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Effectiveness of A nurse-Led Educational Intervention Program on Symptoms, Quality of Life and Progression of Mineral Bone Disorders among Patients with End-Stage Renal Disease

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Abstract
Background: Mineral bone disorders pose significant challenges for patients with end-stage renal disease, contributing to morbidity and mortality. Nurse-led educational intervention program is effective strategy to empower patients in managing disease. **Aim:** The study aimed to evaluate the effectiveness of a nurse-led educational intervention program on symptoms, quality of life and progression of mineral bone disorders among patients with end-stage renal disease. **Methods:** Research design: A quasi-experimental non-randomized design. Sample and setting: A non-randomized sample of 120 patients with end-stage renal disease (control group = 60 patients, study group = 60 patients) was recruited and followed for 6 months in the hemodialysis unit of the internal medicine department at Assiut University Hospitals. Each patient in the study group received orientation and training from researchers on essential knowledge, and dietary recommendations to reduce phosphate intake, as well as exercises to improve bone health and provided with a handout booklet. Tools: The study utilized a patient assessment sheet, a numeric pain rating scale, and the EuroQol-5 dimension to measure outcomes. **Results:** The ages of patients in both groups ranged from 20 to 50 years. A nurse-led educational intervention program demonstrated a significant effect ($p < 0.01$) as regard all outcome measures; reducing symptoms, improving quality of life and limiting disease progression. **Conclusion:** A nurse-led educational intervention program notably reduced symptoms, enhanced quality of life, and slowed the progression of mineral bone disorders in patients with end-stage renal disease. **Recommendation:** Implementation of a nurse-led educational intervention program as a strategic approach to improve patient outcomes in managing mineral bone disorders associated with end-stage renal disease.

Keywords: ***End-stage renal disease, Mineral bone disorders, Nurse-led educational intervention, Quality of life & Symptoms***

Introduction
End-stage renal disease (ESRD) is a significant medical condition characterized by complete or nearly complete failure of kidney function, necessitating specialized care and management. Patients with ESRD face numerous complications, among which mineral bone disorders (MBDs) prominently feature **(Costantinides et al., 2018)**.

Mineral bone disorders encompass a spectrum of skeletal abnormalities often observed in patients with chronic kidney disease, particularly in its advanced stages such as ESRD. The disturbed mineral and bone metabolism in these patients leads to various complications, including bone fractures, pain, and weakness, significantly affecting their quality of life **(Hu et al., 2022)**.

People living with ESRD require dialysis to maintain life. Those requiring dialysis suffer MBDs secondary to phosphate (PO4), calcium (Ca) and parathyroid hormone (PTH) disturbances. Optimal PO4 level may be difficult to achieve and consequently many people on hemodialysis suffer debilitating MBDs. Strategies to maintain optimal serum PO4, Ca and PTH levels include dietary intake, dialysis and medication **(Hu et al., 2022; Sprague et al., 2021)**.

Nursing plays a pivotal role in the comprehensive care of ESRD patients, including the management of MBDs. Recognizing the importance of education in improving patient outcomes, nursing educational programs have been developed to equip patients with the necessary knowledge and skills to address the complexities of managing MBDs. Nurses monitor and assess laboratory values related to Ca, PO4, and PTH levels to detect and manage MBDs. Collaborate with nephrologists and other healthcare providers to develop and implement individualized treatment plans. Providing nutritional counseling to help patients manage their PO4 intake and maintain bone

health. Play a key role in promoting patient adherence to prescribed medications such as PO4 binders and vitamin D supplements to control mineral levels and prevent bone complications **(Amutha, 2021)**.

Patient education by nurses includes guidance on exercise programs to improve bone health and reduce fracture risk. Nursing assessments focus on identifying signs and symptoms of MBDs early to facilitate prompt intervention and prevent disease progression. Provide ongoing support and encouragement to patients, empowering them to actively participate in their care and make informed decisions regarding their health **(Wen et al., 2022)**.

Nurse-led interventions often involve regular monitoring and follow-up to assess patients' progress, address any concerns or questions they may have, and provide ongoing support. This personalized approach can lead to better outcomes, including decreased serum PO4 levels, improved bone health, and reduced incidence of complications such as fractures and cardiovascular events **(Sletvold et al., 2022)**.

Significance of the study

Despite the availability of international and national guidelines to curtail the adverse clinical outcomes associated with ESRD-MBDs, many patients with ESRD are still affected by these abnormalities. Chronic renal disease impacts 5-10% of the global population, with a majority at increased risk of developing bone and mineral metabolism disturbances. These disturbances contribute to a constellation of bone lesions, manifesting as bone pain, muscle ache, muscle weakness, and a high incidence of fractures **(Waziri et al., 2019)**.

This significant clinical issue continues to be studied to enhance the understanding and management of ESRD-MBDs. Investigating the effects of nursing educational intervention programs on MBDs among patients with ESRD is crucial for optimizing patient care and improving clinical outcomes. Unlike dietitian and physiotherapy-led education, which can be challenging to implement, nephrology nurses in the nephrology unit can play a critical role in managing patients with ESRD. However, few studies have investigated the effectiveness of nurse-led educational intervention programs in controlling MBDs among patients with ESRD **(Yuan et al., 2021)**.

Research implications: This study aimed to fill the gap in the literature by providing evidence on the effectiveness of nurse-led educational interventions in managing MBDs among patients with ESRD. The findings can inform future research and guide the development of targeted educational programs.

Nursing implications: Nephrology nurses are uniquely positioned to deliver educational interventions due to their close interaction with patients. This study aimed to underscore the potential of nurse-led program to significantly enhance patient outcomes, highlight the need for incorporating such interventions into standard nephrology care practices.

By emphasizing the importance of nurse-led educational intervention, this study sought to advocate for their inclusion in ESRD management guidelines. The anticipated improvement in patient outcomes would underscored the critical role of nephrology nurses in the multidisciplinary care team, ultimately aiming to improve the quality of life for patients with ESRD-MBDs.

Aim of the study

General objective

This study aimed to evaluate the effectiveness of a nurse-led educational intervention program on symptoms, quality of life and progression of mineral bone disorders among patients with end-stage renal disease.

Specific objectives

1. Design and implement a nurse-led educational intervention program for patients with ESRD to manage MBDs.
2. Evaluate the effectiveness of the nurse-led educational intervention program on reduction of symptoms related to MBDs in patients with ESRD.
3. Determine the effect of the nurse-led educational intervention program on improving the overall quality of life of patients with ESRD.
4. Evaluate the influence of the nurse-led educational intervention program on slowing down the progression of MBDs among patients with ESRD.

Research hypotheses

1. Patients with ESRD who participate in the nurse-led educational intervention program (study group) would experience a significant reduction in symptoms related to MBDs compared to those who did not participate (control group).
2. The quality of life of patients with ESRD would significantly improve after participating in the nurse-led educational intervention program (study group) compared to those who did not participate (control group).
3. The progression of MBDs in patients with ESRD would be significantly slower in those who participate in the nurse-led educational intervention program (study group) compared to those who did not participate (control group).

Operational definition:

A nurse-led educational intervention program refers to a structured educational initiative designed, implemented, and managed by qualified nurses with the primary goal of improving patient health outcomes through targeted educational interventions.

This program typically involves a series of planned activities and sessions aimed at increasing patient knowledge, modifying health behaviors, and enhancing self-management skills for specific health conditions. The program is characterized by its proactive and interactive approach, often tailored to individual patient needs.

Methods

Study design

A quasi-experimental non-randomized design was used to achieve the aim of the current study.

Study variables

The independent variable was a nurse-led educational intervention program while the dependent variables were symptoms, quality of life and other some MBDs related variables.

Study setting

This study was conducted in the hemodialysis unit of the internal medicine department at Assiut University Hospitals, located in Assiut, Egypt. The unit includes a patient waiting area where patients were interviewed by the researchers and the educational intervention program was implemented.

Sample

A purposive non-randomized sampling approach was utilized. The sample consisted of 120 patients, divided non-randomly into two groups: study and control, with 60 patients in each group. The first 60 patients collected formed the control group, and the subsequent 60 patients formed the study group. All accessible patients who met the following criteria were included:

Inclusion criteria:

Both genders aged from 20 – 50 years old, diagnosed with ESRD and on regular hemodialysis for more than 6 months (3 sessions /week, 4 hours each), known the objective of the study, and approved to participate in the current study.

Exclusion criteria:

Patients with acute renal injury, chronic renal disease-non hemodialysis, dialysis duration less than 6 months, congenital rickets, rheumatic disorders, active infection (tuberculosis), active malignancy or trauma or accident were excluded from the study.

Sample size:

It was calculated rely on a study conducted by **Jayaprakash & Anap, (2020)**. The calculation of the sample size ensuring a statistical power of 85%, an effect size of (d = 0.8), and a desired level of significance of 0.05. The formula used for this calculation is $n = (Z_{\alpha/2}+Z_{\beta})^2 \cdot (2\sigma^2) / d^2$, where $Z_{\alpha/2}$ is the Z-value corresponding to the desired level of significance for a two-tailed test, and Z_{β} is the Z-value corresponding to the desired power. Given the values $Z_{\alpha/2} \approx 1.96$, $Z_{\beta} \approx 1.036$ and $\sigma \approx 2.07$. This calculation confirms that a sample size of 60 patients per group, making a total of 120 patients, is appropriate and meets the study's requirements for detecting meaningful differences or effects **(Rosner, 2015)**.

Data collection tools

The data were gathered through the utilization of three study tools.

I. Patient assessment sheet:

Developed by researchers after reviewing related literature **Thomas, (2019)**, encompasses various components. These included:

a) Demographic data: age, gender, marital status, educational level and occupation.
b) Medical data: height, weight, body mass index (BMI), other chronic diseases, duration on hemodialysis, clinical symptoms and take medication to reduce PO4 level.
c) Laboratory investigations: serum total Ca, serum PO4, and PTH levels.

II. Numeric pain rating scale:

It adopted from **McCaffery & Beebe, (1989)** to assess pain intensity. Asking patients to rate their pain on a scale from "0 to 10", where "0 = no pain" and "10 = worst pain". Scoring classified as (0: no pain, 1-3: mild pain, 4-6: moderate pain, 7-10: severe pain).

III. EuroQol-5 Dimension (EQ-5D-5L)

The EQ-5D-5L is a valuable tool adopted from **Herdman et al., (2011)** for assessing health-related quality of life and is widely used in research and healthcare settings to support decision-making and improve patient outcomes. It used to assess health status across five dimensions: mobility, self-care, usual activities, pain/discomfort, and anxiety/depression. Each dimension has five response levels: no problems = 1, slight problems = 2, moderate problems = 3, severe problems = 4 or extreme problems = 5.

In addition to the health state, the EQ-5D-5L includes a visual analog scale (VAS); EQ-5D-5L VAS where patients rate their overall health on a scale from 0 (worst imaginable health) to 100 (best imaginable health).

Procedure

The current study proceeded using the following phases:

Preparatory phase

Tools development:

It included reviewing the related literature to adopt or develop data collection tools (**Thomas, 2019; McCaffery & Beebe, 1989; Herdman et al., 2011)**.

Resource preparation:

The research team tailored the training environment and educational materials, including visual aids; pictures and handouts educational booklet, to specifically meet the needs of the patients.

Additionally, organized the teaching schedule based on the content outlined in the educational booklet and the availability of time.

Validity of study tools:

The study tools were validated by expert panel (two medical-surgical nursing staff and one nephrologist).

The numeric pain rating scale has shown strong concurrent validity compared to other pain assessment tools such as the VAS and verbal rating scale (VRS) with high correlation (r = 0.91) between numeric pain rating scale and VAS scores **(Hawker et al. 2011)**.

The EQ-5D-5L scores correlate well with other established measures of health-related quality of life, such as the SF-36 or EQ-5D-3L. Strong correlation was found between EQ-5D-5L and EQ-5D-3L scores, indicating good convergent validity **(van Hout et al. 2012)**.

The VAS scores of the EQ-5D-5L can predict future health outcomes and health care utilization, providing evidence of its predictive validity **(Feng et al., 2015)**.

Reliability of study tools:

The numeric pain rating scale has excellent test-retest reliability with correlation coefficients from 0.86 to 0.95 **(Ferreira-Valente et al., 2011)**.

The test-retest reliability of EQ-5D-5L and EQ-5D VAS with intraclass correlation coefficients (ICC) exceeding 0.7, indicating acceptable reliability **(Janssen et al. 2013)**.

Ethical considerations:

Prior to commencing the study, formal approval was secured from the head of the internal medicine department at Assiut University Hospitals. This authorization was essential to initiate the research and ensured compliance with institutional guidelines. Obtaining official permission from departmental leadership underscored the commitment to conducting the study in an ethical and accountable manner within the hospital setting. This preparatory phase was a crucial step in establishing the groundwork for the study and demonstrating respect for institutional protocols and oversight.

The study received official approvals from the Faculty of Nursing Research Ethical Committee on 27-4-2022 with ethical code 1120240378. Patients were informed of their right to refuse participation or withdraw from the study at any time. Assurances were given regarding confidentiality of all data, and privacy was upheld throughout the study. Prior to data collection, the aim of the study was explained to each patient and oral consent for participation was obtained from every patient.

Pilot study:

It served as a valuable preparatory phase to optimize the clarity, feasibility, and efficiency of data collection methods. It help to identify and address potential challenges or ambiguities in the study tools before scaling up to the full study sample. This iterative process of refinement enhances the overall quality and reliability of the research outcomes and contributes to the successful implementation of the main study. It was conducted on 12 patients; 6 patients from each group (10% of the total sample) and played a critical role in ensuring the effectiveness and practicality of the research tools used in the main study, ultimately contributing to the methodological rigor and success of the overall research endeavor. Minor modifications were required and done, so, the participants who were part of the pilot study were included in the overall study sample. The modifications included simplifying the language: complex medical terminology was simplified to ensure that patients could understand and respond accurately without confusion. Additionally, more visual aids and simplified explanations were incorporated to accommodate patients with varying literacy levels.

Fieldwork description:

The study conducted data collection over a one-year period, spanning from May 2022 to May 2023, encompassing morning, afternoon, and night shifts in hemodialysis unit of internal medicine department at Assiut University Hospitals. Additionally, a 6-month follow-up period extended until November 2023 was included in the study timeline. This comprehensive approach allowed for a thorough examination of the study variables and outcomes across different time periods and shifts within the hemodialysis unit. The inclusion of a follow-up period further enriched the study findings by assessing longer-term outcomes and trends related to the study objective.

Assessment phase

The study involved recruiting patients from the hemodialysis unit for their regular sessions, which occurred three times a week, each lasting four hours. To ensure transparency and patient comfort, the researchers introduced themselves and initiated communication, explaining that patients might experience minor discomfort during certain exercises.

Upon selection, eligible patients were informed about the aim and nature of the study, and their consent was obtained before categorizing them into either the control or study groups. Baseline assessments were then conducted individually for all patients, focusing on collecting demographic, medical, and laboratory data using Tool I (parts a, b, c).

In addition to the baseline assessments, patients' pain levels were measured using the numeric pain rating scale and their health-related quality of life was assessed using the EQ-5D-5L visual analog scale (VAS) (Tool II). These assessments provided important baseline data necessary for evaluating the

impact of the nurse-led educational intervention on symptom management, quality of life and overall health among patients with ESRD undergoing hemodialysis.

Implementation phase

Following completion of the assessment, nephrology nurses and nursing researchers commenced the delivery of the educational intervention program through sessions.

Nurse-Led Educational Intervention Program:

In the study group, patients received individualized education before their hemodialysis sessions, lasting 40-60 minutes, which occurred 4-times (4-sessions). This educational intervention was conducted in a conversational format, tailored to each patient's needs. The sessions covered the following topics:

First Face-to-Face Educational Intervention Session:

Objective: Provide patients with basic information about ESRD-MBDs.

Duration: 40 minutes.

Content: Inform patients about essential disease information, including the definition of ESRD-MBDs, symptom recognition, laboratory investigations, management, and potential complications. Encourage patient questions and confirm understanding.

Teaching Method/Media: Lecture and distribution of printed handout booklet with illustrated pictures. Concluded with a summary, addressing questions, and outlining plans for the next session.

Second Face-to-Face Educational Intervention Session:

Objective: Empower patients with knowledge about the importance of PO4 control and consequences of uncontrolled PO4 level.

Duration: 40 minutes.

Content: Cover topics including PO4 management, PO4 binders, and dietary considerations related to PO4 control. Use colorful visuals of high and low PO4 foods to enhance understanding.

Teaching Method/Media: Lecture and printed handout booklet with illustrated pictures. Concluded with a summary, addressing questions, and outlining plans for the next session.

Third Face-to-Face Educational Intervention Session:

Objective: Empower patients with knowledge and skills about recommended exercises to actively participate in their care and enhance overall quality of life.

Duration: 60 minutes.

Content: Instructed and trained patients on specific exercises suitable for renal disease patients, including strength, flexibility and balance exercises. These exercises (1-2 times/day) are essential for improving muscle strength, flexibility, balance, coordination, and overall stability, which are crucial for patients with renal disease to maintain mobility and reduce the risk of falls.

Strength exercises

- **The leg lifts exercise in Pilates:** This exercise targets the muscles of the legs, particularly the front thigh muscles, and can help improve muscle strength and stability. It should be performed slowly and with focus on feeling the leg muscles working during the movement, while avoiding excessive muscle tension.
- **The toe raises exercise:** This exercise targets the calf muscles and helps improve ankle stability and strength. Perform the movement slowly and with control to maximize its effectiveness.

Flexibility exercises

- **The shoulder rotation exercise:** This exercise helps improve muscle flexibility, facilitates joint movement smoothly and relieves tension and promotes relaxation.
- **The leg stretch exercise:** This exercise helps improve flexibility and stretch in the legs, targeting the hamstring muscles.

Balance exercise

This exercise is beneficial for improving balance, coordination, and overall stability.

Teaching Method/Media: Lecture and distribution of printed handout booklet with illustrated pictures. Concluded with a summary, addressing questions, and outlining plans for the next session.

Fourth Face-to-Face Educational Intervention Session:

Objective: Supervise patients during specific exercises to ensure correct performance and emphasize the importance of follow-up.

Duration: 60 minutes.

Content: Provide supervision, additional instructions, and training on the previously mentioned specific exercises tailored for renal disease patients, including strength, flexibility, and balance exercises. Emphasize the significance of regular follow-up appointments with nephrologists and other healthcare providers to monitor bone health status and adjust treatment plans accordingly.

Teaching Method/Media: Utilize printed handout booklet with illustrated pictures, engage in interactive conversation, and incorporate active listening or audio/phone media as needed.

On the other hand, the control group received routine medical and social care without any educational materials during the study period. Nevertheless, they were provided with the same educational program after the data collection phase was completed. This systematic approach aimed to empower patients with

ESRD to improve their management of MBDs through comprehensive education and interactive sessions led by a specialized nurse.

Evaluation phase

After three and six months, each patient returned for a scheduled follow-up appointment. During these appointments, patients were evaluated for MBDs symptoms using (tool I, part b), and MBDs progression was assessed through laboratory investigations including Ca, PO4, and PTH using (tool I, part c). Additionally, pain intensity was evaluated using a numeric pain rating scale (tool II), and quality of life and overall health status were evaluated using the EQ-5D-5L VAS (tool III).

Statistical analysis

Categorical variables were presented as numbers and percentages (No., %), while continuous variables were expressed as means and standard deviations (Mean ± SD). The Chi-square test was utilized to compare categorical variables, whereas the independent samples t-test was employed for comparing continuous variables. Spearman correlation coefficients were used to assess correlations. A two-tailed p-value of less than 0.05 was considered statistically significant. All analyses were conducted using IBM SPSS Statistics, version 27.0.

Results

Table (1): Demographic data of the studied groups

Demographic data	Study group (n=60)	Control group (n=60)	X^2/t	P. value
Age				
Minimum - Maximum	20 - 50	20 - 50		
Mean±SD	41.15±7.59	42.08±6.07	-0.744	0.458
Sex				
Male	33(55%)	34(56.67%)	0.034	0.854
Female	27(45%)	26(43.33%)		
Marital status				
Single	15(25%)	8(13.33%)	4.983	0.083
Married	43(71.67%)	52(86.67%)		
Divorced	2(3.33%)	0(0%)		
Educational level				
Non educated	16(26.67%)	26(43.3%)	7.374	0.194
Read and write	10(16.67%)	7(11.7%)		
Primary school	0(0%)	2(3.33%)		
Preparatory school	7(11.67%)	8(13.33%)		
Secondary school	16(26.67%)	11(18.33%)		
University	11(18.33%)	6(10%)		
Occupation				
Office work	10(16.67%)	8(13.33%)	3.333	0.343
Machinery work	0(0%)	3(5%)		
Manual work	5(8.33%)	4(6.67%)		
Not work	45(75%)	45(75%)		

Non-significant p > 0.05

Table (2): Medical and clinical data of the studied groups

Table (2a): Medical data of the studied groups

Medical data	Study group (n=60)	Control group (n=60)	X^2/t	P. value
Height (cm)				
Minimum - Maximum	150 - 180	155 - 178	-0.281	0.779
Mean±SD	163.02±6.66	163.33±5.64		
Weight (kg)				
Minimum - Maximum	47 - 90	44 - 104	-1.748	0.083
Mean±SD	65.25±9.79	69.02±13.51		
Body mass index				
Minimum - Maximum	18.36 - 35.16	16.16 - 37.11	-1.690	0.094
Mean±SD	24.56±3.49	25.86±4.79		
Other chronic co-morbidities				
Cardiovascular diseases				
Yes	10(16.67%)	18(30%)	2.981	0.084
No	50(83.33%)	42(70%)		
Diabetes mellitus				
Yes	4(6.67%)	3(5%)	0.152	0.697
No	56(93.33%)	57(95%)		
Thyroid and parathyroid disease				
Yes	12(20%)	9(15%)	0.519	0.471
No	48(80%)	51(85%)		
Hypertension				
Yes	19(31.67%)	13(21.7%)	1.534	0.215
No	41(68.33%)	47(78.3%)		
Duration in dialysis (years)				
Minimum - Maximum	1 - 11	1 - 13	-1.678	0.096
Mean±SD	4.3±2.43	5.13±2.98		
Use assistive device for ambulation. Dose this reduce pain?				
Yes	9(15%)	11(18.33%)	0.240	0.624
No	51(85%)	49(81.67%)		
Take medication to reduce PO4 level				
Yes	22(36.67%)	17(28.33%)	0.95	0.330
No	38(63.33%)	43(71.67%)		

Non-significant p > 0.05

Table (2b): Clinical symptoms of the studied groups

Clinical symptoms	At assessment		At 3 months		At 6 months	
	Study group (n=60)	Control group (n=60)	Study group (n=60)	Control group (n=60)	Study group (n=60)	Control group (n=60)
Bone pain						
Yes	31(51.67%)	30(50%)	23(38.33%)	27(45%)	14(23.33%)	37(61.67%)
No	29(48.33%)	30(50%)	37(61.67%)	33(55%)	46(76.67%)	23(38.33%)
X^2	0.033		0.549		18.039	
P. value	0.855		0.459		<0.001**	
Weakness						
Yes	25(41.67%)	22(36.67%)	16(26.67%)	23(38.33%)	13(21.67%)	29(48.33%)
No	35(58.33%)	38(63.33%)	44(73.33%)	37(61.67%)	47(78.33%)	31(51.67%)
X^2	0.315		1.861		9.377	
P. value	0.575		0.172		0.002**	
Fatigue						
Yes	33(55%)	43(71.67%)	28(46.67%)	46(76.67%)	23(38.33%)	43(71.67%)
No	27(45%)	17(28.33%)	32(53.33%)	14(23.33%)	37(61.67%)	17(28.33%)
X^2	3.589		11.422		13.468	
P. value	0.058		0.001**		<0.001**	
Powerlessness						
Yes	15(25%)	20(33.33%)	2(3.33%)	23(38.33%)	0(0%)	13(21.67%)
No	45(75%)	40(66.67%)	58(96.67%)	37(61.67%)	60(100%)	47(78.33%)
X^2	1.008		22.282		14.579	
P. value	0.315		<0.001**		<0.001**	
Difficult mobility						
Yes	14(23.3%)	19(31.67%)	2(3.33%)	22(36.67%)	0(0%)	13(21.67%)
No	46(76.7%)	41(68.33%)	58(96.67%)	38(63.33%)	60(100%)	47(78.33%)
X^2	1.045		20.833		14.579	
P. value	0.307		<0.001**		<0.001**	
Muscles pain						
Yes	22(36.67%)	13(21.67%)	14(23.33%)	11(18.33%)	7(11.67%)	20(33.33%)
No	38(63.33%)	47(78.33%)	46(76.67%)	49(81.67%)	53(88.33%)	40(66.67%)
X^2	3.267		0.455		8.076	
P. value	0.071		0.500		0.004**	
Inability to carry out usual activities						
Yes	9(15%)	8(13.33%)	8(13.33%)	10(16.67%)	0(0%)	6(10%)
No	51(85%)	52(86.67%)	52(86.67%)	50(83.33%)	60(100%)	54(90%)
X^2	0.069		0.261		6.316	
P. value	0.793		0.609		0.012*	
Numbness						
Yes	36(60%)	28(46.7%)	28(46.67%)	30(50%)	7(11.67%)	17(28.33%)
No	24(40%)	32(53.3%)	32(53.33%)	30(50%)	53(88.33%)	43(71.67%)
X^2	2.143		0.133		5.208	
P. value	0.143		0.715		0.022*	
Tingling						
Yes	10(16.67%)	11(18.33%)	7(11.67%)	8(13.33%)	0(0%)	8(13.33%)
No	50(83.33%)	49(81.67%)	53(88.33%)	52(86.67%)	60(100%)	52(86.67%)
X^2	0.058		0.076		8.571	
P. value	0.810		0.783		0.003**	
Leg pain						
Yes	21(35%)	23(38.33%)	10(16.67%)	23(38.33%)	3(5%)	22(36.67%)
No	39(65%)	37(61.67%)	50(83.33%)	37(61.67%)	57(95%)	38(63.33%)
X^2	0.144		7.064		18.24	
P. value	0.705		0.008**		<0.001**	

Non-significant p > 0.05 *Significant p < 0.01*

Table (3): Pain characteristics of the studied groups

Pain characters	At assessment		At 3 months		At 6 months	
	Study group (n=60)	Control group (n=60)	Study group (n=60)	Control group (n=60)	Study group (n=60)	Control group (n=60)
Pain nature						
Continuous	11(18.33%)	11(18.33%)	6(10%)	9(15%)	4(6.67%)	14(23.33%)
Intermittent	49(81.67%)	49(81.67%)	54(90%)	51(85%)	56(93.33%)	46(76.67%)
X^2	0.000		0.686		6.536	
P. value	1.000		0.408		0.011*	
Pain location						
Generalized	34(56.7%)	40(66.67%)	22(36.67%)	38(63.33%)	14(23.33%)	42(70%)
Localized	26(43.3%)	20(33.33%)	38(63.33%)	22(36.67%)	46(76.67%)	18(30%)
X^2	1.269		8.533		26.25	
P. value	0.260		0.003**		<0.001**	
What control or relieve pain? (Pain management)						
Medication						
Yes	20(33.3%)	29(48.3%)	33(55%)	16(26.7%)	21(35%)	29(48.33%)
No	40(66.7%)	31(51.7%)	27(45%)	44(73.3%)	39(65%)	31(51.67%)
X^2	2.794		9.968		2.194	
P. value	0.095		0.002**		0.139	
Rest						
Yes	40(66.7%)	33(55%)	60(100%)	41(68.33%)	48(80%)	33(55%)
No	20(33.3%)	27(45%)	0(0%)	19(31.67%)	12(20%)	27(45%)
X^2	1.714		22.574		8.547	
P. value	0.190		<0.001**		0.003**	
None						
Yes	1(1.67%)	0(0%)	1(1.67%)	0(0%)	-	-
No	59(98.33%)	60(100%)	59(98.33%)	60(100%)	60(100%)	60(100%)
X^2	1.008		1.008		-	
P. value	0.315		0.315		-	

Non-significant p > 0.05 *Significant p < 0.01*

Table (4): Numeric pain rating scale (pain intensity) of the studied groups

Numeric pain rating scale	At assessment		At 3 months		At 6 months	
	Study group (n=60)	Control group (n=60)	Study group (n=60)	Control group (n=60)	Study group (n=60)	Control group (n=60)
Pain scale						
Minimum - Maximum	2 - 8	2 - 8	1 - 7	1 - 6	1 - 7	1 - 6
Mean±SD	3.78±1.56	3.95±1.13	2.17±1.32	2.78±1.47	1.73±1.36	2.83±1.57
t	-0.670		-2.417		-4.090	
P. value	0.504		0.017*		<0.001**	
Pain intensity levels						
Mild	27(45%)	23(38.33%)	52(86.67%)	41(68.33%)	53(88.33%)	39(65%)
Moderate	27(45%)	35(58.33%)	6(10%)	19(31.67%)	5(8.33%)	21(35%)
Severe	6(10%)	2(3.33%)	2(3.33%)	0(0%)	2(3.33%)	0(0%)
X^2	3.352		10.061		13.977	
P. value	0.187		0.007**		0.001**	

Non-significant p > 0.05 *Significant p < 0.01*

Table (5): Laboratory investigations of the studied groups

Laboratory investigations	At assessment		At 3 months		At 6 months	
	Study group (n=60)	Control group (n=60)	Study group (n=60)	Control group (n=60)	Study group (n=60)	Control group (n=60)
Serum Ca (Normal 8.5-10.1 mg/dL)						
Minimum - Maximum	7.5 - 9.5	7.5 - 9.5	7.5 - 9.5	8 - 10	8.5 - 10	7.9 - 9.8
Mean±SD	8.37±0.62	8.43±0.56	8.75±0.43	8.75±0.46	9.11±0.33	8.73±0.46
t	-0.556		-0.041		5.156	
P. value	0.579		0.967		<0.001**	
Serum PO4 (Normal 2.6-4.7 mg/dl)						
Minimum - Maximum	4.3 - 7.6	4.3 - 7.5	3.5 - 6	5.5 - 8	4 - 5.5	4.8 - 6.7
Mean±SD	6.34±0.73	6.5±0.8	4.91±0.55	6.39±0.59	4.35±0.37	5.96±0.58
t	-1.146		-14.281		-18.094	
P. value	0.254		<0.001**		<0.001**	
Parathyroid hormone (14-65 pg/mL)						
Minimum - Maximum	210 - 1200	200 - 1000	190 - 810	220 - 900	120 - 800	300 - 900
Mean±SD	513.55±152	455.63±197.0	535.67±135	454.53±153	476±135.4	541.67±172.34
t	1.802		3.062		-2.321	
P. value	0.074		0.003**		0.022*	

Non-significant p > 0.05 *Significant p < 0.01*

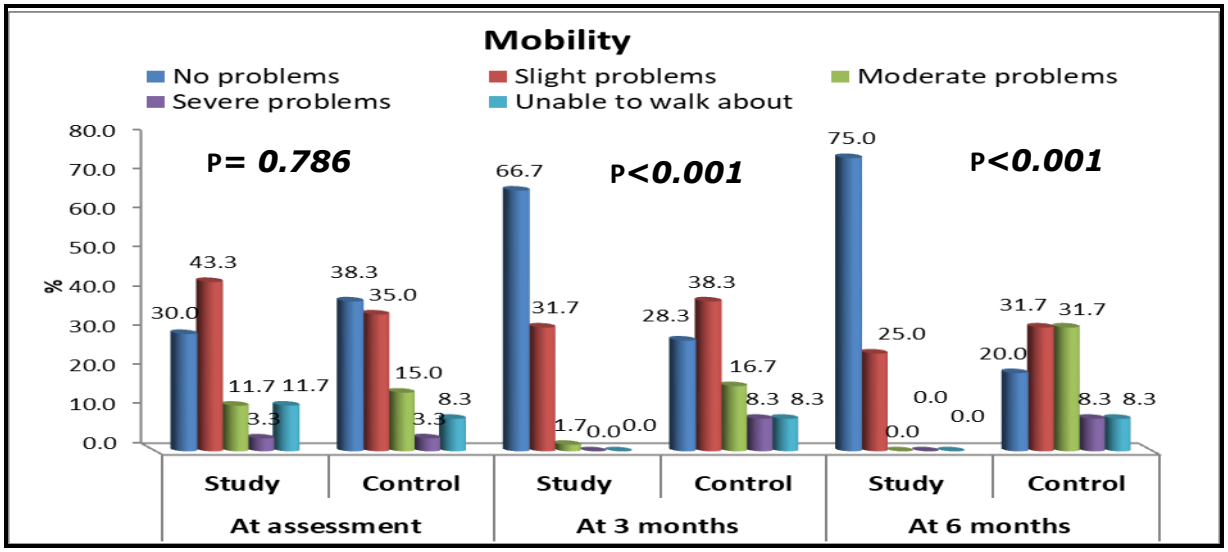

Figure (1): Mobility dimension of the EQ-5D-5L for study and control group patients

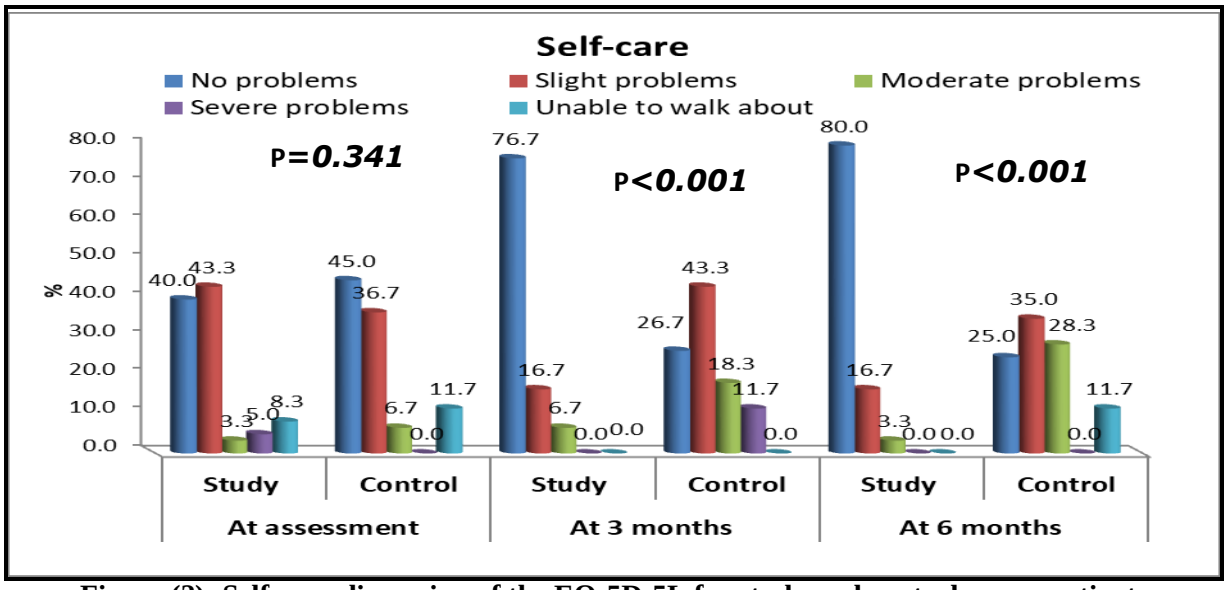

Figure (2): Self-care dimension of the EQ-5D-5L for study and control group patients

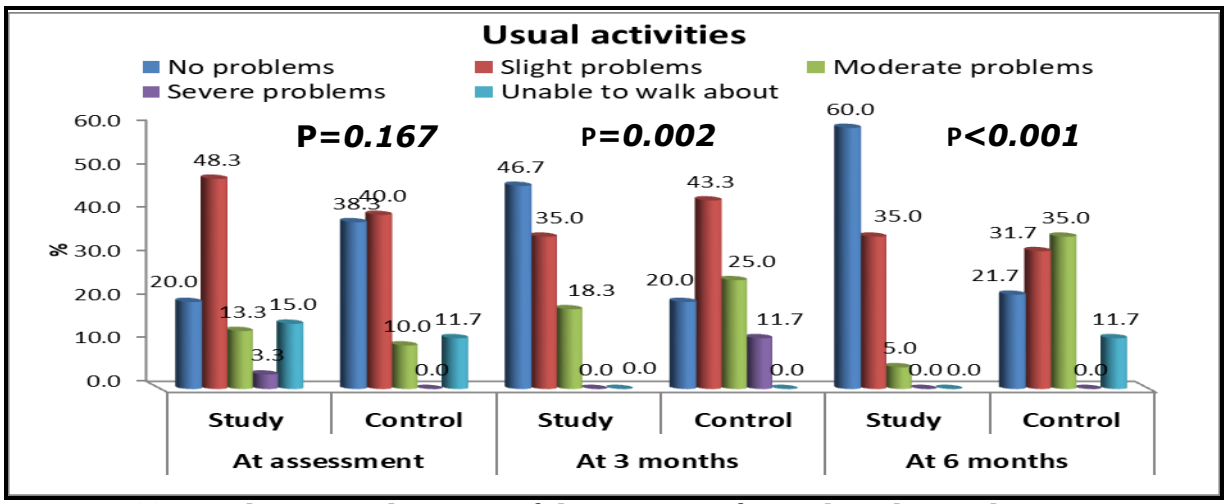

Figure (3): Usual activities dimension of the EQ-5D-5L for study and control group patients

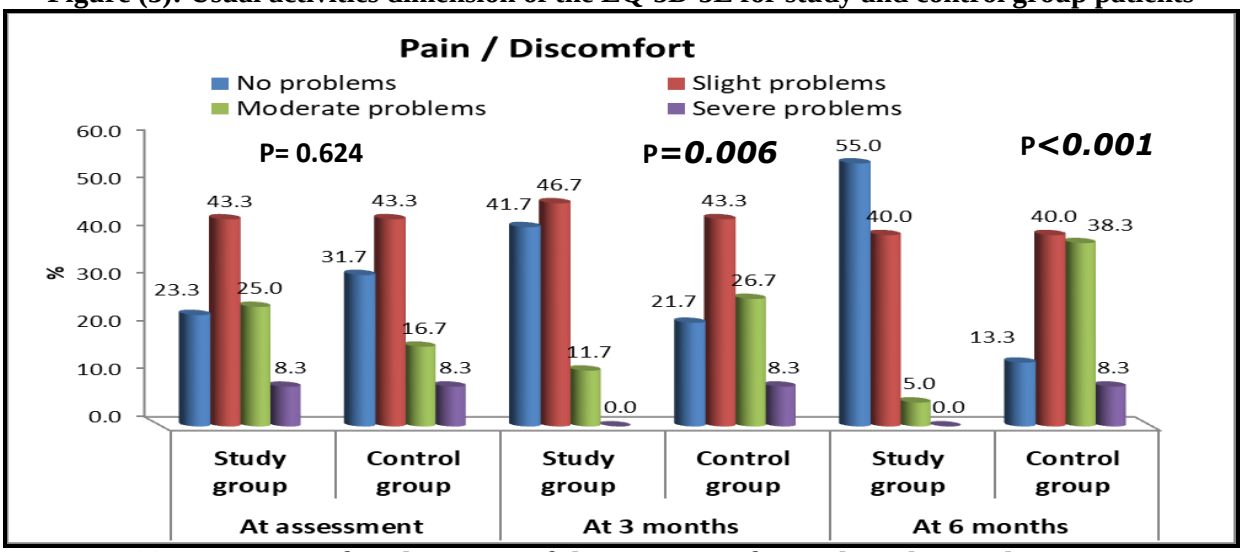

Figure (4): Pain/Discomfort dimension of the EQ-5D-5L for study and control group patients

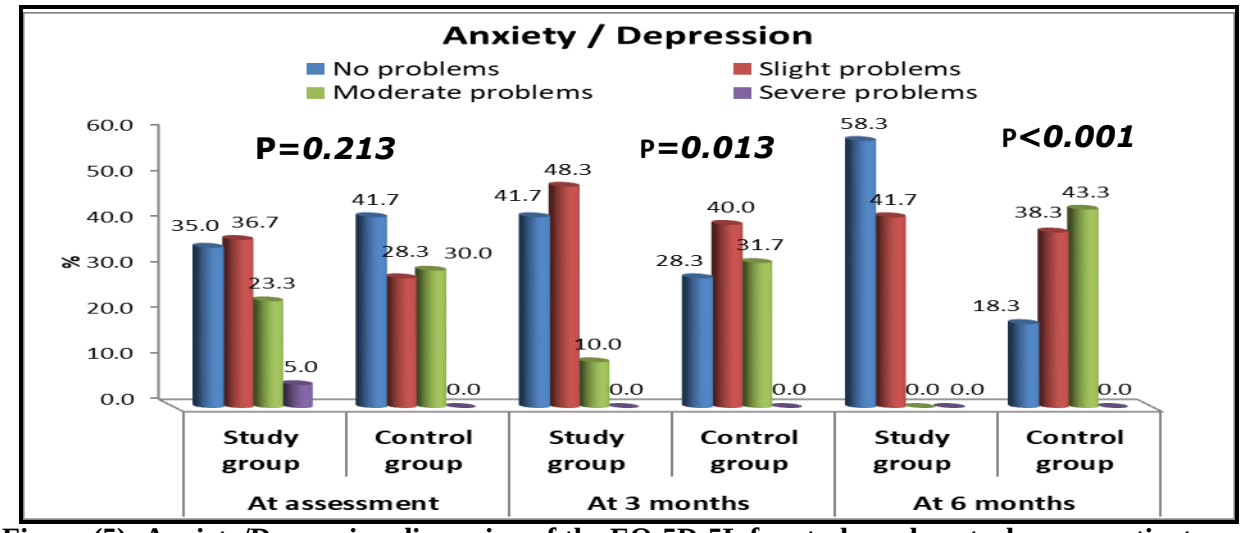

Figure (5): Anxiety/Depression dimension of the EQ-5D-5L for study and control group patients

Table (6): Visual analog scale of the EuroQol-5 dimension of the studied groups

Visual analog scale of the EuroQol-5 dimension	At assessment		At 3 months		At 6 months	
	Study group (n=60)	Control group (n=60)	Study group (n=60)	Control group (n=60)	Study group (n=60)	Control group (n=60)
Would like to know how good or bad your health is today ?						
Minimum-Maximum	50 - 100	50 - 80	55 - 90	50 - 80	60 - 90	50 - 80
Mean±SD	68.08±12.32	64.53±8.2	71.5±10.05	62.92±7.83	73.58±9.26	61.42±9.26
t	1.858		5.218		7.200	
P. value	0.066		<0.001**		<0.001**	

Non-significant p > 0.05 *Significant p < 0.01*

Table (1): This table presents the demographic data for both the study and control groups, showing no statistically significant differences between the groups. No statistically significant differences were found between the study and control groups in terms of age, sex, marital status, educational level, or occupation (P > 0.05). The ages of patients in both groups ranged from 20 to 50 years. The mean age for the study group was 41.15±7.59 years, while the control group had a mean age of 42.08±6.07 years (t = -0.744, P = 0.458). More than half of the patients in the study group 33(55%) and the control group 34 (56.67%) were male (X^2 = 0.034, P = 0.854). The majority of patients in the control group 52 (86.67%) were married, while more than two-thirds of the patients in the study group 43 (71.67%) were married (X^2 = 4.983, P = 0.083). In terms of education, 10 patients (16.67%) in the study group and 7 patients (11.7%) in the control group were read and write. More than half of the patients in the study group 34 (56.66%) and less than half in the control group 27 (45%) educated and had a varying levels of education (X^2 = 7.374, P = 0.194). Additionally, more than two-thirds of the patients in both groups 45 (75%) not working (X^2 = 3.333, P = 0.343).

Table (2a): This table presents the medical data of the study and control groups, with no statistically significant differences observed in any of the parameters (p > 0.05). The height of patients in the study group ranged from 150 cm to 180 cm with a mean of 163.02±6.66 cm, while in the control group, it ranged from 155 cm to 178 cm with a mean of 163.33±5.64 cm (t = -0.281, P = 0.779). The weight of patients in the study group ranged from 47 kg to 90 kg with a mean of 65.25±9.79 kg, compared to the control group which ranged from 44 kg to 104 kg with a mean of 69.02±13.51 kg (t = -1.748, P = 0.083). The BMI for the study group ranged from 18.36 to 35.16 with a mean of 24.56±3.49, while the control group ranged from 16.16 to 37.11 with a mean of 25.86±4.79 (t = -1.690, P = 0.094). Regarding chronic co-morbidities; cardiovascular diseases present in 10 patients (16.67%) of the study group and 18 patients (30%) of the control group (X^2 = 2.981, P = 0.084). Diabetes mellitus present in 4 patients (6.67%) of the study group and 3 patients (5%) of the control group (X^2 = 0.152, P = 0.697). Thyroid and parathyroid diseases present in 12 patients (20%) of the study group and 9 patients (15%) of the control group (X^2 = 0.519, P = 0.471). Hypertension present in 19 patients (31.67%) of the study group and 13 patients (21.7%) of the control group (X^2 = 1.534, P = 0.215). Other variables; the duration of dialysis for the study group ranged from 1

to 11 years with a mean of 4.3±2.43 years, and for the control group ranged from 1 to 13 years with a mean of 5.13±2.98 years (t = -1.678, P = 0.096). Nine patients (15%) in the study group and 11 patients (18.33%) in the control group used assistive devices for ambulation (X^2 = 0.240, P = 0.624). Regarding medication taken to reduce PO4 level, 22 patients (36.67%) in the study group and 17 patients (28.33%) in the control group taken medication to reduce PO4 levels (X^2 = 0.95, P = 0.330).

Table (2b): This table presents the clinical symptoms of the study and control groups at assessment, and at 3 and 6 months with several symptoms show statistically significant differences over time, particularly in favor of the study group (P < 0.01). Clinical symptoms showed no statistically significant differences at the time of assessment (p > 0.05). Several clinical symptoms such as bone pain, weakness, fatigue, powerlessness, difficulty in mobility, muscle pain, inability to carry out usual activities, numbness, tingling, and leg pain showed significant improvement in the study group over time compared to the control group, with many symptoms showing statistically significant differences at the 6-month (P < 0.01).

Table (3): This table presents the pain characteristics of the study and control groups at three time points: initial assessment, 3 months, and 6 months. Regarding pain nature, at initial assessment, the percentage of continuous pain was the same in both groups (18.33%). At 3 months, continuous pain decreased in the study group (10%) compared to the control group (15%), but this difference was no statistically significant (P=0.408). At 6 months, the study group showed a significant decrease in continuous pain (6.67%) compared to the control group (23.33%) with a significant P value (0.011). Regarding pain location, at initial assessment, there was no significant difference between the groups (P=0.260). At 3 months, localized pain significantly improved in the study group (63.33%) compared to the control group (36.67%) with a significant P value (0.003). At 6 months, generalized pain decreased significantly in the study group (23.33%) while it increased in the control group (70%) with a highly significant P value (<0.001). As regard pain management with medication, at 3 months, more participants in the study group used medication for pain control (55%) compared to the control group (26.7%), showing a significant difference (P=0.002). At 6 months, there was no significant difference between the groups in medication use (P=0.139). Pain management with rest, at initial assessment, there was no significant difference between the groups (P=0.190). At 3 months, all participants in the study group benefited from rest (100%) compared to the control group (68.33%), with a highly significant P value (<0.001). At 6 months, a higher percentage of the study group (80%) still benefited from rest compared to the control group (55%) with a significant P value (0.003). Greater improvement in pain characteristics and management in the study group compared to the control group over 6 months, with several statistically significant differences P value (<0.01, <0.001).

Table (4): This table presents the numeric pain rating scale (pain intensity) for the study and control groups at three time points: initial assessment, 3 months, and 6 months. At assessment both groups had similar pain scales ranging from 2 to 8, with the study group mean being 3.78±1.56 and the control group mean being 3.95±1.13 (P=0.504). At 3 months pain intensity decreased in both groups, with the study group having a lower mean (2.17±1.32) compared to the control group (2.78±1.47), showing a significant difference (P=0.017). At 6 months the study group continued to show a greater reduction in pain intensity (mean 1.73±1.36) compared to the control group (mean 2.83±1.57), with a highly significant difference (P<0.001). At assessment there was no significant difference between the groups in the distribution of mild, moderate, and severe pain (P=0.187). At 3 months the study group had a significantly higher percentage of mild pain (86.67%) compared to the control group (68.33%), with fewer patients experiencing moderate pain, showing a significant difference (P=0.007). At 6 months the study group maintained a higher percentage of mild pain (88.33%) compared to the control group (65%), with significant differences in the reduction of moderate pain (P=0.001). The data indicates that the study group experienced a greater reduction in pain intensity over time compared to the control group, with significant differences observed at both 3 and 6 months P value (<0.01, <0.001).

Table (5): Shows the laboratory investigations of the study and control groups at three time points: initial assessment, 3 months, and 6 months. At assessment both groups had similar serum Ca levels, with no significant difference (P=0.579). At 3 months there was still no significant difference between the groups (P=0.967). At 6 months the study group showed a significant increase in serum Ca levels (mean 9.11±0.33) compared to the control group (mean 8.73±0.46), with a highly significant P value (<0.001). At assessment both groups had similar serum PO4 levels, with no significant difference (P=0.254). At 3 months the study group had significantly lower serum PO4 levels (mean 4.91±0.55) compared to the control group (mean 6.39±0.59), with a highly significant P value (<0.001). At 6 months the study group maintained

significantly lower serum PO4 levels (mean 4.35±0.37) compared to the control group (mean 5.96±0.58), with a highly significant P value (<0.001). At assessment there was no significant difference in PTH levels between the groups (P=0.074). At 3 months the study group had significantly higher PTH levels (mean 535.67±135.9) compared to the control group (mean 454.53±153.7), with a significant P value (0.003). At 6 months the control group had significantly higher PTH levels (mean 541.67±172.34) compared to the study group (mean 476±135.4), with a significant P value (0.022). The data indicates significant changes in serum Ca, PO4, and PTH levels in the study group over time, particularly at the 6-month mark, compared to the control group P value (<0.01, <0.001).

Figure (1): Illustrates the mobility dimension of the EQ-5D-5L for study and control group patients at three time points: initial assessment, 3 months, and 6 months. The data shows no statistical difference (P= 0.786) at initial assessment. The study group showed significant improvement over time with the percentage of patients reporting "no problems" increasing from 30.0% at assessment to 75.0% at 6 months. Reduction in all other categories over time, with "slight problems" dropping to 25.0% and both "moderate" and "severe problems" dropping to 0% by 6 months. In the control group slight fluctuations with no clear improvement. The percentage of patients with "no problems" varied slightly, peaking at 38.3% at assessment and lowest at 31.7% at 6 months. The percentage of patients reporting "slight problems" decreased over time, but there was an increase in "moderate" and "severe problems" at 6 months compared to assessment. The study group experienced a highly statistical significant differences at 3 and 6 months P value (<0.001) indicating substantial improvements in mobility over time, particularly in reducing the incidence of severe and moderate problems, while the control group did not show similar improvements.

Figure (2): Illustrates the self-care dimension of the EQ-5D-5L for study and control group patients at three time points: initial assessment, 3 months, and 6 months. The data shows no statistical difference (P=0.341) at initial assessment. The study group showed marked improvement in self-care capabilities over the course of the study, whereas the control group showed a lesser degree of improvement, with some metrics worsening over time P value (<0.001). Study group with the percentage of patients reporting "no problems" increasing from 40.0% at assessment to 80.0% at 6 months. Decrease in "slight problems" from 43.3% at assessment to 16.7% at 6 months. Moderate and severe problems reduced to 0% at 6 months. Control group shows less pronounced improvement compared to the study group. The percentage of patients with "no problems" decreased from 45.0% at assessment to 35.0% at 6 months. An increase in "moderate problems" from 6.7% at assessment to 28.3% at 6 months. A decrease in "severe problems" from 11.7% at assessment to 11.7% at 6 months.

Figure (3): Illustrates the usual activities dimension of the EQ-5D-5L for study and control group patients at three time points: initial assessment, 3 months, and 6 months. The data shows no statistical difference (P=0.167) at initial assessment. The study group demonstrated a notable improvement in their ability to perform usual activities over the course of the study, while the control group showed more variable results with some improvement by 6 months but still facing moderate and severe problems P value (<0.001). The study group showed significant improvement over time, with the percentage of patients reporting "no problems" increasing from 20.0% at assessment to 60.0% at 6 months. Decrease in "slight problems" from 48.3% at assessment to 35.0% at 6 months. Reduction in "moderate problems" from 13.3% at assessment to 5.0% at 6 months. Severe problems were eliminated by 3 months and remained at 0.0% at 6 months. Control group showed slight fluctuations in the percentage of patients reporting "no problems," decreasing from 36.7% at assessment to 20.0% at 3 months, then increasing to 31.7% at 6 months. Slight problems decreased from 49.0% at assessment to 35.0% at 6 months. Increase in "moderate problems" from 11.7% at assessment to 25.0% at 3 months, then a slight decrease to 21.7% at 6 months. Severe problems emerged by 3 months at 11.7% and remained the same at 6 months.

Figure (4): Illustrates the pain/discomfort dimension of the EQ-5D-5L for both the study group and the control group at three different time points: at assessment, at 3 months, and at 6 months. The data shows no statistical difference (P= 0.624) at initial assessment. The study group appears to significantly reduce pain and discomfort over time compared to the control group, with a highly significant P value at 3 and 6 months (0.006, <0.001 respectively). Over time, the study group showed significant increase in the percentage of patients reporting no problems, rising from 23.3% at assessment to 55.0% at 6 months. The percentage of patients with severe problems drops to 0% by the 3-month and remains there at 6 months. In the control group, the percentage of patients reporting no problems decreases slightly from 31.7% at assessment to 13.3% at 6 months. The percentage reporting moderate problems increases from 16.7% at assessment to 38.3% at 6 months. By 6 months, the study group has a much higher percentage of patients

with no problems (55.0%) compared to the control group (13.3%). Additionally, the control group has a higher percentage of patients with moderate problems (38.3%) compared to the study group (5.0%).

Figure (5): Illustrates the anxiety/depression dimension of the EQ-5D-5L for both the study group and the control group at three different time points: at assessment, at 3 months, and at 6 months. The data shows no statistical difference (P= 0.213) at initial assessment. Anxiety and depression reduced over time in the study group compared to the control group with a highly significant P value at 3 and 6 months (0.006, <0.001 respectively). Over time, the study group shows a significant increase in the percentage of patients reporting no problems with anxiety or depression, rising from 35.0% at assessment to 58.3% at 6 months. By the 6-month, there are no patients reporting moderate or severe problems. In the control group, the percentage of patients reporting no problems decreases from 41.7% at assessment to 18.3% at 6 months. There is a notable increase in the percentage of patients with moderate problems, rising from 30.0% at assessment to 38.3% at 6 months. By 6 months, the study group has a significantly higher percentage of patients with no problems (58.3%) compared to the control group (18.3%). The control group has higher percentages of patients with slight (43.3%) and moderate (38.3%) problems compared to the study group.

Table (6): Presents the results of the VAS for the EuroQol-5 dimension, comparing health assessments between the study group and the control group at three time points: initial assessment, 3 months, and 6 months. The initial assessment showed no significant difference (P= 0.066). At 3 months the study group showed an improvement with scores ranging from 55 to 90, whereas the control group scores remained between 50 and 80. The t-value was 5.218 with a p-value of <0.001, indicating a statistically significant difference between the two groups. At 6 months the study group scores ranged from 60 to 90, showing further improvement. The control group range remained unchanged at 50 to 80. The t-value was 7.200 with a p-value of <0.001, reinforcing the significant difference between the two groups. Over the six-month period, the study group consistently showed improvement in their health as measured by the VAS of the EuroQol-5 dimension, with statistically significant differences compared to the control group at both the 3-month and 6-month.

Correlations

- Significant positive correlations were found between duration on dialysis with mobility (r = 0.372, p = 0.003), self-care (r = 0.388, p = 0.002), and usual activities (r = 0.379, p = 0.003). These findings suggest that longer duration on dialysis is associated with better outcomes in terms of mobility, self-care, and usual activities.
- There was a significant negative correlation between serum PO4 with pain/discomfort (r = -0.307, p = 0.017). Similarly, a significant negative correlation was found with anxiety/depression (r = -0.338, p = 0.008). These results indicate that higher serum PO4 levels are associated with increased pain and discomfort, as well as heightened anxiety and depression.
- No significant correlations were found between medication use to reduce PO4 level and serum levels of Ca (r = -0.209, p = 0.110), PO4 (r = -0.121, p = 0.357), and PTH (r = 0.100, p = 0.903).

Discussion

End-stage renal disease and associated MBDs are recognized as common comorbidities in patients undergoing hemodialysis. The complex interplay between impaired kidney function, disturbed mineral metabolism, and skeletal abnormalities underscores the significance of addressing MBDs in this patient population. Understanding the management of these disorders is crucial for optimizing patient outcomes and quality of life in hemodialysis settings **(Ketteler et al., 2017)**.

The results of this study highlight the efficacy of the nurse-led educational intervention in empowering patients with ESRD to manage MBDs effectively. By providing tailored education and support, nurses play a critical role in improving patients' outcomes. The significant improvements observed in various outcome measures underscore the importance of integrating nurse-led educational intervention into routine care for patients with ESRD.

The age range of the studied patients was from twenty to fifty years old, as specified in the inclusion criteria of the current study. This age group was chosen because significant physiological changes in bone occur after the age of fifty, including decreased density, altered microarchitecture, and disruptions in the bone remodeling process. Understanding these changes is essential for preventing age-related bone disorders and associated complications in the context of this study.

From the researchers' perspective, aging beyond fifty years leads to significant physiological changes in bone that can impact overall skeletal health and increase the risk of bone disorders. One notable effect is decreased bone mineral density (BMD), which occurs due to imbalances in bone remodeling processes, including reduced osteoblastic activity and increased osteoclastic resorption. This decline in BMD contributes to osteoporosis and increases susceptibility to fractures. Additionally, alterations in bone microarchitecture occur, characterized by

changes in trabecular and cortical bone structure, which further compromise bone strength and integrity. Age-related hormonal changes, such as declining estrogen levels in women and testosterone levels in men, also play a role in bone loss. Furthermore, aging influences the responsiveness of bone to mechanical loading, leading to reduced adaptive capacity and impaired repair mechanisms. This viewpoint is supported by the literature review conducted by **Pignolo et al., (2021)**.

The findings of the current study indicate that there was no statistically significant difference observed between the studied groups with regard to thyroid and parathyroid diseases, and a lower percentage of these conditions was identified in both patient groups.

Thyroid and parathyroid dysfunction in patients with ESRD undergoing hemodialysis significantly contribute to the development of metabolic bone diseases such as renal osteodystrophy. Thyroid disorders, secondary hyperparathyroidism, and alterations in mineral metabolism collectively contribute to bone demineralization, osteoporosis, and other bone abnormalities **(Hou et al., 2018)**.

The findings of the current study indicate that there were no statistically significant differences observed between the studied groups at the time of assessment regarding clinical symptoms, including bone pain, muscle ache, weakness, fatigue, powerlessness, difficult with mobility, inability to carry out usual activities, numbness, tingling, and/or leg pain.

End-stage renal disease-MBDs encompass a group of bone disorders that arise from chronic renal disease and associated mineral and hormonal imbalances. Common signs and symptoms include bone pain, fractures, bone deformities, muscle weakness, joint stiffness, numbness, and tingling **(Eknoyan & Moe, 2022; Zhou & Yang, 2020)**.

From the researchers' perspective, the occurrence of these clinical manifestations in ESRD-MBDs can be explained by the underlying pathophysiology of chronic renal disease and its effects on mineral and hormonal balance. Chronic renal disease disrupts the balance of Ca, and PO4 metabolism, leading to alterations in bone structure and increased bone resorption, which can cause pain. Mineral imbalances and alterations in hormone levels affect muscle function. Elevated PTH levels contribute to muscle weakness and fatigue. Calcium deposits in joints and connective tissues contribute to reduced range of motion and joint discomfort. Abnormal levels of Ca and PO4 can affect nerve function, leading to sensations of numbness, tingling, or muscle cramps (termed uremic neuropathy).

The findings of the current study indicate that there were statistically significant differences observed between the studied groups during the follow-up period, particularly after 6 months, regarding clinical symptoms. These symptoms included bone pain, muscle aches, weakness, fatigue, lack of strength, difficult with mobility, inability to perform usual activities, numbness, tingling, and/or leg pain.

The study conducted by **Hosseini & ZiaeiRad, (2016)** corroborated the findings of the current study, which concluded that education, training and consultation through social networks can enhance the self-care knowledge of hemodialysis patients, consequently increasing self-efficacy levels. This improvement in self-efficacy plays a crucial role in reducing symptoms and complications.

Nutritional strategies are crucial in delaying or preventing the occurrence of MBDs commonly seen in ESRD. This involves careful management of dietary PO4 and Ca intake, along with optimizing vitamin D levels to support bone health and mineral metabolism **(Cupisti & Bolasco, 2016)**.

From the researchers' perspective, these outcomes could be attributed to the impact of a nurse-led educational intervention program aimed at reducing symptoms of MBDs among study group patients with ESRD. Through adherence to recommended knowledge, dietary practices and exercises, this intervention likely contributed to reduction of symptoms included bone pain, muscle aches, weakness, fatigue, lack of strength, difficult with mobility, inability to perform usual activities, numbness, tingling, and/or leg pain.

The findings of the current study indicate that there were no statistically significant differences observed between the studied groups at the time of assessment regarding laboratory investigations, including Ca, PO4, and PTH levels. Some patients experienced hypocalcemia, hyperphosphatemia, and/or hyperparathyroidism.

In this context, **Jat et al., (2016)** reported that ESRD-MBDs are characterized by alterations in serum levels of PTH, Ca, PO4, and vitamin D, which consequently impair bone turnover.

From the researchers' perspective, the decline in renal function is associated with PO4 retention, resulting in hypocalcemia and hyperphosphatemia, which further stimulates PTH secretion. This cascade leads to increased PO4 excretion and the development of secondary hyperparathyroidism in ESRD. The mechanism that counterbalances PO4 retention enhanced fibroblast growth factor production, which increases early in ESRD. This factor derived from osteocytes and osteoblasts, playing a role in direct bone-renal and bone-parathyroid interactions as vitamin D and PO4 metabolism, thus contributing to the development of ESRD-MBDs. This viewpoint is supported by the literature review conducted by **Waziri et al., (2019)**.

The findings of the current study indicate that there were statistically significant differences observed between the studied groups at the follow-up period regarding laboratory investigations. There were significant changes in Ca levels observed after 6 months, and in PO4 and PTH levels observed after 3 and 6 months. Patients in the study group demonstrated significant improvement compared to those in the control group.

Consistent with the findings of the current study, the study by **St-Jules et al., (2021)** highlighted that intensive dietary interventions aimed at reducing PO4 intake could be beneficial in decreasing PO4 retention and improving Ca-PO4 metabolism in patients undergoing hemodialysis. Patients who received additional education demonstrated positive changes, which could be advantageous in managing hyperphosphatemia.

From the researchers' perspective, these outcomes could be attributed to the impact of a nurse-led educational intervention program aimed at limiting the progression of MBDs among study group patients with ESRD. Through adherence to recommended knowledge and dietary practices aimed at lowering PO4 levels, this intervention likely contributed to improvements in laboratory values including Ca, PO4, and PTH levels.

The results of the current study indicate that there were no statistically significant differences observed between the studied groups at the time of assessment in terms of numeric pain rating scale mean scores, pain intensity, and pain characteristics. All patients experienced pain, the most frequently reported pain was bone and muscle pain.

Pain is a prevalent symptom frequently observed in patients with ESRD-MBDs. End stage renal disease-MBDs represent a painful syndrome with a multifaceted origin; one of its most prevalent complications is musculoskeletal pain. Bone pain was reported as the primary complaint among patients **(Dos Santos et al., 2021)**.

Continuing in the same line of inquiry, a study by **Pozo et al., (2017)** involving hemodialysis patients found that the prevalence of pain was notably high among the studied patients; sixty-nine of participants experiencing pain with musculoskeletal pain being the most frequent, primarily located in the lower limbs. More than half of the patients rated pain as severe.

From the researchers` perspective, ESRD-MBDs is a syndrome marked by disruptions in mineral and bone metabolism due to chronic renal disease. Musculoskeletal pain is a prevalent complication of ESRD-MBDs, likely stemming from these factors specifically bone pain is commonly reported by patients with ESRD-MBDs.

The findings of the current study indicate statistically significant differences between the studied groups at follow-up regarding numeric pain rating scale scores, pain intensity, and pain characteristics. Study group showed greater improvement in pain reduction than control group after implementation of a nurse-led educational intervention program.

Barriers to effective pain management in hemodialysis units include insufficient awareness of the issue, inadequate medical education, concerns about potential drug-related side effects, and common misconceptions about the inevitability of pain in these patients. The healthcare team working in hemodialysis units should recognize the importance of patient education in mitigating the potential impact of pain and identify strategies to empower patients in managing their pain **(Coluzzi, 2018)**.

Continuing in the same line of inquiry, a study conducted by **Bayati et al., (2019)** highlighted that education can empower patients by enhancing their knowledge and skills, resulting in improved disease management and better health outcomes.

From the researchers' perspective, these outcomes may be attributed to the effects of a nurse-led educational intervention program aimed at alleviating symptoms, including pain, among patients with ESRD. By promoting adherence to recommended knowledge, dietary practices, and exercise, this intervention likely contributed to a significant reduction in pain.

The study results initially showed no significant difference in the mean quality of life scores and overall health between the studied groups before implementation of a nurse-led educational intervention program.

Continuing in the same line of inquiry, studies by **Gebrie et al., (2023) & Dembowska et al., (2022)** have shown that despite ongoing advancements in treatment, patients with ESRD-MBDs undergoing hemodialysis often experience poor health-related quality of life. These individuals encounter various challenges associated with symptoms, treatment burdens, and psychosocial factors, all of which can significantly impact their overall well-being and daily functioning.

From the researchers' perspective, musculoskeletal system involvement remains a common morbidity which decreases the physical function of patients with ESRD. This viewpoint is supported by the literature review conducted by **Afifi et al., (2019)**.

The study results showed significant differences between the studied groups after implementation of a nurse-led educational intervention program at the time of follow-up in mean quality of life scores and overall health with obvious improvement in quality of life and overall health of study group patients.

Based on the findings of **Pooresmaeil et al., (2023)**, there was a significant improvement in patients' quality of life and overall health, progressing from unfavorable levels in the pre-intervention period to high levels by the end of the third month of the intervention. This suggests that a well-structured and planned educational intervention can effectively enhance the quality of life for patients undergoing hemodialysis.

From the researchers' perspective, the significant differences observed between the studied groups after implementing a nurse-led educational intervention program indicate its positive impact on improving the quality of life and overall health of patients in the study group. Dietary modifications, nutritional counseling, and monitoring are essential to address the unique needs and challenges associated with ESRD-MBDs. Additionally, educating patients on the importance of adhering to prescribed treatments and dialysis sessions, along with recommended exercises, plays a crucial role in enhancing quality of life and supporting overall health outcomes.

The study findings showed that significant positive correlations between duration on dialysis with mobility, self-care, and usual activities. Longer duration on dialysis is associated with better outcomes in terms of mobility, self-care, and usual activities.

Based on the findings of **So et al., (2023) & Noto et al., (2021)**, extended duration on dialysis enables patients to adapt more effectively and develop better management strategies, leading to significant enhancements in mobility, self-care, and usual activities. This period of adaptation and the consequent improvements highlight the critical importance of continuous support and personalized interventions for patients undergoing long-term dialysis. These tailored strategies not only improve the overall quality of life but also help patients maintain their functional abilities over time.

From the researchers' perspective, this could reflect patient adaptation over time, better management of their condition, and increased familiarity with the dialysis process, which together contribute to an improved quality of life.

The study findings showed a significant negative correlations between serum PO4 with pain/discomfort and anxiety/depression. These results indicate that higher serum PO4 levels are associated with increased pain and discomfort, as well as anxiety and depression.

Supporting this, a study by **Mosleh et al., (2020)** found that patients with higher PO4 levels reported greater levels of pain and discomfort, which can significantly impact their quality of life and psychological well-being. Additionally, **Jiang et al., (2023)** highlighted that patients undergoing hemodialysis frequently experience higher levels of anxiety and depression, partly influenced by fluctuations in their biochemical markers, including serum PO4.

From the researchers' perspective, the interplay between high serum PO4 levels and physical and health challenges can be understood through the physiological stress induced by PO4 toxicity, which potentially contributes to neuromuscular irritability and cardiovascular complications. This physiological burden, in turn, exacerbates psychological stress, leading to higher incidences of pain, anxiety and depression.

The findings of this study, indicating no significant correlations between PO4-lowering medication and serum levels of Ca, PO4, and PTH, suggest a limited impact of these medications on Ca and PTH homeostasis.

This result align with previous study of **Sekercioglu et al., (2017)**, which has shown that the influence of PO4 binders on Ca and PTH levels is often minimal and variable. Also, study of **Lim et al., (2018)** stated that education including PO4-lowering medication does not necessarily lead to improved serum PO4 levels. More effective education strategies and further research that consider the individual's healthcare needs within the context of their social environment may have a greater impact on serum PO4 levels.

From the researchers' perspective, these results might be due to the complex regulatory mechanisms of Ca and PTH in patients with ESRD undergoing hemodialysis, where multiple factors, including individual patient variations and the type of binder used, can affect the outcomes. Future research should continue to explore these dynamics to optimize treatment protocols for managing MBDs in patients with ESRD.

Limitations

The lack of randomization and the fact that the study was conducted exclusively on patients undergoing hemodialysis at Assiut University Hospitals in Assiut, Egypt, limit the generalizability of the results to all hemodialysis patients. Additionally, one of the limitations of the research is that we intended to monitor vitamin D and alkaline phosphatase levels, as they are crucial in identifying and managing MBDs. However, due to their high cost, these tests were not performed for patients.

Conclusion

A nurse-led educational intervention program represent valuable intervention in managing MBDs for patients with ESRD undergoing hemodialysis. It involves equipping patients with knowledge and skills, regular monitoring and follow-up to assess

patients' progress, address any concerns or questions they may have, and provide ongoing support. This personalized approach led to better outcomes, including reduced symptoms, limiting disease progression, and improved quality of life and overall health.

Recommendations

It is recommended that the impact of a nurse-led educational intervention program be further examined using a larger sample size and a longer follow-up period.

It is recommended to incorporate a nurse-led educational intervention program into the standard care plan for patients undergoing hemodialysis.

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