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Original Article

Association Between Vitamin D Deficiency and Chronic Musculoskeletal Pain in Physiotherapy Patients

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ABSTRACT\

Background: Vitamin D deficiency may coexist with chronic musculoskeletal pain and functional impairment, but evidence from physiotherapy populations remains limited. Objective: To estimate the prevalence of vitamin D deficiency and examine its associations with pain severity and functional disability among adults attending outpatient physiotherapy. Methods: This cross-sectional study included 85 adults aged 18–60 years with musculoskeletal pain lasting more than 12 weeks. Serum 25-hydroxyvitamin D [25(OH)D] was classified as deficient, insufficient, or sufficient. Pain was assessed using the Visual Analog Scale, while disability was evaluated using the Oswestry Disability Index or WOMAC and converted to normalized percentages. Pearson correlation and one-way analysis of variance were used. Results: Vitamin D deficiency was present in 53 participants (62.4%), insufficiency in 19 (22.4%), and sufficiency in 13 (15.3%). Serum 25(OH)D was inversely correlated with pain ($r = -0.68$; $p < 0.001$) and disability ($r = -0.62$; $p < 0.001$). Mean pain scores were 7.1 ± 1.4, 5.8 ± 1.5, and 4.3 ± 1.6 across deficient, insufficient, and sufficient groups, respectively ($p < 0.001$). Corresponding disability scores were 47.6% ± 11.8%, 38.2% ± 12.5%, and 28.4% ± 13.2% ($p < 0.001$). Conclusion: Lower vitamin D status was associated with greater pain and disability, although causal relationships could not be established. Keywords: 25-Hydroxyvitamin D; Chronic Musculoskeletal Pain; Cross-Sectional Studies; Functional Disability; Hypovitaminosis D; Physiotherapy; Visual Analog Scale.

INTRODUCTION

Chronic musculoskeletal pain is a common cause of persistent discomfort, activity limitation, reduced work capacity, and impaired quality of life. It is generally defined as pain arising from musculoskeletal structures that persists or recurs for longer than three months. Patients with chronic musculoskeletal pain constitute an important proportion of those attending physiotherapy services and may continue to experience pain and functional limitations despite exercise therapy, manual therapy, education, and other conventional rehabilitation interventions. Persistent symptoms may reflect the interaction of mechanical, psychological, behavioural, inflammatory, and metabolic factors rather than structural pathology alone (1,2).

Vitamin D is a secosteroid hormone that contributes to calcium and phosphate regulation, bone mineralization, skeletal muscle function, immune modulation, and several neurological processes. Vitamin D receptors are expressed in skeletal muscle and neural tissues, providing biological plausibility for an association between vitamin D status and musculoskeletal symptoms. Deficiency may contribute

to osteomalacic pain, proximal muscle weakness, altered inflammatory activity, and reduced physical performance. Several observational studies have consequently examined whether reduced serum 25-hydroxyvitamin D [25(OH)D] concentrations are associated with chronic musculoskeletal pain and disability (3,6).

Evidence regarding this relationship has remained inconsistent. Some studies have reported a greater prevalence of vitamin D deficiency among patients with musculoskeletal disorders and inverse associations between serum 25(OH)D concentrations and pain-related outcomes (6,9). Conversely, other investigations have not established a consistent relationship after accounting for demographic, clinical, behavioural, and environmental factors. Interpretation is further complicated by the possibility of reverse causation because patients with severe pain and mobility limitations may spend less time outdoors and consequently receive less sunlight exposure. Vitamin D status may therefore function as a contributing factor, a consequence of reduced mobility, or a marker of other health and lifestyle characteristics.

Patients presenting to physiotherapy clinics represent a clinically relevant but heterogeneous population. Their vitamin D status may be influenced by age, sex, occupational environment, sunlight exposure, physical activity, diet, body composition, medication use, and coexisting medical conditions. At the same time, their pain severity and functional disability may vary according to the anatomical region involved, underlying diagnosis, pain duration, and degree of activity restriction. Evaluating these variables within a physiotherapy setting may help clarify the burden of hypovitaminosis D and generate evidence for more comprehensive clinical assessment; however, observational findings alone cannot establish that vitamin D deficiency causes pain or that supplementation improves rehabilitation outcomes.

This study therefore aimed to estimate the prevalence of vitamin D deficiency among adults attending an outpatient physiotherapy clinic with chronic musculoskeletal pain and to examine the associations of serum 25(OH)D concentrations with pain severity and functional disability. The study also described the distribution of vitamin D status according to the recorded demographic, occupational, and sunlight-exposure characteristics of the participants.

MATERIALS AND METHODS

A cross-sectional study was conducted at a specialized outpatient physiotherapy clinic in an industrial and urban region of Punjab, Pakistan, from October to December 2025. Adult patients presenting to the clinic with chronic musculoskeletal pain were screened for eligibility. The study was conducted after institutional ethical approval had been obtained. All participants received information about the study and provided written informed consent before enrolment. Participant information was handled confidentially, and the study procedures were conducted in accordance with accepted ethical principles for research involving human participants.

Patients aged 18–60 years with a primary complaint of musculoskeletal pain persisting for more than 12 weeks were eligible to participate. Individuals with diagnosed inflammatory arthropathies, advanced hepatic or renal impairment, metabolic bone disease, primary hyperparathyroidism, current vitamin D supplementation, or oral corticosteroid use were excluded to reduce the influence of major conditions and treatments known to affect pain or vitamin D metabolism. A total of 85 eligible patients completed the clinical assessment and serum vitamin D testing during the study period.

Demographic and exposure-related information was collected at enrolment. The recorded variables included age, sex, occupational environment, and average daily sunlight exposure. Occupational environment was categorized as sedentary or predominantly indoor and active or predominantly outdoor. Daily sunlight exposure was classified as less than 15 minutes, 15–30 minutes, or more than 30

minutes. These variables were treated as descriptive participant characteristics rather than independent evidence of causal risk.

Pain severity was assessed using the Visual Analog Scale. Participants rated the intensity of their musculoskeletal pain experienced during the preceding week, with higher scores indicating greater pain severity. Functional disability was assessed according to the principal anatomical region of the presenting complaint. The Oswestry Disability Index was administered to participants with spinal pain, whereas the Western Ontario and McMaster Universities Osteoarthritis Index was used for participants with lower-limb joint pain. Because the instruments have different scoring structures, the obtained scores were converted to percentages of their respective total possible scores, with higher percentages representing greater functional disability. These percentage scores were used to summarize disability within each instrument group and to generate the normalized disability variable used in the reported association analyses. The instrument-specific results were retained separately to preserve the distinction between the clinical populations assessed with the two measures.

Venous blood samples were obtained by trained personnel for measurement of serum 25(OH)D concentration. Vitamin D status was classified as deficient when the serum concentration was below 20 ng/mL, insufficient at 20–29 ng/mL, and sufficient at 30 ng/mL or higher. Serum 25(OH)D was examined both as a continuous variable and according to these three clinical categories.

Data were analysed using IBM SPSS Statistics version 26.0. Continuous variables were summarized using means and standard deviations, while categorical variables were presented as frequencies and percentages. The distribution of continuous variables was evaluated using the Shapiro–Wilk test before parametric analyses were undertaken. Pearson correlation coefficients were calculated to examine the direction and strength of the relationships between serum 25(OH)D concentration, pain severity, and normalized functional disability. Differences in pain and disability scores across the deficient, insufficient, and sufficient vitamin D groups were evaluated using one-way analysis of variance. Independent-samples t tests were used for reported two-group comparisons where applicable. Statistical tests were two-tailed, and a p-value below 0.05 was considered statistically significant. Analyses were based on participants with complete clinical and biochemical measurements.

RESULTS

Higher scores indicate greater pain or functional disability. ODI and WOMAC scores were converted to percentages of their respective total possible scores. ODI, Oswestry Disability Index; SD, standard deviation; WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index.

Positive values indicate higher pain or disability in the vitamin D-deficient group. Mean differences, confidence intervals, p-values, and Hedges' g were derived from the reported group sizes, means, and standard deviations using unequal-variance comparisons. These derived estimates should be verified against participant-level data before final publication.

Table 1. Demographic, Exposure-Related, and Vitamin D Characteristics of Participants (N = 85)

Characteristic	Category	n (%) or Mean ± SD
Age, years	—	41.6 ± 11.2
Age group, years	18–35	28 (32.9)
	36–50	39 (45.9)
	51–60	18 (21.2)
Sex	Male	35 (41.2)
	Female	50 (58.8)
Occupational environment	Sedentary or predominantly indoor	58 (68.2)
	Active or predominantly outdoor	27 (31.8)
Average daily sunlight exposure	<15 minutes	51 (60.0)
	15–30 minutes	21 (24.7)
	>30 minutes	13 (15.3)

Characteristic	Category	n (%) or Mean ± SD
Vitamin D status	Deficient, <20 ng/mL	53 (62.4)
	Insufficient, 20–29 ng/mL	19 (22.4)
	Sufficient, ≥30 ng/mL	13 (15.3)

Table 2. Prevalence of Vitamin D Status Among Participants (N = 85)

Vitamin D status	n	Prevalence, %	95% CI
Deficient, <20 ng/mL	53	62.4	51.7–71.9
Insufficient, 20–29 ng/mL	19	22.4	14.8–32.3
Sufficient, ≥30 ng/mL	13	15.3	9.2–24.4

Confidence intervals were derived using the Wilson method. CI, confidence interval.

Table 3. Pain and Functional Disability Outcomes

Outcome measure	n	Observed range	Mean ± SD
Visual Analog Scale score	85	3.0–9.5	6.4 ± 1.8
Oswestry Disability Index, %	52	20.0–68.0	44.2 ± 13.1
WOMAC score, %	33	15.0–72.0	38.8 ± 15.9
Normalized functional disability, %	85	15.0–72.0	42.1 ± 14.5

Table 4. Correlations Between Serum 25(OH)D, Pain, and Functional Disability (N = 85)

Variable pair	Pearson r	95% CI	p-value
Serum 25(OH)D and VAS pain score	−0.68	−0.78 to −0.55	<0.001
Serum 25(OH)D and normalized disability	−0.62	−0.74 to −0.47	<0.001
VAS pain score and normalized disability	0.71	0.59 to 0.80	<0.001

Confidence intervals for correlation coefficients were derived using Fisher's z transformation. 25(OH)D, 25-hydroxyvitamin D; CI, confidence interval; VAS, Visual Analog Scale.

Table 5. Pain and Functional Disability According to Vitamin D Status

Outcome	Deficient, <20 ng/mL (n = 53)	Insufficient, 20–29 ng/mL (n = 19)	Sufficient, ≥30 ng/mL (n = 13)	F (df = 2, 82)	p-value	η^2
VAS pain score	7.1 ± 1.4	5.8 ± 1.5	4.3 ± 1.6	21.34	<0.001	0.34
Normalized disability, %	47.6 ± 11.8	38.2 ± 12.5	28.4 ± 13.2	14.57	<0.001	0.26

Values are mean ± standard deviation. F statistics and η^2 values were recalculated from the reported group sizes, means, and standard deviations. η^2 represents the proportion of total variation associated with vitamin D status. VAS, Visual Analog Scale.

Table 6. Deficient Versus Sufficient Vitamin D Groups: Derived Mean Differences

Outcome	Mean difference	95% CI	p-value	Hedges' g
VAS pain score	2.80	1.78–3.82	<0.001	1.92
Normalized disability, percentage points	19.20	10.75–27.65	<0.001	1.57

Of the 92 patients screened during the study period, 85 met the eligibility criteria and completed the clinical and biochemical assessments, corresponding to 92.4% of those screened. The seven patients who did not enter the final analysis were excluded before completion of data collection. The analysed participants had a mean age of 41.6 ± 11.2 years; 50 (58.8%) were female and 35 (41.2%) were male. Most participants worked in sedentary or predominantly indoor environments (68.2%), and 60.0% reported less than 15 minutes of average daily sunlight exposure.

Vitamin D deficiency was identified in 53 participants, corresponding to a prevalence of 62.4% (95% CI, 51.7%–71.9%). A further 19 participants were vitamin D insufficient, representing 22.4% (95% CI, 14.8%–32.3%), whereas only 13 participants had sufficient vitamin D concentrations, representing 15.3% (95% CI, 9.2%–24.4%). Thus, 72 of 85 participants (84.7%) had serum 25(OH)D concentrations below 30 ng/mL.

The mean VAS pain score in the total sample was 6.4 ± 1.8. Among the 52 participants assessed using the ODI, the mean disability score was 44.2% ± 13.1%. The 33 participants assessed using WOMAC had

a mean score of 38.8% ± 15.9%. After conversion of both instrument scores to percentages of their respective total possible scores, the mean normalized functional disability score for the entire sample was 42.1% ± 14.5%.

Serum 25(OH)D concentration was strongly and inversely correlated with pain severity ($r = -0.68$; 95% CI, −0.78 to −0.55; $p < 0.001$). A similarly strong inverse association was observed between serum 25(OH)D and normalized functional disability ($r = -0.62$; 95% CI, −0.74 to −0.47; $p < 0.001$). Pain severity was positively correlated with functional disability ($r = 0.71$; 95% CI, 0.59–0.80; $p < 0.001$), indicating that participants reporting greater pain also tended to report greater activity limitation.

Pain scores differed significantly across the deficient, insufficient, and sufficient vitamin D categories ($F[2,82] = 21.34$; $p < 0.001$; $\eta^2 = 0.34$). Mean VAS scores decreased across the three categories from 7.1 ± 1.4 in the deficient group to 5.8 ± 1.5 in the insufficient group and 4.3 ± 1.6 in the sufficient group. Vitamin D status accounted for approximately 34% of the observed variation in pain scores within the unadjusted group comparison. Normalized functional disability also differed across vitamin D categories ($F[2,82] = 14.57$; $p < 0.001$; $\eta^2 = 0.26$). Mean disability was highest in the deficient group at 47.6% ± 11.8%, followed by 38.2% ± 12.5% in the insufficient group and 28.4% ± 13.2% in the sufficient group. The unadjusted association between vitamin D category and disability accounted for approximately 26% of the total variation in normalized disability scores. In the direct comparison of the deficient and sufficient groups, participants with vitamin D deficiency had a mean VAS score 2.80 points higher (95% CI, 1.78–3.82; $p < 0.001$; Hedges' $g = 1.92$). Their normalized disability score was also 19.20 percentage points higher (95% CI, 10.75–27.65; $p < 0.001$; Hedges' $g = 1.57$). These findings represented large unadjusted between-group differences; however, they did not account for potential differences in age, sex, diagnosis, pain duration, occupational environment, sunlight exposure, or other confounding variables.

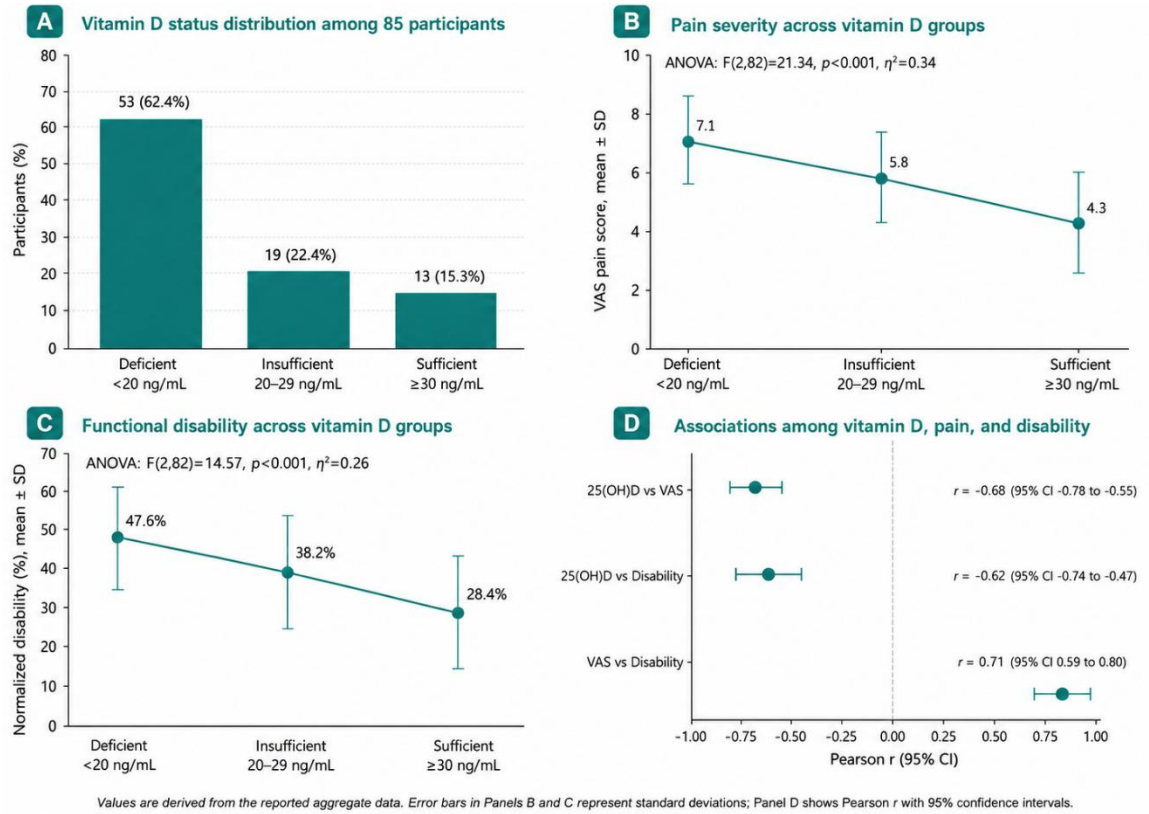

Figure 1. Vitamin D status, pain severity, and functional disability among physiotherapy patients with chronic musculoskeletal pain. Panel A presents the distribution of vitamin D status among the 85 participants. Panels B and C show mean pain severity and normalized functional disability, respectively, across deficient, insufficient, and sufficient vitamin D groups; error bars represent standard deviations. Panel D presents Pearson correlation coefficients with 95% confidence intervals for the relationships among serum 25-hydroxyvitamin D [25(OH)D], Visual Analog Scale pain scores, and normalized functional disability. ANOVA statistics and effect-size estimates were recalculated from the reported group sizes, means, and standard deviations. CI, confidence interval; SD, standard deviation; VAS, Visual Analog Scale.

DISCUSSION

This cross-sectional study identified a high prevalence of suboptimal vitamin D status among adults attending physiotherapy for chronic musculoskeletal pain. Nearly two-thirds of the participants were vitamin D deficient, while fewer than one-sixth had serum 25-hydroxyvitamin D [25(OH)D] concentrations within the sufficient range. Lower serum 25(OH)D concentrations were associated with greater pain severity and functional disability, and both outcomes showed a graded pattern across the deficient, insufficient, and sufficient vitamin D groups. These findings support an association between vitamin D status and the clinical burden of chronic musculoskeletal pain but do not establish the direction or causality of that relationship.

The observed prevalence of vitamin D deficiency was broadly consistent with evidence indicating that hypovitaminosis D is common among patients presenting with musculoskeletal disorders. Ali and Uddin reported a substantial burden of vitamin D deficiency among patients seeking physiotherapy and identified demographic and behavioural characteristics that may influence vitamin D status (5). A recent systematic review similarly concluded that lower serum vitamin D concentrations were frequently associated with chronic musculoskeletal pain, although considerable heterogeneity existed across populations, diagnostic categories, laboratory thresholds, and pain measures (4). Differences among studies may reflect variation in geographical location, season, clothing practices, dietary intake, physical activity, body composition, comorbid conditions, medication use, and the underlying musculoskeletal diagnosis.

The inverse correlation between serum 25(OH)D and pain severity was relatively strong in the present sample. Vitamin D has recognised roles in bone metabolism, skeletal muscle function, immune regulation, and neural activity, which provide several plausible mechanisms for an association with musculoskeletal symptoms (3,7). Deficiency may contribute to impaired mineralisation, muscle weakness, altered inflammatory signalling, and increased sensitivity to mechanical or nociceptive stimuli. Nevertheless, the clinical relationship is unlikely to be explained by a single pathway. Chronic pain is multidimensional and is influenced by biological, psychological, behavioural, occupational, and social factors (2). Serum vitamin D concentration may therefore represent one component of a broader clinical profile rather than an isolated determinant of pain.

Reverse causation remains an important alternative explanation. Patients with persistent pain and functional limitation may reduce outdoor mobility, occupational activity, and recreational exercise, thereby limiting sunlight exposure and contributing to lower vitamin D concentrations. Reduced physical activity may also coexist with higher body mass index, poorer dietary patterns, sleep disturbance, or chronic disease, each of which may affect both vitamin D status and pain-related outcomes. Because measurements were obtained at one point in time, the present study could not determine whether vitamin D deficiency preceded chronic pain, developed as a consequence of activity restriction, or reflected shared confounding factors.

Functional disability also showed an inverse association with serum 25(OH)D and progressively higher values across worsening vitamin D categories. This pattern was clinically notable because participants in the deficient group had substantially higher normalized disability scores than those in the sufficient group. However, disability was assessed using two different instruments according to the anatomical region involved. The Oswestry Disability Index was used for spinal pain, whereas WOMAC was used for lower-limb joint complaints. Although both scores were converted to percentages of their respective total possible scores, they measure related but non-identical constructs. Consequently, the combined normalized disability analysis should be interpreted cautiously and should not be considered equivalent to assessment with a single validated instrument across the entire sample.

The positive correlation between pain severity and functional disability was expected and supported the internal clinical coherence of the findings. Greater pain may restrict movement, reduce participation in

daily activities, and increase fear of activity, while functional limitation may in turn contribute to deconditioning and persistence of symptoms. Biomarker research has increasingly recognised that pain-related outcomes may reflect interactions among inflammatory, metabolic, neural, and behavioural factors rather than a direct effect of any single laboratory measure (6). The observed associations therefore warrant contextual interpretation alongside clinical diagnosis, pain duration, psychosocial status, physical activity, and other relevant patient characteristics.

A strength of the study was its focus on patients receiving physiotherapy for chronic musculoskeletal pain, a clinically relevant group in which persistent symptoms may prompt consideration of factors beyond mechanical impairment. Vitamin D was measured biochemically, and pain and disability were assessed using established clinical instruments. The analysis also examined serum 25(OH)D both categorically and continuously, allowing the findings to be evaluated as group differences and correlations.

Several limitations should be considered. The cross-sectional design precluded temporal or causal inference. The study was conducted in a single outpatient clinic with a relatively small sample, limiting generalisability to other clinical, geographical, and socioeconomic settings. The recruitment method and formal sample-size calculation were not available in the reported study information. Participants with different anatomical sites and musculoskeletal diagnoses were combined, and the diagnostic distribution and duration of pain were not reported. The combined disability variable was derived from two different instruments and may not represent a fully comparable construct across participants.

The reported analyses were unadjusted and did not account for potential confounding by age, sex, body mass index, diagnosis, pain duration, season, physical activity, diet, occupational environment, sunlight exposure, medication use, or comorbid illness. Sunlight exposure and occupational environment were recorded in broad categories and may have been affected by recall or classification error. Data collection was limited to October through December, and seasonal variation may have influenced serum vitamin D concentrations. Laboratory assay characteristics, quality-control procedures, and the continuous distribution of serum 25(OH)D were not available in the manuscript. The small number of participants in the sufficient group also reduced the precision of between-group comparisons.

The findings indicate that lower vitamin D status and greater pain-related impairment occurred together in this sample. They may support consideration of vitamin D status within a comprehensive clinical assessment when biochemical testing is otherwise clinically indicated. However, the study did not evaluate routine screening, vitamin D supplementation, treatment response, cost-effectiveness, or rehabilitation outcomes. Prospective studies with larger multicentre samples, uniform outcome measures, detailed diagnostic classification, and adjustment for major confounding variables are needed. Randomized controlled trials would be required to determine whether correction of vitamin D deficiency improves pain or functional outcomes among patients undergoing physiotherapy.

CONCLUSION

Vitamin D deficiency was common among adults attending physiotherapy with chronic musculoskeletal pain, and lower serum 25(OH)D concentrations were associated with greater pain severity and functional disability. Pain and disability also increased progressively across sufficient, insufficient, and deficient vitamin D categories. These findings demonstrate clinically relevant associations but do not establish that vitamin D deficiency caused the observed symptoms or that supplementation would improve rehabilitation outcomes.

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