Inflammation Score (MIS) or Subjective Global Assessment (SGA), alongside routine laboratory testing and body composition measurement—could help make nutritional assessment more practical in day-to-day care.

6. Conclusion

Over one year, patients on maintenance hemodialysis maintained stable body composition despite significant changes in several laboratory markers, underscoring the value of regular biochemical monitoring as part of nutritional assessment. The more pronounced magnesium decline among hypertensive patients points to a subgroup that may benefit from closer monitoring of this electrolyte. Adding magnesium and MCV to routine testing may offer a more complete picture alongside standard hemoglobin and albumin measures, though this warrants confirmation in prospective studies. As an observational, single-center study, these findings reflect associations rather than causal relationships and should be interpreted accordingly.

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