

Effects of magnetic stimulation and kinesitherapy on inflammatory and nutritional parameters in hemodialysis patients: a pilot study

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Purpose: The study evaluated the effects of low-frequency magnetic field and kinesitherapy on selected parameters of nutritional status and inflammation in patients with chronic kidney disease (CKD) undergoing hemodialysis.

Methods: The study included 25 hemodialysis patients with stage G5 CKD, divided into three groups: magnetic stimulation + kinesitherapy, kinesitherapy only, and a control group. Magnetic stimulation was applied three times a week for 12 weeks. Blood tests were performed to assess nutritional status (TP, ALB, TC, TG), inflammation (CRP) and liver enzymes AST and ALT.

Results: Before treatment, there were no statistically significant differences in TC ($P = .675$), TG ($P = .861$), ALT ($P = .991$), AST ($P = .840$), TP ($P = .509$), or ALB ($P = .276$). CRP values trended toward statistical significance ($P = .069$); the highest median was seen in Group 2 (10.50 mg/L). After therapy, there was a significant decrease in CRP levels in Group 2 ($P = .013$). Other parameters showed no significant changes. TC decreased in all groups, with the greatest decrease observed in the control group. TG levels varied among groups: they increased in Group 1, decreased in the control group, and remained stable in Group 2 ($P = .245$). AST and ALT stayed within normal limits. ALB levels slightly decreased in Groups 1 and 2, which, along with higher CRP, suggests an association with inflammation.

Conclusion: Some patients with advanced CKD on haemodialysis have elevated CRP levels and low albumin, which may signal malnutrition. Both treatments can affect inflammatory and nutritional status.

Keywords: hemodialysis, magnetic stimulation, kinesitherapy, inflammatory, nutritional parameters hemodialysis

Introduction

Chronic kidney disease (CKD) progressing to end-stage renal disease (stage G5) not only requires hemodialysis, which is highly burdensome for the patient, but also causes impaired renal excretory and endocrine functions. These dysfunctions disrupt the body's homeostasis.¹ Impaired kidney function is just one aspect of the challenges faced by hemodialysis patients. They often have multiple other health conditions, often related to advanced age. The most common comorbidities among hemodialysis patients are cardiovascular diseases, especially coronary heart disease and congestive heart failure. Diabetes mellitus, with its many complications affecting various organs, is also prevalent.²⁻⁵ Some patients with stage G5 CKD (end-stage renal disease within CKD) develop nutritional issues that lead to protein-calorie malnutrition, which can be seen in lab tests through decreased plasma protein levels, especially albumin. Lipid profile abnormalities, such as low cholesterol and triglyceride levels, may also occur.^{6,7} A major challenge for this group is chronic inflammation, often indicated by elevated CRP levels in the blood.^{8,9} The combination of these health problems

and the necessity of regular hemodialysis impose a heavy burden on patients. Hemodialysis is typically performed three times a week, each session lasting about four hours, which often significantly reduces physical activity.² Patients undergoing repeated hemodialysis often experience anxiety and uncertainty about engaging in physical activity. They fear that improper exercise selection or incorrect techniques could worsen their health and well-being. Additionally, concerns about potential damage to vascular access for dialysis, such as arteriovenous fistulas or dialysis catheters, contribute to their reluctance to exercise.^{10,11} Another significant barrier preventing hemodialysis patients from participating in physical activity is the lack of adequate physiotherapy care and standardized kinesitherapy protocols that could be implemented during treatment, as well as the absence of structured exercise programs designed for home use, which dialysis centers could offer. There is also a lack of established guidelines for choosing the appropriate type and specificity of exercises for this group of chronically ill patients.^{4,11-14} Consequently, due to insufficient preparation and supervision, patients are often afraid to engage in physical activity on their own, leading to a significant reduction in

mobility, decreased vitality, and progressive muscle atrophy, often accompanied by sarcopenia. As a result, their quality-of-life declines, and their overall health deteriorates regardless of the underlying disease and comorbid conditions, ultimately increasing the risk of mortality in this patient population.^{3,4,15-18} Given the specific nature of the disease and the need to perform general fitness exercises that engage as many links of the individual kinematic chains as possible while maintaining a moderate training load, it seems beneficial to introduce protocols based on JBJTA training.^{19,20} This approach allows for a holistic involvement of the musculoskeletal system and helps improve both its stability and mobility; therefore, it appears very advantageous for patients suffering from chronic conditions.²¹

It is also sensible to include not only aerobic exercises but also resistance training, which not only helps prevent muscle atrophy but also positively impacts cognitive functions and overall well-being. This effect is particularly significant for older adults.²² These challenges drive the search for solutions that can improve the quality of life and overall condition of hemodialysis patients in a simple and minimally invasive way.^{4,13,23,24} In addition to kinesiotherapy, which is the most widely used and frequently discussed in the literature, systemic magnetic stimulation has emerged as a promising method. This approach, commonly used in physiotherapy, employs low-frequency magnetic fields. Treatments were performed using the Viofor JPS System device and the most common applicator, a mat that covers the entire body, was utilized. The frequency and induction parameters generated by this applicator have specific effects on the body. Frequency influences biophysical, electrodynamic, and magneto mechanical processes, while the indicated induction values affect bioelectrical, bioenergetic, and biochemical processes. Systemic magnetic stimulation has been shown to positively affect the body by supporting oxidation-reduction processes, stimulating cell regeneration, improving blood circulation, and

aiding in the maintenance of homeostasis. Importantly, this procedure has few contraindications compared to the extensive list of potential indications for its use.²⁵⁻²⁷ The application of magnetic stimulation and kinesiotherapy in patients with CKD may influence inflammatory and nutritional parameters. These considerations led researchers to evaluate the effects of systemic magnetic stimulation and kinesiotherapy on patients with stage G5 CKD undergoing chronic hemodialysis, focusing on their influence on specific laboratory markers of inflammation and nutrition.

Methods

Participants

The study included 25 patients with stage G5 CKD who were treated with chronic hemodialysis (HD) using the Braun Dialog+ dialysis machine (B. Braun, Germany). The participants were divided into three groups. The first group consisted of six individuals (three women and three men) who received systemic magnetic stimulation and kinesiotherapy. The second group included nine patients (three women and six men) who underwent kinesiotherapy following a schedule like that of the first group. The third group comprised 10 individuals (4 women and 6 men) and served as the control group, with no study-specific treatments administered. The age of all participants was similar, with the first group at 67.50±5.96 years, the second group at 66.90±7.05 years, and the third group at 66.00±12.06 years. The average body weight of participants receiving magneto stimulation combined with exercise was 74.70±5.47 kg. In the exercise-only group, the average body weight was 68.40±16.13 kg, while in the control group it was 75.90±10.07 kg. The mean height of patients in the LF-EMF and exercise group was 170.20±7.33 cm; in the exercise-only group, it was 167.20±9.89 cm; and in the control group, 169.20±8.30 cm. BMI (Table 1) of individuals receiving

Table 1. Characteristics of the Study Participants.

Group	Gender	Patients (N)	Age (years)	Body mass (kg)	Body height (cm)	BMI (kg/m ²)
Exercise and LF-EMF	Women	3	70.30±5.79	75.60±3.68	163.30±.47	28.40±1.38
	Men	3	64.70±4.64	73.60±6.65	177.00±3.74	23.50±2.22
	Overall	6	67.50±5.96	74.70±5.47	170.20±7.33	25.90±3.04
Exercise	Women	3	69.30±9.46	60.80±21.97	156.00±7.79	24.30±6.37
	Men	6	65.70±5.02	72.20±10.27	172.80±4.70	24.20±3.60
	Overall	9	66.90±7.05	68.40±16.13	167.20±9.89	24.20±4.71
Control	Women	4	66.50±7.30	68.00±8.89	165.70±4.81	24.50±2.23
	Men	6	66.70±14.37	81.20±6.79	171.50±6.79	27.80±4.08
	Overall	10	66.00±12.06	75.90±10.07	169.20±8.30	26.50±3.81

Note: all data are expressed as mean/SD.

magnetic stimulation with exercise was 25.90±3.04 kg/m²; in the exercise-only group was 24.20±4.71 kg/m²; and in the control group was 26.50±3.81 kg/m². The inclusion criteria for the study were: providing written informed consent to participate in the research, absence of medical contraindications to participation in any of the study groups and undergoing regular hemodialysis for at least one year. Exclusion criteria included refusal to participate at any stage, contraindications to any procedures outlined in the study protocol, significant deterioration in the participant's overall health, or death occurring between the initial and final blood tests. All patients, due to multiple health burdens and limited knowledge before the study, did not engage in organized physical activity. A diagnostic survey method was

used. Their physical activity was limited to daily routine tasks.

Experimental Design

Systemic magnetic stimulation treatments were administered using a mat-shaped applicator with the Viofor JPS System Controller (Clinic Device, Med & Life Ltd., Komorów, Poland). The base frequency of this applicator ranges from 180 Hz to 195 Hz. The frequency of pulse packets varies from 12.50 Hz to 29 Hz, groups of pulse packets from 2.80 Hz to 7.60 Hz, and series from .08 Hz to .30 Hz. The average induction values are lower than those of magnetic stimulation, ranging from 11.50 μT to 276 μT. Parameters were adjusted to match the patients' condition during therapy, and the MIP2 1-6 protocol was selected. The symbol M indicates the method of application,

and the numerical value indicates the stage of the condition, with 1 representing chronic conditions. The letter P signifies the program; the study used the basic program designated by the manufacturer as value 2. Values 1-6 indicate treatment intensity. The intensity was increased each day of therapy—starting at level 1 on the first day and reaching level 6 on the sixth day. Once the maximum intensity for the chosen therapeutic program was reached, it was maintained until the end of the treatment cycle. Magneto stimulation was administered to patients three times a week for the next 12 weeks. Additionally, patients in the first and second groups received an exercise program to perform during hemodialysis sessions and at home on dialysis-free days. Due to the presence of venous fistulas in participants, exercises involved only the lower limbs and trunk. Extending the exercise protocol to include the upper limbs should be supported by profiling the risk of venous fistula injuries. (LIT) Each day, patients performed four sets of 10 repetitions of two types of exercises. The first, called the triple flexion, involved simultaneous flexion of the lower limb at three joints (ankle, knee, and hip) and pulling the knee toward the abdomen. The second exercise consisted of isometric tensioning of the thigh muscles, maintained for 10 seconds. This exercise was also performed in four sets of 10 repetitions.

Instruments

Laboratory tests to evaluate selected blood parameters were conducted twice in each of the three study groups. The first blood sample was collected in the morning on the first day of the study, before starting hemodialysis, and the second sample was taken 12 weeks later, after completing the treatment cycle, also prior to hemodialysis. Blood samples were collected by trained medical personnel. The volume of blood drawn matched the capacity of the tubes provided by the hospital laboratory, which were standard 4 ml laboratory tubes. The blood samples were analyzed using the Au480-Beckman Coulter analyser (Beckman Coulter Life Sciences, GB). The Au480-Beckman Coulter is an automatic biochemical analyser. The measurement principle is based on spectrophotometry and potentiometry. The assessment of the analysed blood biochemical parameters was performed in accordance with the manufacturer's instructions for this analyser. The blood drawn from participating patients was used exclusively for research purposes, and the collected data were analyzed to evaluate the effects of systemic magnetic stimulation and kinesiotherapy on selected laboratory markers of inflammation such as C-reactive protein (CRP) as well as on nutritional parameters, including total cholesterol (TC), triglycerides (TG), total protein (TP), and albumin (ALB). Additionally, the effects of the treatments on selected laboratory markers of liver and skeletal muscle function, such as alanine aminotransferase (ALT) and aspartate aminotransferase (AST), were examined.

Statistical analyses

Data were analyzed statistically using Statistica 13.3 software (TIBCO Software Inc.), which enables advanced data modeling, statistical analysis, and result visualization. The Shapiro-Wilk test was used to assess the normality of data distribution. Differences between dependent variables were evaluated with the Wilcoxon test. Comparisons of independent variables were conducted using the Kruskal-Wallis test. To estimate the effect size for the Kruskal-Wallis test, the epsilon-squared value (ϵ^2) was calculated. The power of the test was also determined. The level of statistical significance was set at $P < .05$, with a Bonferroni correction applied for multiple comparisons where appropriate.

Results

The mean blood parameter values assessed in each group before therapy are shown in Table 2. The data analysis shows that the total cholesterol (TC) level was highest in the control group. In the other two study groups, TC was similar but lower than in the control group. However, these differences were not statistically significant. The median TC level in the control group was slightly higher (4.74 mmol/L) than in the exercise groups (4.17 mmol/L and 4.22 mmol/L), and this difference was also not statistically significant. A similar pattern was observed for triglycerides (TG), with no statistically significant differences found ($P = .245$).

Median TG levels remained within normal limits across all groups, with the highest values observed in Group 2 (exercise group). For aspartate aminotransferase (AST), levels were also within the normal range in all groups, like the TG in Group 2. The highest median AST level was seen in Group 2 (20.10 U/L), although the difference was not statistically significant ($P = .642$). Alanine aminotransferase (ALT) levels were within normal limits in all groups. The median ALT in the exercise group (13.80 U/L) was slightly higher than in the LF-EMF group (12.15 U/L) and the control group (11.90 U/L), both of which showed the smallest range of values. However, these differences were not statistically significant ($P = .375$). No significant differences were observed for total protein (TP) ($P = .926$) or albumin (ALB) ($P = .101$). TP levels remained within normal limits across all groups. The median albumin (ALB) level was highest in the control group (37.60 g/L) and was like that in Group 1 (exercise + LF-EMF). The lowest median albumin level was in the exercise group (34.70 g/L), which was slightly below normal. The only parameter showing a trend toward statistical significance was CRP ($P = .013$). The highest CRP value was recorded in Group 2 (exercise only), with a median of 10.50 mg/L, indicating increased inflammation. CRP levels in Groups 1 and 3 were significantly lower (3.10 mg/L and 3.40 mg/L, respectively). In addition to the elevated CRP levels in Group 2, indicating inflammation, the lower-than-normal TG levels in all groups and ALB levels in Group 2 may suggest the presence of nutritional disorders in patients with stage G5 CKD. However, the remaining parameters measured were within normal limits. Effect size (ϵ^2) analysis indicated that most biochemical parameters (total cholesterol, ALT, AST, CRP, total protein) showed no effect ($\epsilon^2 = .000$). TG and albumin displayed a small effect ($\epsilon^2 = .030$ and $\epsilon^2 = .096$). After the procedures were completed, blood parameters were re-evaluated (Table 2).

Before the intervention, Group 2 had the highest CRP levels, exceeding the normal range. However, the CRP level decreased compared to the baseline value. In the other two groups, CRP levels remained significantly lower and within the normal range. Though it was not statistically significant ($P = .013$). Low statistical power (Power $< .10$) suggests the sample size may have been too small to reveal subtle differences. After the procedures were finished, blood parameters were re-evaluated (Table 2). As before the intervention, Group 2 had the highest CRP levels, exceeding the normal range. However, the CRP level decreased compared to the baseline value. In the other two groups, CRP levels remained significantly lower and within the normal range. The therapeutic measures used, including physical exercise and low-frequency electromagnetic field (LF-EMF) exposure, may have also influenced lipid levels, which changed from baseline values. Total cholesterol (TC) levels decreased across all groups, with the largest decline observed in the control group. Triglyceride (TG) levels showed different

Table 2. Blood parameters at baseline and after intervention.

Variable	Group	Baseline Q1	Baseline Median	Baseline Q3	Post Q1	Post Median	Post Q3	ΔMedian	H	P	ε ²	Power
TC (mmol/l)	Exercise +LF-EMF	3.20	4.17	4.78	3.52	3.69	3.72	− .48	.789	.675	.000	.069
	Exercise	3.89	4.22	4.66	3.45	3.90	4.20	− .32	.789			
	Control	3.54	4.74	5.50	2.78	3.46	4.24	−1.28	.789			
TG (mmol/l)	Exercise +LF-EMF	.89	1.12	2.00	1.27	1.36	2.04	+ .24	2.815	.245	.030	.091
	Exercise	.95	1.54	1.99	1.31	1.52	1.73	− .02	2.815			
	Control	1.01	1.38	1.91	.94	1.11	1.48	− .27	2.815			
ALT (U/l)	Exercise +LF-EMF	11.10	12.10	15.60	11.70	12.85	16.60	+ .75	1.963	.375	.000	.083
	Exercise	9.60	13.80	16.20	9.50	10.00	12.40	−3.80	1.963			
	Control	7.70	11.90	25.00	10.20	12.25	19.60	+ .35	1.963			
AST (U/l)	Exercise +LF-EMF	12.10	14.80	20.00	11.10	13.85	14.60	− .95	.885	.642	.000	.071
	Exercise	13.20	20.10	21.20	12.80	14.60	18.80	−5.50	.885			
	Control	12.10	16.95	22.80	12.70	15.10	21.30	−1.85	.885			
CRP (mg/l)	Exercise +LF-EMF	2.80	3.10	9.10	3.20	4.00 ^a	5.40	+ .90	.871	.013	.000	.071
	Exercise	4.40	10.50	17.20	7.30	9.30 ^b	14.30	−1.20	.871			
	Control	1.80	3.40	4.60	1.50	2.85 ^a	4.10	− .55	.871			
TP (g/l)	Exercise +LF-EMF	63.80	64.50	67.20	60.50	63.00	66.00	−1.50	.154	.926	.000	.058
	Exercise	54.50	63.10	67.00	59.10	64.40	66.00	+1.30	.154			
	Control	53.50	63.15	65.20	56.90	65.20	67.80	+2.05	.154			
ALB (g/l)	Exercise +LF-EMF	35.10	36.40	40.30	33.20	33.40	40.10	−3.00	4.587	.101	.096	.106
	Exercise	29.10	34.70	38.90	30.80	33.90	35.80	− .80	4.587			
	Control	34.80	37.60	41.10	35.20	38.75	40.20	+1.15	4.587			

Note: H – test statistic; P – P-value for the Kruskal–Wallis test; ε² – effect size; Power – statistical power; Q1, Q3 – first and third quartile; ΔMedian – difference in median (Post – Baseline); a–b different letters indicate significant differences at the level of α = .05 (Bonferroni-corrected threshold α = .0071 for seven comparisons).

trends: an increase in Group 1, a decrease in the control group, and stability in Group 2. The statistical significance was $P = .675$ for TC and $P = .245$ for TG. All values remained within the laboratory reference range. Similar results were found for liver and skeletal muscle function indicators (ALT and AST). No statistically significant differences were noted for ALT ($P = .375$) or AST ($P = .642$), though the median AST was higher in the control group (15.10 U/L) than in the LF-EMF group (13.85 U/L) and the exercise group (14.60 U/L). The results following the interventions show a decrease in ALT levels in Group 2 and a reduction in AST levels in Groups 1 and 2 compared to the baseline values of these parameters. No statistically significant differences were observed in nutritional status indicators (TP: $P = .926$; ALB: $P = .101$). However, it was noted that the median albumin (ALB) level was higher in the control group (38.75 mg/mL) compared to the intervention groups (33.40 mg/mL and 33.90 mg/mL, respectively). As noted at the beginning of the study, TG levels remained below normal in all groups even after the intervention. Group 1 (exercise + magnetic field) and Group

2 (exercise) showed a slight decrease in albumin levels, with the highest CRP levels. This may suggest a possible link between inflammation and nutritional disorders. The values of the other parameters assessed were within the normal range. Most of the biochemical parameters analyzed did not show a significant effect of the intervention, as indicated by zero ε² values. Only albumin and triglyceride levels showed a small effect (ε² = .096 and ε² = .030).

Discussion

Long-term hemodialysis in patients with stage G5 CKD (end-stage renal failure in chronic kidney disease) involves many complications. Often, these complications also lead to a significant reduction in physical activity or even complete cessation. This, in turn, contributes to complications related to hypokinesia, which can even result in premature death.^{2,5} For this reason, it is crucial to implement measures to enhance the overall health and quality of life for hemodialysis patients.

Among physiotherapy approaches, kinesitherapy and systemic magnetic stimulation stand out due to their minimal health contraindications. Researchers who have observed the benefits of kinesitherapy include Anding-Rost et al. In their study, they noted an improvement in vitality, confirmed, among other things, by data collected using the 36-item Short Form Health Survey (SF-36) questionnaire.⁵ Beneficial changes resulting from exercise interventions were also noted in the study by Perez-Dominguez et al.,¹¹ who observed improvements in physical fitness, physical activity levels, and quality of life among study participants. Similarly, Hargrove et al., in their meta-analysis, demonstrated the positive effects of exercise on sleep disturbances, anxiety, depression, and even the incidence of leg cramps and fatigue. Kinesitherapy may also influence other parameters, including blood components. In our study, changes were observed only in CRP levels. These changes were not statistically significant and concerned patients in the exercise group whose CRP values remained above normal before and after the intervention. However, these values decreased after therapy. Elevated CRP levels in dialysis patients in stage G5 are directly related to impaired homeostasis, which promotes the development of chronic low-grade inflammation. This chronic inflammatory state may also contribute to the faster progression of sarcopenia, a common complication of chronic kidney disease (CKD), which is worsened by patients' sedentary lifestyles.^{28,29} Incorporating regular physical activity may help slow this process and potentially reduce inflammatory markers.^{17,18} We also observed changes in TC levels, which decreased in both treatment groups. However, TG levels remained nearly unchanged in the exercise-only group but increased in the magnetic stimulation group. In contrast, Nowicki et al. found in their study that TG levels decreased in hemodialysis patients who maintained an average daily step count of 3,500 recorded using pedometers, while ALB parameters remained unchanged.³⁰ Similar observations were made by Zamojska et al.,³¹ who reported no significant changes in hemoglobin levels but found an increase in albumin levels in study participants. In the case of serum albumin, changes were found at a level of $R = .32$, $P = .010$, and in the case of changes in hemoglobin, $R = .44$, $P = .001$. In our study, however, we observed a decrease in ALB levels in both treatment groups (Groups 1 and 2), falling below normal after the end of treatments. This could be linked to the effects of the applied therapeutic interventions, especially since ALB levels increased in the control group. Torres et al. highlighted the benefits of physical activity. They noted that regular exercise not only improves the fat-to-lean body mass ratio but also positively impacts lipid profiles, leading to lower TG levels (125.8 ± 54.0 vs 108.2 ± 44.6 mg/dL, $P = .006$).³² In our study, exercise had a positive effect on TC levels, yet TG levels increased after magnetic stimulation combined with kinesitherapy, whereas they remained unchanged in the exercise-only group. AST and ALT levels decreased after kinesitherapy, which may indicate insufficient exercise in both treatment groups. At the same time, it should be considered that the overall condition of the subjects did not allow for overly intense activity, which could have caused a significant increase in these parameters, as occurs with intense training.³³ An overall improvement in the blood parameters of hemodialysis patients, possibly related to physical activity, was also observed in the study by Zhang et al. This researcher and his team, reviewing the literature on the subject, also found a positive association between higher levels of physical activity and increased survival rates in patients undergoing chronic hemodialysis.²⁴ The same relationship was described in studies by Martins et al.,²³ who analyzed the relevant literature together

with his team, and Yamamoto et al., who conducted a 3-year survival study in hemodialysis patients.³⁴ The results of our study are not statistically significant but may suggest eating disorders and malnutrition in some patients with CKD at stage G5. Protein-calorie malnutrition is common among these patients. This is supported by studies such as that of Cerda-Mendez et al., who evaluated the association between inflammation levels and malnutrition in patients with metabolic syndrome while also highlighting issues with impaired taste perception and loss of appetite.³⁵ Similar conclusions were drawn in studies by Nemutlu et al.,³⁶ who used anthropometric measurements, 7-point SGA (7p-SGA), nutritional risk index (NRI) for adults, mini nutritional assessment (MNA), and geriatric nutritional risk index (GNRI) and Rodríguez-Chávez et al.,³⁷ who, in their research involving 105 hemodialysis patients at stage G5, found that up to 92.40% were affected by malnutrition. They used the Malnutrition-Inflammation Score (MIS) scale in their study. The second treatment we evaluated in our study was systemic magnetic stimulation using the Viofor JPS System device. We chose this procedure because it is easy to apply and has fewer contraindications compared to other physical treatments. Furthermore, studies conducted so far show that this treatment benefits cellular regeneration, boosts the immune system, and delays cell aging processes. Our study did not reveal many statistically significant changes in the blood parameters of patients undergoing this treatment, but most indicators showed some improvement. The only variable approaching statistical significance was CRP, which increased after therapy ended. Slight increases were also seen in triglyceride (TG) and ALT levels, but these changes were not statistically significant. The levels of other parameters we measured decreased, especially total cholesterol (TC) and albumin (ALB), but these changes also did not reach statistical significance. In reviewing scientific publication databases related to medical and biological sciences, we found only one study examining the effect of magnetic stimulation in patients on long-term hemodialysis. This study, conducted by Hwang et al., involved repetitive transient magnetic stimulation (rTMS). One month after the intervention, patients reported improved mood and fewer depressive symptoms. The study also noted a significant improvement in glycated hemoglobin levels. Like our study, cholesterol and albumin levels were evaluated, but no significant changes were observed. The authors analyzed 13 other blood parameters, including hemoglobin, urea, and creatinine, but found no significant differences after treatment.³⁸ Our research shows that magnetic stimulation caused some changes in specific blood parameters, especially related to nutrition (TC, TG, ALB), inflammation (CRP), and AST. Although these changes were not statistically significant, they suggest the need for further research with a larger sample size. While comprehensive data on magnetic stimulation's effects on hemodialysis patients are limited, many reports on its use and positive effects in other diseases suggest that beneficial changes may also occur in this patient group.^{26,39,40}

Practical Applications

The interventions used (physical exercise and LF-EMF) proved to be metabolically safe for patients with stage G5 CKD. The downward trend in CRP suggests their potential to reduce inflammatory processes. Reduced albumin levels in the intervention groups may indicate a connection between inflammation and nutritional disorders. Although changes in lipid parameters did not reach statistical significance, they may point to the potential benefits of the therapy. The low power of

the analysis highlights the need for studies with a larger sample of patients. The results support further evaluation of these interventions as a supplementary part of nephrological treatment.

Conclusions

Our study's results and a review of the literature confirm that both kinesitherapy and systemic magnetic stimulation are effective treatments for patients with stage G5 CKD undergoing the interventions used (physical exercise and LF-EMF) proved to be metabolically safe for patients with stage G5 CKD. The downward trend in CRP suggests their potential to reduce inflammatory processes. Reduced albumin levels in the intervention groups may indicate a connection between inflammation and nutritional disorders. Although changes in lipid parameters did not reach statistical significance, they may point to the potential benefits of the therapy. The low power of the analysis highlights the need for studies with a larger sample of patients. The results support further evaluation of these interventions as a supplementary part of nephrological treatment hemodialysis and may influence laboratory parameters related to inflammation and nutrition. It is important to expand our study and include more dialysis patients. This would not only allow us to gather more substantial data but also facilitate an assessment of how and in what ways these treatments could be used to improve health and quality of life in this patient group.

Acknowledgments

The authors gratefully thank the patients for their cooperation during the study.

Informed Consent Statement

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

Ethical Committee approval

The Bioethics Committee at the Medical University of Łódź, Łódź, Poland. Resolution of the Bioethics Committee on the medical experiment project No. RNN/353/15/KE dated December 15, 2015.

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Topic

Medical Science

Conflicts of interest

The authors have no conflicts of interest to declare.

Funding

Rector's Subsidy of the Józef Piłsudski University of Physical Education, Warsaw, Poland.

Author-s contribution

Conceptualization, P.B. and P.W.; methodology, P.W. and P.B.; software, Ł.T.; validation, P.B. and P.W.; formal analysis, Ł.T.; investigation, P.W. and P.B.; resources, P.B. and P.W.; data curation, Ł.T.; writing—original draft preparation, P.W. and P.B.; writing—review and editing, P.B., P.W. and Ł.T.; visualization, Ł.T. and P.W.; supervision, P.B. and P.W.; project administration, P.W. All authors have read and agreed to the published version of the manuscript.

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Received: 23.07.2025.

Accepted: 17.09.2025.

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