

Original Research Article

Prevalence, pattern, and determinants of musculoskeletal pain among maintenance hemodialysis patients: a cross-sectional analytical study

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ABSTRACT

Background: Musculoskeletal pain is common but frequently under-recognized among patients receiving maintenance hemodialysis (MHD). It may impair mobility, sleep, daily activities, functional independence, and participation in dialysis treatment. This study evaluated the prevalence, clinical pattern, functional impact, and determinants of musculoskeletal pain among adults receiving MHD.

Methods: This cross-sectional analytical study included 1,000 consecutive adults receiving MHD who attended the nephrology outpatient department of a tertiary care center between May 2021 and April 2026. Musculoskeletal pain was assessed during a single outpatient visit using an 11-point numerical rating scale and was characterized according to anatomical site, severity, duration, laterality, and functional impact. Demographic, clinical, dialysis-related, nutritional, and chronic kidney disease-mineral and bone disorder variables were compared between participants with and without pain. Independent factors associated with musculoskeletal pain were identified using multivariable logistic regression.

Results: Musculoskeletal pain was reported by 620 participants, corresponding to a prevalence of 62.0%. Moderate pain was most common (54.5%), followed by severe pain (26.5%) and mild pain (19.0%). The knee (54.2%), lower back (46.5%), and shoulder (32.9%) were the most frequently affected sites. Functional limitation and pain-related sleep disturbance were reported by 53.9% and 46.1% of affected participants, respectively. In multivariable analysis, older age ($p<0.001$), female sex ($p=0.041$), diabetes mellitus ($p=0.002$), longer dialysis vintage ($p<0.001$), higher serum phosphate ($p<0.001$), higher alkaline phosphatase ($p=0.001$), higher intact parathyroid hormone ($p<0.001$), and vitamin D deficiency ($p=0.001$) were independently associated with greater odds of musculoskeletal pain. Higher hemoglobin ($p=0.007$) and serum albumin ($p=0.003$) were independently associated with lower odds of pain.

Conclusions: Musculoskeletal pain affected nearly two-thirds of this MHD population and was frequently accompanied by functional limitation and sleep disturbance. Its independent associations with nutritional status, anemia, dialysis duration, and mineral-bone abnormalities suggest that structured pain assessment and targeted evaluation of potentially modifiable contributors should be incorporated into routine outpatient care of patients receiving maintenance hemodialysis.

Keywords: Chronic kidney disease-mineral and bone disorder, Functional limitation, Maintenance hemodialysis, Musculoskeletal pain, Pain prevalence, Quality of life

INTRODUCTION

Chronic kidney disease (CKD) is a major contributor to global morbidity and mortality, and patients with kidney

failure receiving maintenance hemodialysis (MHD) experience substantial physical symptom burden, impaired functional capacity, hospitalization, and reduced health-related quality of life.¹ Symptom surveys have shown that

pain, fatigue, sleep disturbance, pruritus, and psychological distress are common, severe, and frequently under-recognized during routine hemodialysis care.²

Pain is among the most prevalent and distressing symptoms in MHD. Early clinical studies found pain in approximately half of hemodialysis patients, often at moderate or severe intensity, with inconsistent assessment and treatment.³ Systematic reviews have subsequently demonstrated wide variation in reported prevalence because of differences in pain definitions, recall periods, study populations, and assessment tools.⁴ More recent pooled evidence suggests that chronic pain affects approximately 60% of patients receiving hemodialysis.⁵

Pain in dialysis populations may be musculoskeletal, neuropathic, ischemic, visceral, procedure-related, or attributable to comorbid disease.⁶ Musculoskeletal pain involving the back, knees, shoulders, hands, feet, muscles, and periarticular structures is particularly important because it can interfere with mobility, sleep, self-care, occupational activity, and dialysis attendance.⁷ Musculoskeletal symptoms and chronic pain have been associated with poorer physical functioning, psychological health, sleep, and overall quality of life.⁸⁻¹⁰

The pathogenesis is multifactorial. Ageing, diabetes mellitus, reduced physical activity, anemia, nutritional impairment, degenerative disease, and longer dialysis exposure may all contribute; clinical clustering of musculoskeletal disorders by age and dialysis vintage supports the importance of both patient-related and dialysis-associated factors.¹¹ CKD-mineral and bone disorder (CKD-MBD) provides an additional biological basis through abnormalities of calcium, phosphate, parathyroid hormone, vitamin D metabolism, bone turnover, mineralization, and soft-tissue calcification.¹² Renal osteodystrophy includes high-turnover bone disease, adynamic bone disease, osteomalacia, and mixed lesions, while secondary hyperparathyroidism can promote bone pain, cortical bone loss, fractures, and muscle weakness.^{13,14} Abnormal calcium, phosphate, parathyroid hormone, and alkaline phosphatase concentrations are also associated with adverse outcomes in dialysis populations.^{15,16} Dialysis-associated amyloidosis, periarticular calcification, destructive spondyloarthropathy, tendon disease, osteonecrosis, and infection may further contribute to musculoskeletal morbidity.¹⁷

Large outpatient studies describing the prevalence, anatomical distribution, functional consequences, and determinants of musculoskeletal pain among MHD patients receiving treatment at different dialysis facilities remain limited. This study therefore aimed to determine the prevalence, pattern, severity, and functional impact of musculoskeletal pain and to identify demographic, clinical, dialysis-related, nutritional, and CKD-MBD factors independently associated with its presence.

METHODS

Study design, setting, and participants

This cross-sectional analytical observational study was conducted in the nephrology outpatient department of a tertiary care center between May 2021 and April 2026. A total of 1,000 consecutive adults receiving MHD were evaluated during a single outpatient visit, irrespective of the center at which their regular dialysis was performed, and each participant was included once. Eligibility criteria were age 18 years or older, MHD for at least 3 months, clinical stability at assessment, and ability to provide reliable symptom information. Patients were excluded for acute systemic illness or active infection; hospitalization, major trauma, fracture, or orthopedic surgery during the preceding 3 months; known inflammatory rheumatological disease; active malignancy; severe cognitive or communication impairment; or incomplete clinical or laboratory data required for analysis.

Clinical and laboratory data collection

Demographic and clinical information was collected using a structured case-record form. Variables included age, sex, body mass index, primary kidney disease, diabetes mellitus, hypertension, cardiovascular disease, dialysis vintage, weekly dialysis frequency and duration, vascular access, dialysis adequacy, relevant medications, and history of fracture or musculoskeletal disease. Dialysis-related information was obtained from available dialysis cards, treatment records, prescriptions, laboratory reports, and patient interviews. The most recent predialysis laboratory values available within 4 weeks of the outpatient assessment were recorded, including hemoglobin, serum albumin, total calcium, phosphate, alkaline phosphatase, intact parathyroid hormone, 25-hydroxyvitamin D, and single-pool Kt/V. Corrected calcium was calculated as measured total calcium + $0.8 \times [4.0 - \text{serum albumin (gm/dl)}]$. Vitamin D deficiency was defined as a 25-hydroxyvitamin D concentration below 20 ng/ml.

Musculoskeletal pain assessment

Musculoskeletal pain was defined as pain arising from muscles, bones, joints, the spine, or periarticular structures that was present at assessment or had occurred recurrently during the preceding 3 months. Pain clearly attributable to acute trauma, recent surgery, active infection, or a non-musculoskeletal cause was excluded. A structured interviewer-administered questionnaire recorded pain presence, anatomical site, duration, frequency, laterality, functional consequences, analgesic use, and previous medical consultation. Assessed sites included the neck, shoulders, elbows, wrists or hands, upper and lower back, hips, knees, ankles or feet, and generalized musculoskeletal pain; more than one site could be reported. Intensity was measured using an 11-point numerical rating scale from 0 (no pain) to 10 (worst

imaginable pain) and classified as mild (1-3), moderate (4-6), or severe (7-10). For multisite pain, the highest score determined overall severity. Functional impact included interference with walking, standing, stair climbing, upper-limb activity, sleep, household or occupational activity, and attendance at scheduled dialysis sessions.

Outcomes and ethical considerations

The primary outcome was the prevalence of musculoskeletal pain. Secondary outcomes were its anatomical distribution, duration, severity, laterality, and functional impact and its associations with age, sex, comorbidities, dialysis vintage, hemoglobin, albumin, corrected calcium, phosphate, alkaline phosphatase, intact parathyroid hormone, vitamin D status, dialysis adequacy, and other relevant variables. The protocol was approved by the institutional ethics committee of the tertiary care center and was conducted in accordance with the ethical principles of the Declaration of Helsinki. Written informed consent was obtained from all participants. Confidentiality was maintained, and data were anonymized before analysis.

Statistical analysis

Statistical analysis was performed using IBM SPSS Statistics for Windows, version 26.0 (IBM Corp., Armonk, NY, USA). Distribution was assessed using histograms, quantile-quantile plots, and the Shapiro-Wilk test. Normally distributed continuous variables were summarized as mean±standard deviation, skewed variables as median with interquartile range, and categorical variables as number and percentage. Pain prevalence was reported with a Wilson 95% confidence

interval. Groups were compared using the independent-samples t test, Mann-Whitney U test, chi-square test, or Fisher exact test, as appropriate. Univariable logistic regression identified factors associated with pain; variables with $p < 0.10$ and clinically relevant covariates were entered into a multivariable model. Results were expressed as odds ratios (ORs) and adjusted ORs with 95% CIs. Multicollinearity was assessed using variance inflation factors. Calibration was evaluated by the Hosmer-Lemeshow test and discrimination by the area under the receiver operating characteristic curve. Complete-case analysis was used. All tests were two-sided, and $p < 0.05$ was considered statistically significant.

RESULTS

Study population and prevalence of musculoskeletal pain

A total of 1,000 adults receiving maintenance hemodialysis were included in the analysis. Musculoskeletal pain was reported by 620 participants, corresponding to an overall prevalence of 62.0% [95% confidence interval (CI), 59.0-65.0%]. The remaining 380 participants (38.0%) did not report musculoskeletal pain.

Participants with musculoskeletal pain were significantly older than those without pain (56.8 ± 11.9 versus 52.7 ± 12.4 years; $p < 0.001$). Women represented a greater proportion of the pain group, as reflected by the lower proportion of men among participants with pain compared with those without pain (59.4% versus 65.8%; $p = 0.043$). Diabetes mellitus was also more common among participants with musculoskeletal pain (43.9% versus 33.7%; $p = 0.001$). In contrast, the prevalence of hypertension was similar between the two groups (83.9% versus 81.3%; $p = 0.296$).

Table 1: Clinical and laboratory characteristics according to the presence of musculoskeletal pain.

Variables	Musculoskeletal pain (n=620)	No musculoskeletal pain (n=380)	P value
Age, years	56.8±11.9	52.7±12.4	<0.001
Male sex	368 (59.4)	250 (65.8)	0.043
Body mass index, kg/m ²	23.5±3.8	23.1±3.5	0.112
Diabetes mellitus	272 (43.9)	128 (33.7)	0.001
Hypertension	520 (83.9)	309 (81.3)	0.296
Dialysis vintage, months	38 (22-64)	28 (16-48)	<0.001
Hemoglobin, gm/dl	9.8±1.3	10.3±1.4	<0.001
Serum albumin, gm/dl	3.62±0.43	3.81±0.39	<0.001
Corrected calcium, mg/dl	8.72±0.71	8.88±0.66	0.001
Serum phosphate, mg/dl	5.84±1.42	5.29±1.31	<0.001
Alkaline phosphatase, U/l	165 (118-235)	138 (101-194)	<0.001
Intact parathyroid hormone, pg/ml	448 (281-692)	338 (214-515)	<0.001
25-hydroxyvitamin D, ng/ml	18.4±7.6	22.1±8.2	<0.001
Single-pool Kt/V	1.34±0.19	1.36±0.18	0.154

Data are presented as mean±standard deviation, median (interquartile range), or number (percentage), as appropriate. Comparisons used the independent-samples t test, Mann-Whitney U test, chi-square test, or Fisher exact test. All tests were two-sided.

Participants with pain had a significantly longer dialysis vintage, with a median duration of 38 months [interquartile range (IQR), 22-64 months], compared with 28 months (IQR, 16-48 months) among participants without pain ($p<0.001$). Mean body mass index did not differ significantly between the groups (23.5 ± 3.8 versus 23.1 ± 3.5 kg/m²; $p=0.112$). Dialysis adequacy was also comparable, with mean single-pool Kt/V values of 1.34 ± 0.19 in the pain group and 1.36 ± 0.18 in the no-pain group ($p=0.154$).

Several hematological, nutritional, and mineral-bone parameters differed significantly according to pain status. Participants with musculoskeletal pain had lower mean hemoglobin concentrations than those without pain (9.8 ± 1.3 versus 10.3 ± 1.4 gm/dl; $p<0.001$) and lower serum albumin levels (3.62 ± 0.43 versus 3.81 ± 0.39 gm/dl; $p<0.001$). Corrected serum calcium was also lower in the pain group (8.72 ± 0.71 versus 8.88 ± 0.66 mg/dl; $p=0.001$).

In contrast, serum phosphate was significantly higher among participants with pain (5.84 ± 1.42 versus 5.29 ± 1.31 mg/dl; $p<0.001$). Median alkaline phosphatase was 165 U/L (IQR, 118-235 U/L) in the pain group compared with 138 U/L (IQR, 101-194 U/L) in the no-pain group ($p<0.001$). Median intact parathyroid hormone was similarly higher among participants with pain [448 pg/ml (IQR, 281-692 pg/ml) versus 338 pg/mL (IQR, 214-515 pg/ml); $p<0.001$]. Mean 25-hydroxyvitamin D concentration was significantly lower in participants with musculoskeletal pain than in those without pain (18.4 ± 7.6 versus 22.1 ± 8.2 ng/ml; $p<0.001$). These between-group findings are summarized in Table 1.

Pattern, severity, and functional impact of musculoskeletal pain

Among the 620 participants who reported musculoskeletal pain, the median duration of symptoms was 18 months [interquartile range (IQR), 8-36 months], indicating that pain was generally persistent rather than transient. The mean numerical rating scale score was 5.9 ± 1.8 , corresponding to an overall moderate level of pain intensity.

Moderate pain was the most common severity category, affecting 338 participants (54.5%). Severe pain was reported by 164 participants (26.5%), while 118 (19.0%) experienced mild pain. Thus, more than four-fifths of affected participants reported moderate-to-severe musculoskeletal pain.

The knee was the most frequently affected anatomical site, reported by 336 participants (54.2%), followed by the lower back in 288 (46.5%) and the shoulder in 204 (32.9%). Ankle or foot pain was present in 142 participants (22.9%), wrist or hand pain in 118 (19.0%), hip pain in 98 (15.8%), generalized musculoskeletal pain in 96 (15.5%), and neck pain in 86 (13.9%). Participants could report pain at more than one anatomical site; therefore, the site-

specific percentages were not mutually exclusive and did not total 100%.

Table 2: Pattern, severity, and functional impact of musculoskeletal pain among affected patients.

Characteristics	Value
Pain duration, months	18 (8-36)
Numerical rating scale score	5.9 ± 1.8
Mild pain	118 (19.0)
Moderate pain	338 (54.5)
Severe pain	164 (26.5)
Knee pain	336 (54.2)
Lower-back pain	288 (46.5)
Shoulder pain	204 (32.9)
Ankle or foot pain	142 (22.9)
Wrist or hand pain	118 (19.0)
Hip pain	98 (15.8)
Neck pain	86 (13.9)
Generalized pain	96 (15.5)
Bilateral pain	392 (63.2)
Functional limitation	334 (53.9)
Sleep disturbance due to pain	286 (46.1)
Regular analgesic use	241 (38.9)

Data are mean $\pm$ standard deviation, median (interquartile range), or number (percentage). Percentages use 620 affected participants as the denominator. Pain was mild at scores 1-3, moderate at 4-6, and severe at 7-10. Multiple anatomical sites could be reported; site percentages therefore do not total 100%.

Bilateral pain was reported by 392 participants (63.2%), suggesting that symptoms commonly involved both sides of the body rather than a single localized region. Functional limitation attributable to pain was present in 334 participants (53.9%), indicating interference with activities such as walking, standing, climbing stairs, upper-limb use, household work, or occupational activities. Pain-related sleep disturbance was reported by 286 participants (46.1%), while 241 (38.9%) reported regular analgesic use. The detailed distribution, severity, laterality, and functional consequences of musculoskeletal pain are presented in Table 2.

Factors associated with musculoskeletal pain

In univariable logistic regression analysis, older age, female sex, diabetes mellitus, longer dialysis vintage, lower hemoglobin, lower serum albumin, higher serum phosphate, higher alkaline phosphatase, higher intact parathyroid hormone, and vitamin D deficiency were significantly associated with musculoskeletal pain. All clinically relevant variables and variables with $p<0.10$ in univariable analysis were entered into the multivariable logistic regression model.

After adjustment for potential confounders, increasing age remained independently associated with musculoskeletal pain. Each 10-year increase in age was associated with

28% higher odds of pain [adjusted odds ratio (aOR), 1.28; 95% confidence interval (CI), 1.12-1.46; $p<0.001$]. Female participants had 34% higher adjusted odds of musculoskeletal pain than male participants (aOR, 1.34; 95% CI, 1.01-1.79; $p=0.041$). Diabetes mellitus was also independently associated with pain, with affected participants having 58% higher odds than those without diabetes (aOR, 1.58; 95% CI, 1.19-2.09; $p=0.002$).

Longer dialysis exposure remained a significant predictor after adjustment. Each additional year of dialysis vintage was associated with a 9% increase in the odds of musculoskeletal pain (aOR, 1.09; 95% CI, 1.04-1.14; $p<0.001$). Higher serum phosphate was similarly associated with greater pain risk, with a 19% increase in the adjusted odds for every 1-mg/dL increase in phosphate concentration (aOR, 1.19; 95% CI, 1.08-1.32; $p<0.001$).

Markers of increased bone turnover were also independently associated with musculoskeletal pain. For every 50-U/l increase in alkaline phosphatase, the odds of pain increased by 16% (aOR, 1.16; 95% CI, 1.06-1.27; $p=0.001$). Each 100 pg/ml increase in intact parathyroid

hormone was associated with a 7% increase in the odds of pain (aOR, 1.07; 95% CI, 1.03-1.11; $p<0.001$). Participants with vitamin D deficiency had 63% higher adjusted odds of musculoskeletal pain than those without deficiency (aOR, 1.63; 95% CI, 1.22-2.18; $p=0.001$).

In contrast, higher hemoglobin and serum albumin were independently associated with lower odds of pain. Each 1-gm/dl increase in hemoglobin was associated with a 16% reduction in the adjusted odds of musculoskeletal pain (aOR, 0.84; 95% CI, 0.74-0.95; $p=0.007$). Similarly, each 1 gm/dl increase in serum albumin was associated with a 44% reduction in the odds of pain (aOR, 0.56; 95% CI, 0.38-0.82; $p=0.003$).

No clinically important multicollinearity was identified among the variables entered into the final model. The Hosmer-Lemeshow goodness-of-fit test indicated acceptable model calibration ($p=0.47$). The model also demonstrated acceptable discriminatory ability, with an area under the receiver operating characteristic curve of 0.76 (95% CI, 0.73-0.79). The unadjusted and adjusted associations are presented in Table 3.

Table 3: Logistic regression analysis of factors associated with musculoskeletal pain.

Variables	Unadjusted OR (95% CI)	Adjusted OR (95% CI)	P value
Age, per 10-year increase	1.34 (1.19-1.51)	1.28 (1.12-1.46)	<0.001
Female sex	1.32 (1.01-1.72)	1.34 (1.01-1.79)	0.041
Diabetes mellitus	1.54 (1.18-2.01)	1.58 (1.19-2.09)	0.002
Dialysis vintage, per 1-year increase	1.12 (1.07-1.17)	1.09 (1.04-1.14)	<0.001
Hemoglobin, per 1 gm/dl increase	0.80 (0.72-0.89)	0.84 (0.74-0.95)	0.007
Serum albumin, per 1 gm/dl increase	0.45 (0.32-0.64)	0.56 (0.38-0.82)	0.003
Serum phosphate, per 1 mg/dl increase	1.23 (1.13-1.34)	1.19 (1.08-1.32)	<0.001
Alkaline phosphatase, per 50 U/l increase	1.19 (1.10-1.29)	1.16 (1.06-1.27)	0.001
Intact parathyroid hormone, per 100 pg/ml increase	1.09 (1.05-1.13)	1.07 (1.03-1.11)	<0.001
Vitamin D deficiency	1.76 (1.35-2.29)	1.63 (1.22-2.18)	0.001

Musculoskeletal pain was the dependent variable. Variables with $P<0.10$ in univariable analysis and clinically relevant covariates entered the multivariable model. OR, odds ratio; CI, confidence interval.

DISCUSSION

In this large OPD-based cross-sectional study, musculoskeletal pain affected 62.0% of adults receiving MHD. Moderate pain predominated, the knee, lower back, and shoulder were the most frequent sites, and more than half of affected patients reported functional limitation. Older age, female sex, diabetes, longer dialysis vintage, hyperphosphatemia, higher alkaline phosphatase and parathyroid hormone, and vitamin D deficiency were independently associated with pain, whereas higher hemoglobin and albumin were associated with lower odds. These findings support a multifactorial model linking comorbidity, dialysis exposure, nutrition, and CKD-MBD to musculoskeletal symptom burden.

The observed prevalence is consistent with pooled estimates indicating chronic pain in approximately 60% of

hemodialysis patients, although published estimates vary widely because studies differ in pain definitions, recall periods, inclusion of non-musculoskeletal pain, and assessment methods.^{4,5} Targeted clinical evaluation may reveal abnormalities that routine questioning misses. Ultrasonographic studies have demonstrated frequent enthesal abnormalities in hemodialysis patients, while structured pain surveys show marked variation in location, intensity, duration, and analgesic use.^{18,19}

International studies also demonstrate that pain is closely linked to patient-centered outcomes. Multicenter data from China and Palestine associated chronic pain with poorer physical and psychological quality of life, and studies from Tunisia and Egypt described substantial effects on daily activity, fatigue, sleep, emotional health, and social functioning.²⁰⁻²³ The high rates of functional limitation and sleep disturbance in the present dataset are therefore

clinically important and suggest that pain assessment should extend beyond a single intensity score.

The predominance of knee and lower-back pain likely reflects a combination of degenerative joint and spinal disease, altered gait, muscle weakness, inactivity, diabetes, and CKD-MBD. Shoulder, wrist, and hand symptoms may also be related to rotator-cuff disease, adhesive capsulitis, carpal tunnel syndrome, vascular-access biomechanics, and dialysis-related amyloidosis. Long-term hemodialysis cohorts have documented amyloid-associated shoulder pain, bone cysts, carpal tunnel syndrome, and destructive arthropathy, and dialysis-related amyloidosis preferentially affects osteoarticular and periarticular tissues.^{24,25}

The independent association with dialysis vintage is biologically plausible because longer exposure may reflect cumulative CKD-MBD, inflammation, deconditioning, repeated procedures, degenerative change, and beta-2 microglobulin retention. Nevertheless, dialysis vintage cannot be interpreted as proof of amyloidosis. A retrospective administrative study reported a lower coded incidence of chronic musculoskeletal pain among dialysis-treated patients than among matched controls, illustrating how diagnostic coding, competing illness, and under-recognition can produce results that differ from direct symptom surveys.²⁶

The associations with phosphate, alkaline phosphatase, parathyroid hormone, and vitamin D deficiency support a possible contribution from mineral-bone abnormalities. Persistent phosphate retention and secondary hyperparathyroidism can increase bone turnover and cortical loss, whereas over-suppression of parathyroid hormone can produce adynamic bone disease.¹²⁻¹⁶ However, cross-sectional biochemical associations cannot establish that CKD-MBD caused the reported pain. Total alkaline phosphatase may have hepatic as well as skeletal sources, and vitamin D deficiency may reflect limited sunlight exposure, poor nutrition, reduced physical activity, or illness. Similarly, low albumin and hemoglobin may indicate inflammation, malnutrition, volume disturbance, anemia-related fatigue, or greater overall disease burden.

Age, sex, and diabetes should be interpreted as markers of overlapping biological and social pathways. Ageing is associated with osteoarthritis, sarcopenia, spinal degeneration, and frailty. Women may have different bone health, body composition, pain perception, occupational exposure, and healthcare-seeking behavior. Diabetes may contribute through neuropathy, limited joint mobility, adhesive capsulitis, vascular disease, and muscle dysfunction. Residual confounding is therefore likely despite multivariable adjustment.

The numerical rating scale is practical and has established measurement properties for adult pain assessment, but intensity alone does not capture frequency, duration,

neuropathic features, emotional consequences, or interference with daily life.²⁷ Patient-centered dialysis care increasingly prioritizes symptoms, functioning, and quality of life.²⁸ Poorer health-related quality of life predicts hospitalization and mortality, pain interacts with insomnia and daytime sleepiness, and nutritional impairment, depression, and sleep disorders frequently coexist.²⁹⁻³¹ Reduced muscle strength is also prognostically important in hemodialysis populations.³²

These observations support routine structured screening during outpatient reviews. Assessment should include location, intensity, duration, sleep effects, functional interference, analgesic use, and red flags for infection, fracture, ischemia, neurological compromise, severe hyperparathyroid bone disease, calcific periarthritis, or amyloidosis. Management should address reversible contributors and prioritize non-pharmacological and non-opioid strategies when appropriate, with careful consideration of renal clearance, dialyzability, drug interactions, and active metabolite accumulation.^{33,34} Opioids require particular caution because exposure in hemodialysis patients has been associated with altered mental status, falls, and fractures.³⁵

Exercise and rehabilitation may improve physical function and quality of life, although protocols and certainty of evidence vary across studies.^{36,37} Individualized physiotherapy, graded activity, strengthening, sleep management, nutritional review, and optimization of CKD-MBD may therefore be useful components of multidisciplinary care. The standardised outcomes in nephrology-hemodialysis initiative has emphasized outcomes that matter directly to patients, supporting inclusion of pain, function, and life participation in future dialysis research.³⁸

Strengths of this study include the large sample, inclusion of patients receiving dialysis at different centers, standardized pain characterization, and simultaneous evaluation of clinical, nutritional, dialysis-related, and CKD-MBD factors. Limitations include the cross-sectional design, which prevents causal inference; possible referral and selection bias from a tertiary-care OPD population; self-reported pain and functional effects; variation in laboratory assays and timing across dialysis facilities; absence of imaging, bone density, neuropathic pain testing, depression assessment, physical-activity measurement, dialysis membrane data, and beta-2 microglobulin; and possible residual confounding and chance findings from multiple comparisons

CONCLUSION

Musculoskeletal pain was common among adults receiving maintenance hemodialysis and was frequently accompanied by functional limitation and sleep disturbance. Its associations with demographic factors, diabetes, dialysis vintage, anemia, hypoalbuminemia, and CKD-MBD markers indicate a multifactorial clinical

problem rather than an isolated symptom. Routine structured screening and targeted correction of modifiable contributors may improve recognition and support more individualized symptom management. Longitudinal studies are required to determine causality and evaluate whether multidisciplinary interventions improve pain, physical function, and quality of life.

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