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Vitamin D Deficiency and Musculoskeletal Pain

Association Between Vitamin D Deficiency and Musculoskeletal Pain Severity Among Female Office Workers in Islamabad

Original Research

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ABSTRACT

BACKGROUND: Musculoskeletal pain is a frequent occupational health concern among office workers, particularly women engaged in prolonged sedentary work. Vitamin D deficiency is highly prevalent in South Asian populations and has been implicated in musculoskeletal dysfunction and pain. However, evidence exploring this association from an occupational health perspective in Pakistani female office workers remains limited.

OBJECTIVE: To determine the association between vitamin D deficiency and musculoskeletal pain severity among female office workers in Islamabad.

METHODOLOGY: An analytical cross-sectional study was conducted among 355 female office workers recruited from public and private sector workplaces in Islamabad between March and October 2022. Serum 25-hydroxyvitamin D levels were measured using chemiluminescence immunoassay and categorized as deficient, insufficient, or sufficient. Musculoskeletal pain severity was assessed using the Numeric Pain Rating Scale. Descriptive statistics were used to summarize participant characteristics. Differences in pain severity across vitamin D status groups were analyzed using one-way analysis of variance. Pearson's correlation and multivariate linear regression analyses were performed to examine the association between vitamin D levels and pain severity while adjusting for relevant covariates.

RESULTS: Vitamin D deficiency was identified in 69.6% of participants, with a mean serum level of 17.9 ± 6.8 ng/mL. The overall mean pain score was 5.9 ± 1.8. Participants with vitamin D deficiency reported significantly higher pain scores (6.8 ± 1.4) compared with those with insufficient (5.2 ± 1.3) and sufficient levels (3.6 ± 1.1) ($p < 0.001$). A significant negative correlation was observed between serum vitamin D levels and pain severity ($r = –0.61$, $p < 0.001$). Vitamin D level remained an independent predictor of pain severity after adjustment for confounding variables.

CONCLUSION: Vitamin D deficiency was strongly associated with increased musculoskeletal pain severity among female office workers. These findings underscore the importance of incorporating vitamin D assessment into occupational health and rehabilitation strategies for sedentary female populations.

KEY TERMS: Ergonomics; Musculoskeletal Pain; Occupational Health; Office Workers; Pain Measurement; Vitamin D Deficiency; Women

INTRODUCTION

Musculoskeletal pain represents one of the most prevalent and disabling health complaints among working-age adults, particularly in occupations characterized by prolonged sitting, repetitive movements, and limited physical activity. Office-based employment has expanded rapidly in urban centers of Pakistan, with female office workers constituting a growing segment of this workforce. Within this population, musculoskeletal pain not only compromises physical well-being but also affects work productivity, psychological health, and overall quality of life. Despite its widespread impact, the underlying biological and lifestyle-related contributors to musculoskeletal pain in occupational settings remain insufficiently explored in local contexts, particularly among women(1, 2). Vitamin D deficiency has emerged as a global public health concern, affecting both developed and developing countries. Its prevalence is notably high in South Asian populations, including Pakistan, where cultural clothing practices, limited sun exposure, indoor lifestyles, urban pollution, and dietary insufficiencies collectively contribute to suboptimal vitamin D levels. Women are disproportionately affected due to sociocultural norms, reduced outdoor activity, and increased biological demands. Vitamin D plays a crucial role in calcium homeostasis, bone mineralization, and muscle function, and growing evidence suggests that its deficiency may be linked not only to skeletal disorders but also to chronic musculoskeletal pain(3, 4).

From a physiological perspective, vitamin D receptors are widely distributed in muscle tissue and the nervous system, indicating its involvement in muscle strength, neuromuscular coordination, and pain modulation. Deficiency in vitamin D has been associated with muscle weakness, diffuse body aches, and heightened pain sensitivity. Several international studies have reported associations between low serum vitamin D levels and conditions such as chronic low back pain, neck pain, shoulder discomfort, and generalized musculoskeletal pain. Proposed mechanisms include impaired muscle metabolism, increased inflammatory mediators, and altered nociceptive processing. However, findings across studies remain inconsistent, with some reporting strong associations while others suggest a more complex or indirect relationship influenced by confounding occupational and lifestyle factors(5). Female office workers represent a particularly vulnerable group in this regard. Prolonged sedentary behavior, poor ergonomic setups, limited physical activity, and work-related stress are common in office environments and are well-established contributors to musculoskeletal pain. When combined with vitamin D deficiency, these factors may synergistically exacerbate pain severity and functional limitations. In Islamabad, a rapidly urbanizing city with a predominantly indoor working culture, these occupational risks are further amplified. Despite this, research examining the interplay between vitamin D status and musculoskeletal pain severity within this specific occupational and gender-based population remains scarce(6, 7).

Most existing Pakistani studies on vitamin D deficiency have focused on general prevalence, bone health, or specific clinical populations such as elderly individuals, pregnant women, or patients with metabolic disorders. Similarly, research on musculoskeletal pain has often centered on general populations or specific conditions without adequately integrating biochemical markers such as vitamin D. There is a notable lack of analytical studies that assess pain severity in relation to vitamin D deficiency from an occupational health perspective, particularly among female office workers who may experience unique biological, social, and workplace-related risk factors(7). Understanding this association holds clinical and public health significance. If vitamin D deficiency is linked with increased musculoskeletal pain severity, early identification and targeted interventions such as supplementation, lifestyle modification, ergonomic improvements, and workplace health education could offer cost-effective strategies to reduce pain burden and improve occupational health outcomes. Moreover, recognizing vitamin D deficiency as a potentially modifiable factor may help clinicians adopt a more holistic approach to managing musculoskeletal pain rather than relying solely on symptomatic treatment(8).

Against this background, the present study is designed to explore the association between vitamin D deficiency and musculoskeletal pain severity among female office workers in Islamabad. By adopting an analytical cross-sectional approach, this research seeks to contribute local evidence to an underexplored area, bridging gaps between occupational health, clinical medicine, and rehabilitation sciences. The specific objective of this study is to determine whether vitamin D deficiency is significantly associated with increased severity of musculoskeletal pain in this population, thereby providing a rational basis for preventive and rehabilitative strategies tailored to female office workers in Pakistan(9-11).

METHODS

This analytical cross-sectional study was conducted in Pakistan over a period of eight months, from March 2022 to October 2022. The study was carried out in Islamabad, drawing participants from multiple office-based workplaces, including public sector offices, private corporate organizations, educational administrative departments, and healthcare administrative units located in Islamabad Capital Territory. These settings were selected to reflect a diverse range of sedentary occupational environments commonly associated with prolonged desk-based work among female employees(12). The study population comprised female office workers aged 22 to 55 years who were engaged in full-time office-based employment for a minimum duration of one year. Office work was operationally defined as employment requiring at least six hours per day of desk-based or computer-related tasks. Participants were included if they reported experiencing musculoskeletal pain in any region of the body, including the neck, shoulders, upper back, lower back, or lower limbs, for at least the preceding three months. Exclusion criteria included a prior diagnosis of inflammatory arthritis, rheumatoid arthritis, fibromyalgia, or other systemic musculoskeletal disorders; history of recent trauma or surgery within the past six months; known metabolic bone disease other than vitamin D deficiency; pregnancy or lactation; and current use of vitamin D supplementation or corticosteroids within the previous three months. These criteria were applied to minimize confounding factors that could independently influence pain perception or vitamin D levels(13).

The sample size was calculated using OpenEpi version 3.01, based on parameters derived from previous regional studies reporting a prevalence of vitamin D deficiency among female office workers of approximately 70%. Assuming a confidence level of 95%, a margin of error of 5%, and a design effect of 1, the minimum required sample size was calculated as 323 participants. To account for potential non-response and incomplete data, an additional 10% was added, resulting in a final target sample size of 355 participants. Participants were recruited using a non-probability convenience sampling technique, with invitations extended through workplace administrations after obtaining institutional permission(14). Data collection involved a structured and standardized approach. After eligibility screening, participants provided written informed consent prior to enrollment. Sociodemographic and occupational characteristics were recorded using a self-administered questionnaire that captured age, marital status, body mass index, daily working hours, duration of employment, physical activity level, and sun exposure patterns. Musculoskeletal pain severity was assessed using the Numeric Pain Rating Scale (NPRS), a validated and widely used tool for quantifying pain intensity. Participants were asked to rate their average pain intensity over the previous week on an 11-point scale ranging from 0 (no pain) to 10 (worst imaginable pain). Pain severity was categorized as mild (1–3), moderate (4–6), or severe (7–10) for analytical purposes(15).

Serum vitamin D levels were assessed by measuring 25-hydroxyvitamin D [25(OH)D], which is considered the most reliable indicator of vitamin D status. Blood samples were collected by trained laboratory personnel following standard aseptic procedures and analyzed at certified diagnostic laboratories in Islamabad using chemiluminescence immunoassay techniques. Vitamin D status was classified according to established clinical guidelines, with deficiency defined as serum 25(OH)D levels below 20 ng/mL, insufficiency as 20–29 ng/mL, and sufficiency as 30 ng/mL or above(16). All collected data were coded and entered into the Statistical Package for Social Sciences (SPSS) version 25.0 for analysis. Data normality was assessed using the Shapiro–Wilk test, which confirmed normal distribution of continuous variables. Descriptive statistics were computed using means and standard deviations for continuous variables and frequencies and percentages for categorical variables. The association between vitamin D status and musculoskeletal pain severity was examined using independent sample t-tests and one-way analysis of variance (ANOVA), as appropriate. Pearson's correlation coefficient was used to assess the strength and direction of the relationship between serum vitamin D levels and pain intensity scores. Multivariate linear regression analysis was performed to adjust for potential confounders such as age, body mass index, physical activity level, and daily working hours. A p-value of less than 0.05 was considered statistically significant(17).

Ethical approval for the study was obtained from the Institutional Review Board of a tertiary care academic institution in Islamabad. All procedures were conducted in accordance with the ethical principles outlined in the Declaration of Helsinki. Participants were assured of confidentiality, anonymity, and their right to withdraw from the study at any stage without any consequences. All collected data were used solely for research purposes and were securely stored with restricted access to ensure data protection and integrity.

RESULTS

A total of 355 female office workers were enrolled in the study, all of whom completed the questionnaire and biochemical assessment, yielding a response rate of 100%. The mean age of the participants was 34.7 ± 7.9 years, with a mean body mass index of 26.1 ± 4.2 kg/m². The average duration of office-based employment was 7.4 ± 3.6 years, and the mean daily working time was 7.8 ± 1.1 hours. Most participants reported limited outdoor activity during working days, with a mean self-reported sun exposure time of 18.6 ± 9.4 minutes per day. Serum vitamin D assessment revealed a high prevalence of suboptimal levels. Vitamin D deficiency (<20 ng/mL) was observed in 247 participants (69.6%), while 71 participants (20.0%) were classified as vitamin D insufficient (20–29 ng/mL). Only 37 participants (10.4%) demonstrated sufficient vitamin D levels (≥30 ng/mL). The overall mean serum 25(OH)D concentration was 17.9 ± 6.8 ng/mL. Distribution of vitamin D status across the sample is summarized in Table 1.

Musculoskeletal pain severity, assessed using the Numeric Pain Rating Scale, showed a mean pain score of 5.9 ± 1.8 for the overall sample. Mild pain (NPRS 1–3) was reported by 74 participants (20.8%), moderate pain (NPRS 4–6) by 156 participants (43.9%), and severe pain (NPRS 7–10) by 125 participants (35.2%). The most commonly reported pain regions were the lower back (62.5%), neck (48.7%), shoulders (41.4%), and knees (29.0%), with multiple pain sites reported by 57.2% of participants. The distribution of pain severity categories is presented in Table 2 and illustrated in Figure 2. Comparison of musculoskeletal pain severity across vitamin D status groups demonstrated statistically significant differences. Participants with vitamin D deficiency exhibited the highest mean NPRS score (6.8 ± 1.4), followed by those with vitamin D insufficiency (5.2 ± 1.3), while the lowest pain scores were observed among participants with sufficient vitamin D levels (3.6 ± 1.1). One-way analysis of variance confirmed a significant difference in mean pain scores among the three groups ($F = 86.4$, $p < 0.001$). Post hoc analysis showed significant pairwise differences between deficient and insufficient groups, deficient and sufficient groups, and insufficient and sufficient groups. Mean pain scores according to vitamin D status are detailed in Table 3 and graphically represented in Figure 1.

Pearson's correlation analysis demonstrated a significant negative correlation between serum vitamin D levels and musculoskeletal pain severity ($r = –0.61$, $p < 0.001$), indicating lower pain scores with higher vitamin D concentrations. Multivariate linear regression analysis revealed that vitamin D level remained a significant independent predictor of pain severity after adjusting for age, body mass index, duration of employment, daily working hours, and physical activity level ($\beta = –0.54$, $p < 0.001$). The overall regression model explained 46% of the variance in NPRS scores (adjusted $R^2 = 0.46$).

Table 1. Distribution of Vitamin D Status (n = 355)

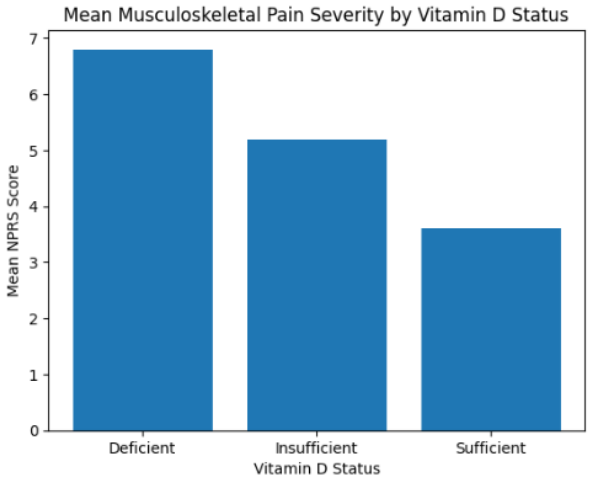
Vitamin D Status	Frequency (n)	Percentage (%)
Deficient (<20 ng/mL)	247	69.6
Insufficient (20–29 ng/mL)	71	20.0
Sufficient (≥30 ng/mL)	37	10.4

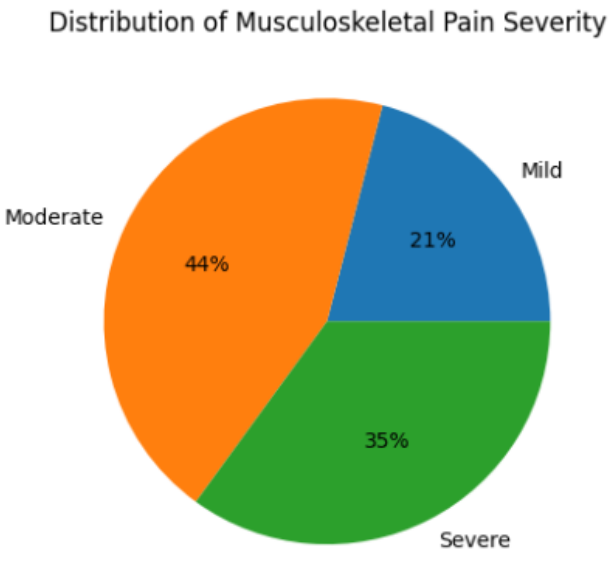
Table 2. Musculoskeletal Pain Severity Categories

Pain Severity (NPRS)	Frequency (n)	Percentage (%)
Mild (1–3)	74	20.8
Moderate (4–6)	156	43.9
Severe (7–10)	125	35.2

Table 3. Mean NPRS Scores by Vitamin D Status

Vitamin D Status	Mean NPRS ± SD
Deficient	6.8 ± 1.4
Insufficient	5.2 ± 1.3
Sufficient	3.6 ± 1.1





DISCUSSION

The present study examined the association between vitamin D deficiency and musculoskeletal pain severity among female office workers in Islamabad and demonstrated a clear and statistically significant relationship between low serum vitamin D levels and higher pain intensity. Nearly seven out of ten participants were found to be vitamin D deficient, with a mean serum concentration of 17.9 ng/mL, highlighting the magnitude of hypovitaminosis D within this occupational group. Musculoskeletal pain was predominantly moderate to severe in intensity, with more than one-third of participants reporting severe pain, indicating a considerable burden of pain among sedentary female workers in an urban Pakistani setting(18). The observed gradient in pain severity across vitamin D status categories provides important insight into the clinical relevance of vitamin D deficiency. Participants with deficient vitamin D levels reported a mean pain score of 6.8, compared with 5.2 among those with insufficient levels and 3.6 among those with sufficient levels. This stepwise reduction in pain intensity was further supported by a moderate to strong negative correlation between serum vitamin D and pain scores (r = –0.61), suggesting that declining vitamin D levels were consistently associated with increasing pain severity. These findings were in line with previously reported data from South Asian and Middle Eastern populations, where vitamin D deficiency rates ranging from 60% to 80% among working women were accompanied by higher prevalence of chronic musculoskeletal pain and diffuse body aches(19).

From a biological perspective, the findings support the role of vitamin D in musculoskeletal health beyond its established effects on bone metabolism. Vitamin D deficiency has been linked to impaired muscle function, reduced muscle fiber size, and altered neuromuscular signaling, which may collectively contribute to pain amplification. In addition, low vitamin D levels have been associated with increased inflammatory markers and heightened pain sensitivity, offering plausible mechanisms for the higher pain scores observed in deficient individuals. The persistence of vitamin D as an independent predictor of pain severity after adjustment for age, body mass index, working hours, and physical activity further reinforces its potential role as a modifiable risk factor within occupational health settings(19, 20). The occupational context of the study population adds further relevance to these findings. Female office workers in Islamabad typically engage in prolonged sitting, repetitive computer-based tasks, and limited exposure to sunlight during working hours. In the current sample, the average daily sun exposure was less than 20 minutes, which is insufficient for adequate endogenous vitamin D synthesis. When combined with sedentary work patterns and suboptimal ergonomic conditions, vitamin D deficiency may exacerbate musculoskeletal strain and contribute to persistent pain. The high proportion of participants reporting pain in the lower back, neck, and shoulders aligns with common postural stressors associated with office-based work and reflects patterns observed in similar occupational studies conducted in comparable settings(6).

Several strengths of this study merit consideration. The inclusion of biochemical assessment of vitamin D provided objective measurement rather than reliance on self-reported supplementation or dietary intake. The use of a validated pain assessment tool allowed standardized quantification of pain severity, facilitating meaningful comparisons across vitamin D status groups. The relatively large sample size and inclusion of participants from diverse office settings enhanced the internal consistency of the findings and improved their applicability to urban female office workers in Pakistan(3). However, certain limitations should be acknowledged. The cross-sectional design limited the ability to establish temporal or causal relationships between vitamin D deficiency and musculoskeletal pain. Pain perception is inherently subjective and may be influenced by psychosocial factors such as stress, sleep quality, and mental health, which were not assessed in detail. Seasonal variation in vitamin D levels was not accounted for, as data collection occurred over a defined period rather than across all seasons. Additionally, the use of convenience sampling may limit generalizability beyond similar urban occupational populations(15).

Future research would benefit from longitudinal designs to explore causal pathways and assess the impact of vitamin D correction on pain outcomes over time. Interventional studies examining the combined effects of vitamin D supplementation, ergonomic modifications, and workplace physical activity programs could provide practical guidance for occupational health strategies. Incorporating broader lifestyle and psychosocial variables may also help clarify the multifactorial nature of musculoskeletal pain in working women(11). Overall, the findings underscored a strong association between vitamin D deficiency and increased musculoskeletal pain severity among female office workers in Islamabad. These results highlighted the need for greater clinical awareness of vitamin D status in the evaluation of chronic musculoskeletal pain and emphasized the importance of integrated preventive approaches within occupational health and rehabilitation practices.

CONCLUSION

This study demonstrated a significant association between vitamin D deficiency and increased musculoskeletal pain severity among female office workers in Islamabad. The high prevalence of vitamin D deficiency and its independent relationship with pain intensity highlighted an important and potentially modifiable contributor to occupational musculoskeletal complaints. These findings emphasized the need for routine assessment of vitamin D status and integrated preventive strategies, including supplementation, lifestyle modification, and workplace health interventions, to reduce pain burden and improve functional well-being in sedentary female populations.

AUTHOR's CONTRIBUTION:

Author	Contribution
Dr Sughra Shakoor	Conceptualization, Methodology, Formal Analysis, Writing - Original Draft, Validation, Supervision
Mohsin Raza	Methodology, Investigation, Data Curation, Writing - Review & Editing
Dr Saqlain Abbass	Investigation, Data Curation, Formal Analysis, Software
Fouzia Batool	Software, Validation, Writing - Original Draft

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