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# Prevalence and Significance of Vitamin D Deficiency in Patients Undergoing Corrective Surgery for Adolescent Idiopathic Scoliosis

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## ABSTRACT

**Background:** The exact etiology of adolescent idiopathic scoliosis (AIS) is unknown, but recently, vitamin D has been suggested to be of importance in the pathophysiology of AIS. This article sought to (1) highlight the prevalence of vitamin D deficiency in patients undergoing corrective surgery for AIS within the United Kingdom and (2) evaluate the correlation and clinical relevance of preoperative back pain with vitamin D deficiency.

**Methods:** Data were collected on 201 consecutive patients undergoing corrective surgery for AIS. Baseline data included patient demographics, medical diagnoses, and standing preoperative Cobb angles. All patients had a preoperative 25-hydroxyvitamin D level recorded. One hundred ninety-six patients completed preoperative Scoliosis Research Society-22 outcome scores to quantify preoperative back pain.

**Results:** A total of 177 (89%) patients were young women, and the mean age at time of surgery was 14.9 years (13–18 years). All patients were diagnosed with AIS. The mean Cobb angles at time of surgery was 64°. Only 11 (5.5%) patients had "normal" vitamin D levels (>75 nmol/L), with 147 (74%) patients having deficient levels requiring treatment with supplementation. There was no correlation between vitamin D levels and preoperative Cobb angles ($r_s = -0.12$), and there was a moderate correlation identified between the severity of preoperative vitamin D levels and preoperative back pain scores ($r_s = 0.42$).

**Conclusion:** Vitamin D deficiency is common in patients with AIS; however, it is comparable to the national prevalence of vitamin D deficiency in healthy adolescent children. There was a strong correlation between preoperative back pain scores and the severity of vitamin D deficiency. These findings suggest that all patients with AIS should be screened for vitamin D deficiency and that supplementation where appropriate may lead to improved pain scores.

**Clinical Relevance:** If vitamin D is prevelant and if vitamin D deficiency is found to cause back pain, then there is an easy/cheap/safe treatement with supplementation.

**Level of Evidence:** 3.

Other & Special Categories

Keywords: scoliosis, back pain, vitamin D

## INTRODUCTION

The etiology of adolescent idiopathic scoliosis (AIS) is largely unknown. Many etiological theories have been suggested, including neuromuscular, metabolic, and genetic causes, but these theories have often been supported by weak evidence.[1]

Progression of curve magnitude in AIS is a concern and can warrant the need for surgical intervention to prevent further curve progression and potential cardiorespiratory compromise. The main risks for curve progression are the curve magnitude, remaining skeletal growth, and the type of curve.[2]

Recent studies from Hong Kong have highlighted vitamin D deficiency as a potential cause for curve progression in patients with AIS, and it has been postulated that treating the vitamin D deficiency with supplementation may significantly improve bone health and potentially reduce the risk of curve progression in these patients.[3]

Previously, back pain was not thought to be associated with AIS; however, in large cohort studies, it has been reported as present in up to 23% of paitents.[4] The exact cause of the back pain in patients with AIS is unknown, it varies in severity, and patients are often investigated with magnetic resonance imaging (MRI) to look for underlying pathological causes of the pain.

A systematic review and meta-analysis of observation studies concluded that vitamin D deficiency is associated with back pain, with stronger associations seen in young women and in patients with severe deficiencies.[5]

There is currently no evidence studying the relationship between AIS and back pain; we hypothesize that vitamin D deficiency could be one of the potential causes of back pain in this cohort of adolescent patients undergoing surgery.

The aim of this prospective longitudinal cohort study was to investigate the presence of vitamin D deficiency in consecutive patients undergoing corrective surgery for AIS within the United Kingdom. We also sought to investigate the relationship between vitamin D deficiency and patient-reported preoperative pain levels. To the best of our knowledge, the present study is the largest and only study specifically investigating this relationship within the UK population.

## MATERIALS AND METHODS

Data were collected on all consecutive patients undergoing corrective surgery for AIS from January 2014 to June 2019 at a single tertiary referral pediatric spinal unit within the United Kingdom.

Any patients with infantile, juvenile, or pathological scoliosis were excluded. All patients included in the study underwent preoperative MRI, which confirmed the idiopathic nature of the curves and excluded any structural causes for their scoliosis.

Vitamin D levels were only collected on patients undergoing corrective surgery; patients with AIS but under clinical observation alone were not included in this study.

Baseline data collection included patient age, patient sex, underlying diagnosis, and any significant medical comorbidities. Preoperative standing Cobb angles were measured and Scoliosis Research Society-22 (SRS-22) questionnaires were completed. The pain domain of the SRS-22 questionnaire comprises 5 discrete 5-point Likert-style questions, and responses from these questions were individually analyzed to produce a numerical result ranging from 1 (severe back pain) to 5 (no back pain) for each patient, which allowed for statistical analysis.

All patients had 25-hydroxyvitamin D level checked preoperatively, and the date of the sample was recorded. The 25-hydroxyvitamin D level was taken on the same date that the SRS-22 scores were completed by the patient to ensure accurate correlation between the two.

Patients who were vitamin D-deficient were treated based on their level of deficiency and on local guidance from the metabolic bone unit. The levels of deficiency were classified according to the National Institute for Health and Care Excellence Clinical Knowledge Summary,[6] as follows:

- Severe deficiency: <25 nmol/L
- Mild deficiency: 25 to 50 nmol/L
- Suboptimal: 50 to 75 nmol/L
- Adequate: >75 nmol/L

Patients with severe deficiency levels required treatment with 10,000 IU oral Pro D3 vitamin D nutritional supplementation; the need for calcium supplementation was also considered; and serum bone profile and vitamin D levels were repeated 2 to 3 months after commencement of treatment. If vitamin D levels remained low, treatment was continued with low-dose daily multivitamin supplementation.

Patients with mild deficiency levels were given vitamin D supplementation provided at a dose of 200 to 400 IU/day (dose-dependent on age/product used). Patients with suboptimal levels required dietary and lifestyle advice, but no supplementation. Adequate levels required no intervention.

### Statistical Analysis

The overall prevalence of vitamin D deficiency and back pain within the cohort was calculated and compared to age and season match national data. Spearman correlation coefficient was calculated to determine correlation between the severity of vitamin D deficiency with both preoperative Cobb angles and back pain scores. An $r_s$ value of 0.20 to 0.39 was considered weak, 0.40 to 0.59 moderate, and 0.60 to 0.79 a strong correlation.

## RESULTS

Within the selected time period, 25-hydroxyvitamin D levels were collected on a total of 201 consecutive patients undergoing corrective surgery for AIS. Preoperative SRS-22 scores were completed by 196 (97.5%) patients. Four patients (2.5%) who did not complete the SRS-22 survey were excluded from statistical analysis.

A total of 177 (88%) patients included were young women and 24 (12%) were young men, which is consistent with the published demographics of AIS patients who require surgical intervention for curves greater than 40°.[7,8] Mean age at time of surgery was 14.9 years (13–18).

The mean preoperative standing Cobb angle was 64.04° (range: 40–99, SD: 10.96). There was no correlation detected between preoperative standing Cobb angle and severity of vitamin D deficiency ($r_s$ = –0.12). The correlation between preoperative Cobb angle and vitamin D should be interpreted with a degree of caution as only patients who warranted surgical intervention were included in our analysis; therefore, all patients included

**Table 1.** Vitamin D deficiency levels by number of patients, mean vitamin D level, mean SRS-22 pain score, and mean Cobb angle.

| 25-Hydroxyvitamin D Level (nmol/L) | No. of Patients (%) | Mean (SD) 25-Hydroxyvitamin D Level (nmol/L) | Mean SRS-22 Pain Score Domain (1–5) | Mean Cobb Angle |
|---|---|---|---|---|
| <25 | 41 (20.4%) | 19.45 (4.5) | 3.28 | 66.5° |
| 25–49 | 108 (53.7%) | 37.97 (7.2) | 3.45 | 64.2° |
| 50–75 | 41 (20.4%) | 61.93 (7.0) | 4.00 | 60.6° |
| >75 | 11 (5.5%) | 96.63 (20.2) | 4.34 | 61.2° |

Abbreviation: SRS-22, Scoliosis Research Society-22.

had significant Cobb angles recorded at the time vitamin D sample was analyzed.

The mean 25-hydroxyvitamin D level was 41.8 nmol/L (range: 8.8–139.1, SD: 20.06). Only 11 (5.5%) patients in the cohort had adequate 25-hydroxyvitamin D levels of 75 nmol/L or greater. Forty-one (20.4%) patients had suboptimal levels of 50 to 75 nmol/L requiring lifestyle advice but no supplementation. One hundred and eight (53.7%) patients had mild deficiency of 25 to 50 nmol/L, and 41 (20.4%) patients had severe deficiency with levels <25 nmol/L (Table 1).

A total of 149 (74%) patients required supplementation to treat vitamin D deficiency. A moderate correlation was identified between the severity of vitamin D deficiency and the severity of preoperative back pain recorded with SRS-22 ($r_s = 0.42$) (Figure 1).

Vitamin D levels were analyzed quarterly at the time of sample analysis, and this shows a typical pattern seen within northern Europe, with the highest levels in the summer months and the lowest in the winter. This reflects the association to direct sunlight exposure and the hours of sunlight/month in the United Kingdom (Figure 2).

## DISCUSSION

The effects of vitamin D deficiency and bone health in patients with AIS have recently become of increasing interest, with growing amounts of literature being produced on the topic. Previous studies have investigated the role of vitamin D in the pathogenesis, skeletal growth, and curve magnitude in patients with AIS.[9–12] A recent study from the United Kingdom highlighted

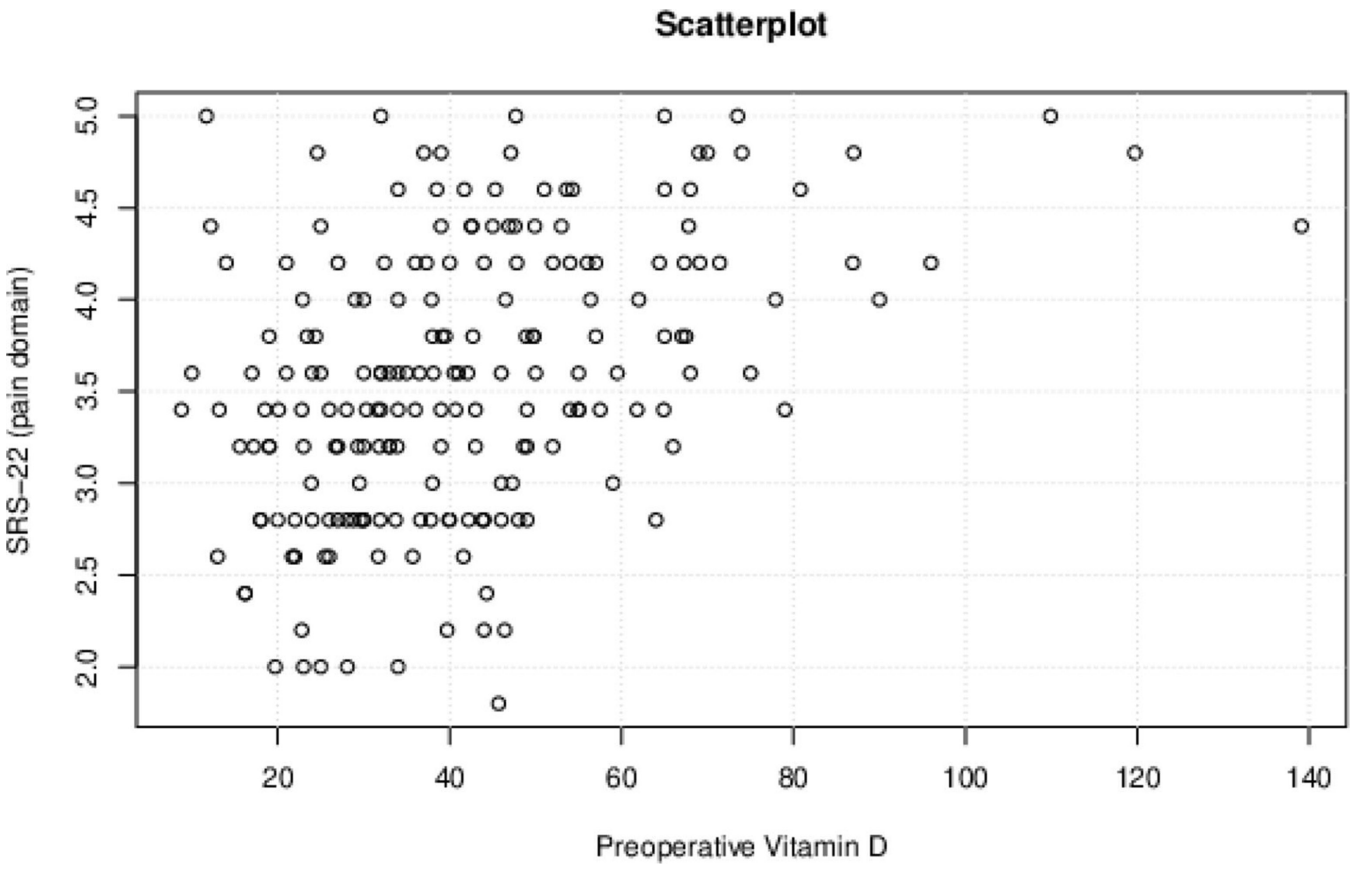


**Figure 1.** Correlation between Scoliosis Research Society-22 (SRS-22) pain score and preoperative vitamin D level ($P < 0.001$, $r^S = 0.42$).

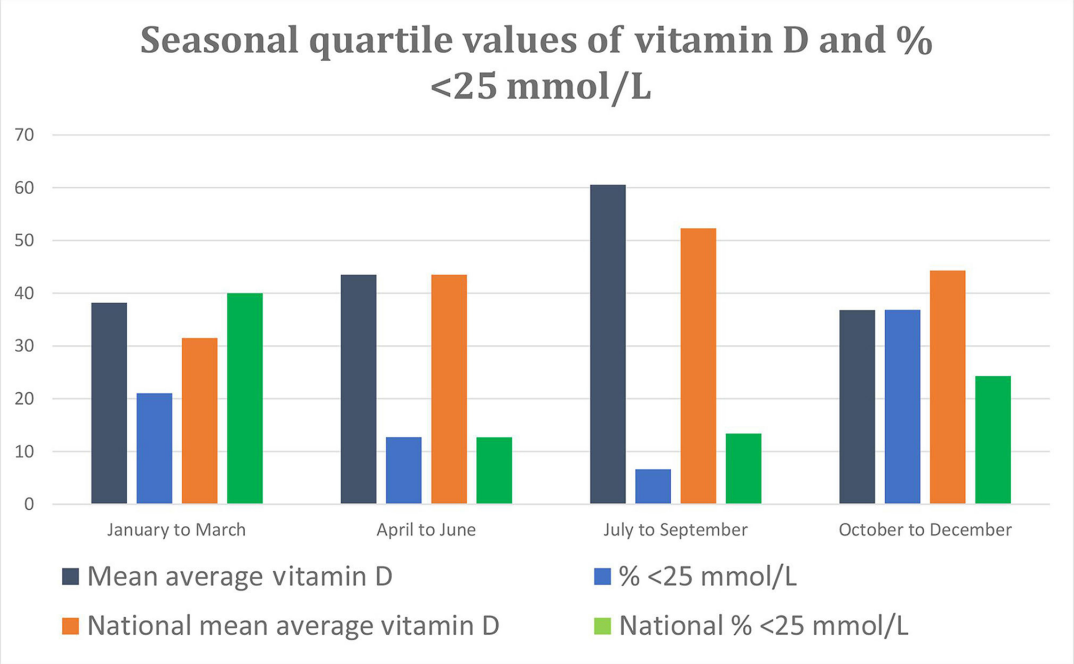


**Figure 2.** Seasonal variation of vitamin D in adolescent idiopathic scoliosis vs healthy national controls. Data from the *Clinical Knowledge Summary*.[6]

concerns that vitamin D deficiency is associated with worse preoperative outcome scores in patients with AIS,[13] but clarity regarding the reason for the lower scores is still awaited. No previous study has investigated the prevalence of vitamin D deficiency in patients with AIS within the UK population or its relationship to preoperative back pain.

We identify a previously unknown moderate correlation between preoperative back pain scores and severity of vitamin D deficiency in patients undergoing surgical intervention for AIS.

This large cohort study including 201 patients treated for AIS showed a high prevalence of vitamin D deficiency, with only 5.5% of patients having adequate levels of vitamin D. The number of patients who required supplementation to treat vitamin D deficiency was particularly high with 74% of patient's requiring treatment. The large prevalence of vitamin D deficiency highlighted in our study is comparable to the general pediatric UK population. National data published as part of the UK national diet and nutrition survey in healthy individuals revealed that the mean 25-hydroxyvitamin D level in girls aged 11 to 18 years was 41.1 nmol/L, which is comparable to the mean level of 41.8 nmol/L in our series of patients with AIS, the large majority of whom were girls 11 to 18 years old. Similarly, the percentage of healthy individuals with severe deficiency less than 25 nmol/L was 24.4%, compared to 20.4% in our series.[14]

Mayes et al performed a similar prevalence study in pediatric patients having scoliosis surgery.[15] They found vitamin D deficiency varied by diagnosis, and in the 126 patients with idiopathic scoliosis, only 10.3% had severe deficiency at <30 nmol/L, much less than in this study where 20.4% had severe deficiency at <25 nmol/L. Vitamin D is known to increase with exposure to sunshine, which is an average of 2335 hours/year in Cincinnati where the Mayes et al study was done compared with 1445 hours/year in Sheffield, UK.

In the cross-sectional study by Gozdzialska et al, vitamin D deficiency was significantly greater in patients with AIS in Poland when compared to healthy girls.[16] The mean vitamin D in the AIS girls was 41.3 nmol/L, which is very similar to our AIS patients; however, their control children had higher levels of vitamin D, especially the postmenarchial girls.

A large proportion of patients in our study experienced preoperative back pain, with 63% of patients complaining of back pain within 6 months.

Vitamin D deficiency is known to cause generalized musculoskeletal pain[17]; this study reveals that there is a correlation between the severity of vitamin D deficiency and the amount of back pain experienced by patients. This correlation has yet to be described in patients with AIS. Although patients complaining of pain should be investigated with MRI to rule out pathological causes for their scoliosis,[18] the treating surgeon should also consider the possibility that vitamin D

deficiency could be a cause of the pain. In our study, all patients had normal preoperative MRI, which excluded other structural causes for back pain, further suggesting that vitamin D deficiency has an association with AIS and back pain.

This study compliments previous studies that highlighted that a large proportion of pediatric patients undergoing surgery are deficient of vitamin D.[19] The correlation between back pain and vitamin D found in this study may be specific to patients with AIS, but we should be observant of the role vitamin D has in muscle strength,[20,21] the body's immune response,[22,23] and scarring process.[24] Successful spinal fusion is integral to the success of surgery for AIS, and symptomatic pseudarthrosis can arise in up to 5% of patients treated for AIS, causing persistent pain, failure of implants, and recurrence of deformity.[25,26] Although this study was not designed to investigate the effects of vitamin D deficiency on spinal fusion rates in patients with AIS, previous studies have highlighted the importance of vitamin D in bone health and promoting spinal fusion rates.[27,28]

It seems apparent that with the high prevalence of vitamin D deficiency and its significant associations, we should be routinely investigating and optimizing vitamin D levels in patients with AIS preoperatively within our Northern European patient population.

AIS is known to be associated with back pain that reduces following surgical intervention.[29] In this study, we treated all patients with vitamin D supplementation when the deficiency was first detected. This, along with the fact that all patients included in this study were undergoing surgical intervention, makes it challenging to determine any postoperative relationship with pain scores.

We appreciate that the spinal pathology could be causing the pain, and in many patients, the cause of pain is likely multifactorial; however, by only including AIS patients and with no correlation between Cobb angle and pain scores, we believe the correlation between vitamin D levels and pain to be important.

The study's main limitation is that only patients undergoing corrective surgery were included for analysis, meaning all patients had reached a curve magnitude warranting surgical intervention. This means we are unable to draw conclusions about the effects of vitamin D on curve progression. Furthermore, larger randomized studies are required to investigate the effect of vitamin D deficiency on early curve progression

## CONCLUSION

Vitamin D deficiency is common in patients with AIS; in the present study, only 5.5% of patients had adequate levels and 74% of patients had levels requiring oral supplementation. We found a strong correlation between the severity of back pain and the level of vitamin D deficiency. Given this correlation, we believe all patients with AIS should be screened for vitamin D deficiency and treated appropriately when deficient. This simple intervention may improve back pain and activity levels in patients with AIS.

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