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Prevalence and Clinical Characteristics of Migraine in Adults with Reduced Vitamin D Levels in Yunnan, China: A Cross-Sectional Study

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Abstract

Background

For migraine patients residing in the low-latitude, high-altitude region of Yunnan, China, the current lack of data regarding vitamin D status and its impact on migraine characteristics has limited both research into vitamin D supplementation as a therapeutic approach and its clinical application. This study aimed to investigate the prevalence of reduced serum 25-hydroxyvitamin D (25(OH)D) levels in adult migraine patients in Yunnan Province and to explore its correlation with the clinical characteristics of migraine.

Methods

A total of 678 adult migraine patients who underwent serum 25(OH)D concentration testing at the outpatient clinic of the Department of Neurology, First People's Hospital of Yunnan Province, between January 1, 2023, and August 31, 2025, were consecutively enrolled. They were divided into three groups: deficient group (< 20 ng/mL), insufficient group (20–30 ng/mL), and sufficient group (> 30 ng/mL). The differences in monthly headache attack frequency, monthly headache days, Visual Analogue Scale (VAS) score, and Headache Impact Test-6 (HIT-6) score were compared among the three groups. Pearson correlation analysis was used to assess the correlations.

Results

Among the 678 patients, the prevalence of reduced vitamin D was 64.31% (436/678), with 18.29% (124/678) classified as deficient and 46.02% (312/678) as insufficient. Additionally, body mass index (BMI) differed significantly among the three groups ($P < 0.001$), exhibiting a stepwise increasing trend, with the vitamin D deficient group having the highest BMI. Patients in the deficient group had significantly higher monthly headache attack frequency (4.6 ± 1.7 attacks), monthly headache days (7.8 ± 2.9 days), and HIT-6 scores (56.3 ± 5.9 points) compared to those in the insufficient and sufficient groups ($P < 0.001$). There was no statistically significant difference in VAS scores among the three groups ($P = 0.057$). Correlation analysis showed that serum 25(OH)D levels were negatively correlated with monthly headache attack frequency, monthly headache days, and HIT-6 scores.

Conclusion

The prevalence of reduced vitamin D levels among adult migraine patients in Yunnan Province was as high as 64.31%. Reduced serum 25(OH)D levels were negatively correlated with monthly headache frequency, monthly headache days, and HIT-6 scores. In addition, a significant association was found between increased BMI and reduced vitamin D levels, suggesting that BMI, as a contributing factor to vitamin D deficiency, may exacerbate the disease burden of migraine.

Introduction

Migraine is a common primary headache disorder with a global prevalence of approximately 14%. According to the Global Burden of Disease (GBD) study, it ranks as the second leading cause of neurological disability worldwide, contributing to a substantial burden on both individual quality of life and socioeconomic systems [1]. Vitamin D, a hormone precursor with neurosteroid-like properties, exerts its effects through receptors widely distributed in brain regions such as the hypothalamus, hippocampus, and trigeminal ganglion, where it plays a key role in modulating neuroinflammation, neurotrophic support, and vasomotor function [2]. Accumulating evidence from observational studies and meta-analyses has demonstrated that serum 25-hydroxyvitamin D (25(OH)D) levels are significantly lower in individuals with migraine compared with healthy controls, with deficiency conferring an approximately two-fold increased risk of migraine (*OR* = 1.95) [3]. Recent large-scale population-based analyses utilizing the National Health and Nutrition Examination Survey (NHANES) database have further corroborated a significant negative correlation between serum vitamin D levels and migraine prevalence [4]. However, most studies have been conducted in European, American, or Northern Chinese populations, and it remains uncertain whether these findings are generalizable to regions with distinctive sunlight exposure patterns, such as Southwest China. Yunnan Province, situated on a low-latitude plateau (21°–29°N), receives abundant sunlight, which theoretically facilitates cutaneous vitamin D synthesis. Given this background, investigating the vitamin D status of migraine patients in Yunnan holds both regional specificity and clinical relevance. Here, we analyzed data from 678 adult migraine patients who underwent serum 25(OH)D testing at the outpatient neurology clinic of the First People's Hospital of Yunnan Province, aiming to determine the prevalence of reduced vitamin D levels in this population and to explore its association with the clinical characteristics of migraine.

Materials and Methods

Patient population

This study was conducted in adult patients with migraine who presented to the outpatient neurology clinic of the First People's Hospital of Yunnan Province between January 1, 2023, and August 31, 2025. The inclusion criteria were: (1) age 18–67 years; (2) diagnosis of migraine without aura, migraine with aura, or chronic migraine according to the International Classification of Headache Disorders, 3rd edition (ICHD-3) [5]; (3) voluntary consent to undergo serum 25(OH)D testing and to complete at least one month of standardized headache diary documentation. Patients were excluded for any of the following: (1) presence of other primary or secondary headache disorders; (2) comorbid conditions affecting vitamin D metabolism, including severe liver, kidney, thyroid, or parathyroid dysfunction, malabsorption syndrome, or malignant tumors; (3) regular use of vitamin D supplements, calcium preparations, or medications affecting vitamin D metabolism (such as antiepileptic drugs or glucocorticoids) within the preceding three months; (4) pregnancy or lactation.

Measurement of Serum Vitamin D Levels and Group Definitions

All patients who met the inclusion and exclusion criteria had 5 ml of fasting cubital venous blood collected between 8:00 and 10:00 a.m. on the day following enrollment. Serum 25(OH)D concentrations were measured using the Roche Cobas e601 fully automated electrochemiluminescence immunoassay system after serum separation. Based on the cutoffs recommended by the Endocrine Society's 2011 Clinical Practice Guideline for the Evaluation, Treatment, and Prevention of Vitamin D Deficiency [6], vitamin D status was classified into three groups: sufficient [25(OH)D > 30 ng/mL], insufficient [25(OH)D 20–30 ng/mL], and deficient [25(OH)D < 20 ng/mL]. Although the Endocrine Society released an updated vitamin D guideline in 2024, it primarily focuses on disease prevention in the general population and does not provide diagnostic thresholds for vitamin D levels [7]. Therefore, this study continues to use the clinical cutoffs from the 2011 guideline for group classification.

Data collection

Patients completed a standardized headache diary for one month following their clinic visit. The diary documented the following: (1) the number of headache episodes per month (an episode was defined as the period from onset to resolution of a headache; episodes separated by a headache-free interval of at least 48 hours were counted as two separate episodes); (2) the total number of headache days per month; (3) headache intensity: the average severity of headaches was assessed using the Visual Analog Scale (0–10 points, where 0 indicates no pain and 10 indicates the most intense pain imaginable); and (4) headache impact: the impact of headaches on daily life was evaluated using the Headache Impact Test-6 (total score range 36–78, with higher scores indicating more severe impact, and a score of ≥ 60 points suggesting a severe impact).

Statistical analysis

All statistical analyses were performed using SPSS software (version 26.0). Categorical data were presented as counts (percentages) and compared among groups using the chi-square test. Continuous data were first tested for normality using the Shapiro-Wilk test. Data conforming to a normal distribution were expressed as mean ± standard deviation (SD); comparisons among multiple groups were performed using one-way analysis of variance (ANOVA), and if the difference was statistically significant, post hoc pairwise comparisons were conducted using the least significant difference *t*-test (LSD-*t*). Data not conforming to a normal distribution were expressed as median (interquartile range) and compared using the Kruskal-Wallis H test. Linear relationships between serum 25(OH)D levels and clinical headache characteristics were preliminarily assessed by scatter plots. After confirming that the linearity assumption was satisfied, Pearson correlation analysis was used to evaluate the correlations between vitamin D levels and headache clinical characteristics. All statistical tests were two-tailed, and a *P*-value < 0.05 was considered statistically significant.

Results

Patient baseline characteristics

Table 1 presents the baseline characteristics of the entire study cohort. This study enrolled 678 eligible patients with migraine, including 215 males (31.71%) and 463 females (68.29%), yielding a male-to-female ratio of 1:2.15. Patients ranged in age from 18 to 67 years, with a mean age of 38.5 ± 11.2 years. Regarding vitamin D status, 242 patients (35.69%) were vitamin D sufficient, 312 (46.02%) were insufficient, and 124 (18.29%) were deficient, giving an overall prevalence of reduced vitamin D levels of 64.31% (436/678). The three groups showed no statistically significant differences in sex or age ($P > 0.05$). However, BMI differed significantly among the three groups ($P < 0.001$), exhibiting a stepwise increasing trend, with the vitamin D deficient group having the highest BMI.

Table 1
Baseline characteristics of the study cohort stratified by vitamin D status ($\bar{x} \pm s$)

Baseline characteristic	The sufficient group (n = 242)	The insufficient group (n = 312)	The deficient group (n = 124)	*P*-value
Sex (male/female)	78/164	103/209	34/90	0.514
Age (years)	38.2 ± 11.3	38.7 ± 11.1	38.6 ± 11.4	0.861
BMI (kg/m²)	22.5 ± 2.8	23.8 ± 3.1*	25.1 ± 3.4*†	< 0.001

Note: One-way ANOVA revealed a statistically significant overall difference in BMI ($P < 0.001$). Post hoc pairwise comparisons using the least significant difference *t*-test (LSD-*t*) showed that compared with the sufficient group, *$P < 0.05$; compared with the insufficient group, †$P < 0.05$.

Headache Characteristics by Vitamin D Status

Table 2 presents detailed headache data recorded from the one-month headache diary across the three groups. The deficient group had a significantly higher monthly headache frequency (4.6 ± 1.7 episodes) than the insufficient group (3.4 ± 1.3 episodes) and the sufficient group (2.8 ± 1.1 episodes), with statistically significant differences ($P < 0.001$). Similarly, the deficient group reported significantly more monthly headache days (7.8 ± 2.9 days) than the insufficient group (5.1 ± 2.2 days) and the sufficient group (4.7 ± 2.0 days) ($P < 0.001$). Regarding HIT-6 scores, the deficient group scored significantly higher (56.3 ± 5.9) than the insufficient group (52.4 ± 6.1) and the sufficient group (50.2 ± 5.8) ($P < 0.001$). However, no statistically significant differences emerged in VAS scores among the three groups.

Further post hoc pairwise comparisons using the least significant difference t-test (LSD-t) revealed that for monthly headache frequency and HIT-6 scores, all pairwise comparisons among the three groups showed significant differences ($P < 0.05$), with the sufficient group having the lowest values and the deficient group the highest. For monthly headache days, the deficient group had significantly more

headache days than the other two groups ($P < 0.05$), whereas the difference between the insufficient and sufficient groups was not statistically significant ($P > 0.05$).

Table 2
Comparison of headache characteristics by vitamin D status ($\bar{x} \pm s$)

headache characteristics	**The sufficient group (n = 242)**	**The insufficient group (n = 312)**	**The deficient group (n = 124)**	***P*-value**
Headache episodes/mo	2.8 ± 1.1	3.4 ± 1.3*	4.6 ± 1.7*†	< 0.001
Headache days/mo	4.7 ± 2.0	5.1 ± 2.2	7.8 ± 2.9*†	< 0.001
VAS score	6.4 ± 1.5	6.3 ± 1.6	6.7 ± 1.4	0.057
HIT-6 score	50.2 ± 5.8	52.4 ± 6.1*	56.3 ± 5.9*†	< 0.001
Note: *$P < 0.05$ compared with the sufficient group; †$P < 0.05$ compared with the insufficient group.				

Pearson Correlation Analysis

We performed Pearson correlation analysis to evaluate the relationships between serum 25(OH)D levels and headache characteristics. Serum 25(OH)D levels were negatively correlated with monthly headache frequency ($r = -0.402$, $P < 0.001$), monthly headache days ($r = -0.385$, $P < 0.001$), and HIT-6 scores ($r = -0.312$, $P < 0.001$). However, the correlation with VAS scores did not reach statistical significance ($r = -0.071$, $P = 0.065$).

Discussion

This single-center cross-sectional study found a 64.31% prevalence of reduced vitamin D levels among adult migraine patients, which is comparable to findings from several international studies. In migraine patients, vitamin D deficiency rates ranging from 53.7% to 77.1% have been reported in studies from South Korea, Iran, and Bangladesh [8-10]. A systematic review published in 2026 reported that the prevalence of vitamin D deficiency (<20 ng/mL) among migraine patients ranges from 65% to 88%, rising to 80%–92% in those with chronic migraine. Even higher rates (75%–90%) have been observed in populations residing at high latitudes (>40°N) [11]. Notably, the study population resided in Yunnan Province, a low-latitude plateau region with abundant sunlight that theoretically favors vitamin D synthesis. Nevertheless, a high prevalence of reduced vitamin D levels was observed. This phenomenon may be attributable to modern lifestyle factors, including predominantly indoor work and routine use of sunscreen, both of which substantially reduce effective sun exposure. Inadequate dietary intake of vitamin D-rich foods (e.g. deep-sea fish, organ meats) may also contribute.

A noteworthy finding was that BMI differed significantly among the three groups ($P < 0.001$). The vitamin D deficient group had the highest BMI, which was significantly greater than that of the insufficient and

sufficient groups, showing a stepwise increase. This suggests that increased BMI may be associated with reduced vitamin D levels. A recent Mendelian randomization study reported a significant negative causal association between BMI and vitamin D levels [12]. Furthermore, a meta-analysis published online in 2025 showed that overweight and obesity are associated with a significantly increased risk of vitamin D deficiency (*OR* = 1.84) [13]. Potential mechanisms include sequestration of vitamin D in adipose tissue, reduced outdoor physical activity leading to insufficient sunlight exposure in individuals with obesity, and differences in dietary patterns [14-16]. The present findings further support a negative correlation between BMI and vitamin D levels in migraine patients, suggesting that clinicians should carefully evaluate vitamin D status in migraine patients with obesity.

The principal finding of this study is that vitamin D deficiency is directly associated with a greater migraine-related disease burden. Patients in the deficient group had significantly higher monthly headache frequency (4.6 episodes), monthly headache days (7.8 days), and HIT-6 scores (56.3 ± 5.9) compared with those in the insufficient and sufficient groups. Furthermore, serum 25(OH)D levels were negatively correlated with monthly headache frequency, monthly headache days, and HIT-6 scores. These findings are consistent with those of a case–control study by Hussein et al., which similarly reported a negative correlation between vitamin D levels and both monthly headache frequency and HIT-6 scores [17]. A systematic review by Gazerani et al. also supports a significant association between low vitamin D levels and increased migraine frequency [18]. In addition, a large retrospective study from the United States found that vitamin D deficiency was significantly associated with functional impairment in migraine patients (*OR* = 3.12) [19].

Of note, the present study revealed no significant association between vitamin D levels and VAS scores for headache pain, a finding consistent with some previous studies [20]. This may suggest that vitamin D deficiency primarily influences the propensity for headache attacks—namely, their frequency and cumulative burden—rather than the perceived intensity of individual episodes. However, given the substantial increases in both attack frequency and total headache days, patients exhibited markedly greater overall functional impairment (as reflected by HIT-6 scores), which carries more profound implications for quality of life. Overall, these findings suggest that for patients with reduced vitamin D levels, the clinical benefits of vitamin D supplementation may lie predominantly in reducing headache frequency and alleviating cumulative disease burden, rather than in directly mitigating the pain intensity of individual attacks.

This study has several limitations. First, the cross-sectional design precludes establishing a causal relationship between vitamin D deficiency and increased migraine burden. Second, as a single-center study, the generalizability of the findings is limited, and caution is warranted when extrapolating the results. Third, we did not collect data on potential confounders such as sunlight exposure duration, sunscreen use, or dietary vitamin D intake, which may influence serum vitamin D levels, thereby limiting our ability to comprehensively assess the role of lifestyle factors.

Our study provides important data on vitamin D status in adult migraine patients in Yunnan Province, a low-latitude, high-altitude region in China. We found that reduced vitamin D levels were negatively correlated with monthly headache frequency, monthly headache days, and HIT-6 scores. These findings suggest that, in addition to addressing migraine itself, clinicians should evaluate vitamin D status in patients with migraine. Future prospective cohort studies are needed to clarify the relationship between vitamin D levels and migraine, and multicenter randomized controlled trials are warranted to evaluate the efficacy of vitamin D supplementation in migraine prevention and to determine the optimal dose and treatment duration.

Conclusion

In conclusion, our study reported a 64.31% prevalence of reduced vitamin D levels among adult migraine patients in Yunnan Province. We found that reduced serum 25(OH)D levels were negatively correlated with monthly headache frequency, monthly headache days, and HIT-6 scores. Additionally, higher BMI was significantly negatively associated with reduced vitamin D levels. This suggests that higher BMI may be a risk factor for vitamin D deficiency and may thereby contribute to the disease burden of migraine.

Abbreviations

25(OH)D, 25-hydroxyvitamin D

VAS, Visual Analogue Scale

HIT-6, Headache Impact Test-6

BMI, body mass index

GBD, Global Burden of Disease

NHANES, National Health and Nutrition Examination Survey

ICHD-3, International Classification of Headache Disorders, 3rd edition

SD, standard deviation

ANOVA, analysis of variance

LSD-t, least significant difference t-test

Mo, month

Declarations

Ethics approval and consent to participate

This study received approval from the Medical Ethics Committee at the First People's Hospital of Yunnan Province (Approval No. YNRY2022-KS009). All methods were carried out in accordance with relevant guidelines and regulations. Written informed consent was obtained from all participants in accordance with the Declaration of Helsinki.

Consent for publication

Not applicable.

Clinical trial number

not applicable.

Availability of data

All data generated or analysed during this study are included in this published article and its supplementary information files.

Competing interests

The authors declare that they have no competing interests.

Funding

Not applicable.

Authors' contributions

RJ, BGC and ZZJ contributed to the study conception and design. RJ wrote the original draft. RJ, BGC, LTY and ZZJ recruited the participants. BGC and LTY were responsible for collecting clinical and demographic data from patients. RJ and ZZJ analyzed the data. RJ and BGC reviewed and edited the final draft. All authors contributed to the article and approved the submitted version.

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