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Systematic Review (Pages: 11-27)

Prevalence of Vitamin D Deficiency and Associated Factors in Healthy Iranian Children and Adolescents: A Systematic Review

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Abstract

Background: Vitamin D deficiency can have significant health implications for children and adolescents, affecting bone development, immune function, and overall well-being. We aimed to investigate the prevalence of vitamin D deficiency and its associated factors in Iranian children and adolescents.

***Materials and Methods*:** In this systematic review, a search of online databases (Medline, Scopus, Web of Science, WHO, CIVILICA, and Google Scholar) was conducted with no time limit up to March 2024. The quality of the information was evaluated using the STROBE checklist.

Results: Finally, 33 related studies were included. The prevalence of vitamin D deficiency in children and adolescents was estimated to be 47.35% (3-91.7%), with a mean value ranging from 7.26 ± 2.81 to 23.46 ± 9.30 ng/dL. The prevalence of vitamin D insufficiency in children and adolescents was estimated to be 55.6% (11.3-100%). The prevalence of vitamin D deficiency in infants was estimated to be 51% (2.8-93.3%), with a mean value ranging from 28.3 ± 19.4 to 61.3 ± 31.4 ng/dL. The prevalence of severe vitamin D deficiency was significantly higher among girls than boys. The concentration of 25(OH)D was associated with BMI ($p = 0.000$, $r = -0.13$), pubertal status ($r = -0.08$, $p= 0.04$), weight ($p = 0.000$, $r = -0.12$), waist circumference ($r = -0.112$, $p = 0.047$), age ($p = 0.000$, $r= -0.13$), height ($p < 0.05$), pubertal status ($r=- 0{\cdot}08$, $p=0{\cdot}04$), sunlight exposure ($r = 0.10$, $p = 0.04$), gender ($p = 0.01$), maternal vitamin D deficiency ($p < 0.01$), daily intake of vitamin D ($p < 0.05$), and the areas ($p < 0.05$).

***Conclusion*:** The prevalence of vitamin D deficiency among Iranian children and adolescents is alarmingly high, with various studies indicating significant rates across different age groups, genders, and regions. This deficiency poses serious health risks, necessitating urgent public health interventions.

Key Words: Adolescents, Children, Iran, Prevalence, Vitamin D deficiency.

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1- INTRODUCTION

Vitamin D plays a crucial role in the metabolism of calcium and phosphate, which are essential for maintaining bone mineral density. Research indicates that up to 75% of children with fractures may have vitamin D deficiency, highlighting its importance in preventing skeletal problems (1). Furthermore, nutritional rickets, a condition caused by vitamin D deficiency, remains a significant concern in pediatric populations (2). Recent studies indicate a correlation between low vitamin D levels and adverse lipid profiles in children, potentially increasing their risk for cardiometabolic diseases (3). The influence of vitamin D extends beyond musculoskeletal health; it also plays a significant role in immune function and may affect various pathologies (4). Vitamin D deficiency among children is a pressing public health issue globally, with significant variations in prevalence across different regions. Recent studies highlight alarming levels of deficiency and insufficiency, underscoring the urgent need for targeted interventions. A study in China (2024) found that 21.4% of children aged 0-17 were deficient in vitamin D, while 31% were insufficient, with a median serum level of 29.72 ng/mL (5).

Research in Qatar indicates that 40% of teenagers aged 10-17 experienced severe vitamin D deficiency, with females at a higher risk (30.4%) compared to males (15.3%) (6). In Saudi Arabia, the prevalence of vitamin D deficiency was reported at 17.6%, with 25.6% classified as insufficient. Additionally, older children (ages 10-14) exhibited higher deficiency rates (7). Another study in Karachi found that 71.8% of children under five were deficient in vitamin D (8). A systematic review and meta-analysis conducted in Iran in 2018 showed that the prevalence of vitamin D deficiency was 35% for boys (95% confidence interval [CI]: 34–37), and 61% for girls (95% CI: 60–63). In addition, the overall prevalence of vitamin D insufficiency among Iranian children and adolescents was 31% (95% CI: 30–31) (9). According to a meta-analysis conducted in Iran in 2018, the prevalence of vitamin D deficiency among the overall population was found to be 45.64%. The prevalence among females was significantly higher at 61.90%, and among pregnant women, it was also notably high at 60.45% (10). Results of another study showed that the prevalence of vitamin D deficiency in both sexes increased in the year 2000 compared to the year 2010 (11).

Khazaei et al. (2018) highlighted a significant public health concern regarding vitamin D deficiency among healthy individuals in Iran, with 73% of 102 participants showing levels below 20 ng/mL and only 9% normal (12). A study from 2016-2017 found 51% prevalence of vitamin D deficiency in Tehran children aged 1-6 years (significant public health issue), including 4.51% severe deficiency (<10 ng/mL) (13). Another study on adolescent girls aged 14-17 years in Boukan showed mean serum 25(OH)D of 7.26 ± 2.81 ng/mL, with 100% insufficiency (14).

Studies indicate that vitamin D deficiency is a significant public health issue among children and adolescents in Iran, with prevalence rates varying across different regions and age groups. We aimed to conduct a systematic review to estimate the prevalence of vitamin D deficiency among healthy Iranian children and adolescents and to identify related factors.

2- MATERIALS AND METHODS

The Preferred Reporting Items for Systematic review and Meta-Analysis (PRISMA) statement was used as the template for this review (15). According to the Endocrine Society Clinical Practice Guideline, a serum level of 25(OH) D under 50 nm/L or 20 ng/ml and between 20 and 30 ng/ml are considered vitamin D

deficiency and insufficiency, respectively (16, 17).

2-1. Eligibility criteria

The PICO (Participants, Interventions, Comparison, and Outcomes) framework was utilized with a particular emphasis on the Participants and Outcomes due to the descriptive nature of the research.

- **Participants**: Healthy Iranian children/adolescents (under 18 years).
- **Interventions**: Since the included studies were non-interventional, there was no specific intervention group.
- **Comparison**: The studies did not include a comparison group.
- **Outcome**: The primary outcome measured the proportion of vitamin D deficiency in children and/or adolescents. Vitamin D insufficiency was the secondary outcome indicator.

2-2. Search strategy

The following keywords were converted into PubMed Medical Subject Headings (MeSH) terms and used to find studies that were related: vitamin D, 25-hydroxy vitamin D, 25(OH) D, vit D deficiency, children, adolescents, prevalence, and Iran. The Boolean operators "OR" and "AND" matched the required keywords.

2-3. Information sources

A systemic search of electronic databases Medline (via PubMed), CIVILICA, Web of Science, Scopus, and WHO database, as well as the Google Scholar search engine, was conducted for studies on the prevalence of Vitamin D deficiency in Iranian children and adolescents and related factors, up to March 2024. The search was done independently and in duplication by two reviewers, and any disagreement was dissolved by the supervisor.

2-4. Included and exclusion Criteria

We considered the following criteria for inclusion in this review: studies that investigated the prevalence of vitamin D deficiency in healthy Iranian children/adolescents, clinical trials that investigated vitamin D deficiency management in Iran, and studies that included patients under 18 years old published up to March 2024 and written in English or Persian. The exclusion criteria were abstracts without the full article, articles not written in English or Persian, review articles, studies reporting the prevalence in ages higher than 18 years, systematic reviews and meta-analyses, letters to the editor, editorials, short reports, commentaries, and case reports.

2-5. Quality assessment

The risk of bias was assessed using the standard STROBE (STrengthening the Reporting of Observational Studies in Epidemiology) guidelines (18). STROBE is a valuable tool for evaluating the quality of observational studies. This checklist consists of 22 items, each scored based on its relevance to the present study. The final score of the checklist was 30, with a minimum score of 15.0. The assessment was conducted independently by two reviewers, and any discrepancies were resolved by a third reviewer.

2-6. Data extraction

A data collection form was designed and implemented by two independent authors. The data collected from the selected studies included the authors' names, the date of the survey, the type of study, the target population, age and sex groups, settings, sample size, and main findings.

2-6. Synthesis of results

Due to the different sample sizes, definitions of deficiency and insufficiency, goals and outcomes, and the age groups involved, a meta-analysis was not performed. As a result, the authors selected a narrative summary of the studies

that described their methodology and key findings.

2-7. Ethical considerations

Approval from a research ethics committee was not necessary, as the study analyzed only publicly available articles. The research adhered to ethical standards by respecting copyright laws and ensuring transparency in its methods and sources.

3- RESULTS

In the present analysis, 33 related studies on a total of 43,079 individuals were selected based on specific inclusion and exclusion criteria (**Figure 1**). All these studies met acceptable quality standards according to the STROBE scale. The main characteristics of the selected studies are summarized in **Table 1** and the following:

1. A nationwide cross-sectional study aimed to determine the reference interval of circulating vitamin A and D levels among 2,596 Iranian students aged 7 to 18 years based on sex, age, and region of residence. The results showed that children aged 7 to 12 had higher serum 25(OH)D concentrations than adolescents aged 13 to 18 (26.96 ± 8 ng/mL versus 26.04 ± 10 ng/mL, p = 0.007). There were significant variations in both retinol and 25(OH)D concentrations across different age groups (19).

2. A cross-sectional study aimed to determine the association between body mass index (BMI), and serum levels of vitamin D in 215 children aged 2-7 years who were outpatients at Taleghani Paediatric Hospital in Gorgan, Iran. The results showed that 85.6% of the subjects had vitamin D deficiency. There was a linear relationship between waist circumference and serum vitamin D levels (p < 0.01). The mean serum vitamin D levels in girls and boys were 22.76 ± 11.62 nmol/L and 23.46 ± 9.30 nmol/L, respectively; however, this difference was not statistically significant. Although there was no significant relationship between BMI and vitamin D levels, variations were noted across different ethnic groups, and a correlation was found between waist circumference (WC), and vitamin D levels (20).

3. A cross-sectional study aimed to assess vitamin D status and examine its possible relationship with sex, residing area, and duration of sun exposure in 257 children aged 9-12 years in Tehran. The results showed that the mean serum 25(OH)D concentration was 21.9±15.6 nmol/L. Vitamin D status was significantly different between boys and girls (p = 0.01), and among different areas (p=0.004). The findings indicate a high prevalence of vitamin D deficiency among children in Tehran, with notable differences based on gender and geographic location, aligning with previous research that highlights similar trends in vitamin D status across various demographics in the region (21).

4. A nationwide study aimed to investigate the association of vitamin D with mental health and violent behaviors in a sample of 1,095 Iranian adolescents. The results showed that 40% of subjects had serum 25(OH)D values below 10 ng/mL (vitamin D deficient), and 39% had levels between 10-30 ng/mL (vitamin D insufficient). Risk estimates indicated that subjects with vitamin D insufficiency and deficiency had higher odds of reporting worry than those in the normal vitamin D group, with an odds ratio (OR) of 2.417 (95% CI: 1.483-3.940) for vitamin D-insufficient students, and an OR of 2.209 (95% CI: 1.351-3.611) for vitamin D-deficient students (p= 0.001) (22).

5. A cross-sectional study aimed to determine the prevalence of vitamin D deficiency in children in Birjand, located in eastern Iran. The results indicated that vitamin D levels among the subjects ranged from a minimum of 4.3 ng/dL to a maximum of 63.1 ng/dL, with a mean

value of 15.4 ± 8.1 ng/dL. The prevalence of vitamin D levels categorized as deficient, insufficient, and sufficient was found in 76.9%, 18.5%, and 4.6% of the students, respectively. Furthermore, vitamin D deficiency was significantly more prevalent among females (23).

6. A qualitative analytical study aimed to assess Vitamin D deficiency (VDD) prevention policies in Iran through a policy analysis of agenda setting using the multiple streams framework (MSF). According to Kingdon's MSF theory, the problem stream included the high prevalence of VDD among Iranian infants (23.3%), adolescents (76%), and adults (59.1%) (24).

7. A national cross-sectional study aimed to examine the association between Vitamin D deficiency (VDD) and subjective health complaints (SHC) in 2,596 Iranian children and adolescents aged 8-18 years. The results indicated that serum levels of vitamin D in approximately 70% of these individuals were lower than 30 ng/mL. The most prevalent SHCs reported were irritability (40.9%) and feelings of anxiety (33.7%). Furthermore, multiple complaints among students with VDD were found to be 2.5 times greater than those with sufficient vitamin D concentrations ($p<0.001$) (25).

8. A cross-sectional study aimed to assess the 25(OH)D status among 807 Iranian volunteers aged 1 to 16 years. The results showed that 25.27% of children were deficient in 25(OH)D, while 59.1% were insufficient. A significant negative correlation was found between serum 25(OH)D levels and weight ($p=0.000$, $r=-0.12$), BMI ($p=0.000$, $r=-0.13$), and age ($p=0.000$, $r=-0.13$) (26).

9. A cross-sectional study aimed to determine the prevalence of vitamin D insufficiency (VDI) among 963 students aged 7–18 living in Tehran. VDI was defined as a serum 25-OHD level of less than 20 ng/ml. The results indicated that the prevalence of VDI was 53.6% in girls and 11.3% in boys (27).

10. A cross-sectional descriptive-analytical study aimed to assess the prevalence of vitamin D deficiency in a group of 1,047 students from four junior high and six high schools in Shahroud, Iran. The results showed that the mean vitamin D levels in the studied population were 14.7±9.4 ng mL. Only 7.2% of the boys and 3.8% of the girls had adequate sun exposure. This indicates that vitamin D deficiency is prevalent among Iranian adolescents (28).

11. A nationwide cross-sectional study aimed to assess vitamin D status according to the climate of the living area in a nationally representative sample of 1,095 adolescents aged 10-18 years, selected using a multistage cluster sampling method from 27 provinces of Iran. The results indicated that vitamin D deficiency was present in 40% of participants, with 40.70% of boys and 39.30% of girls affected. There was a significant difference in 25(OH)D concentrations among participants living in three different climates ($p < 0.05$). The highest frequency of hypovitaminosis D (45.2%) was documented among boys residing in humid-rainy regions (29).

12. A cross-sectional study aimed to evaluate the sex- and age-related prevalence of vitamin D deficiency in 7,504 subjects aged 6 to 65 years in Mashhad, northeastern Iran. The results indicated that vitamin D deficiency among Iranian children and adolescents was notably high, with prevalence rates reported as 56.3% in girls and 11.3% in boys aged 6 to 18 years old (30).

13. A cross-sectional study aimed to investigate the prevalence of vitamin D deficiency in 288 children aged 1 to 6 years and its relation to their age, sex, and body mass index. The results showed that the prevalence of vitamin D deficiency

was 51%, with severe deficiency at 4.51% (vitamin D level < 10 ng/mL). Additionally, vitamin D levels had a statistically significant relationship with age, indicating that serum levels of 25(OH) vitamin D decreased by 3.47 ng/mL for each additional year of age ($p<0.001$) (13).

14. A cross-sectional study aimed to examine the prevalence and determinants of vitamin D deficiency in 2,596 Iranian children and adolescents. The results showed that the prevalence of vitamin D deficiency among these children and adolescents was 71.1%, with no significant difference between boys (72.0%) and girls (70.1%). In the multivariate regression model, both genders who reported sun exposure for at least 30 minutes per day and those taking vitamin D supplementation had lower odds of vitamin D deficiency (all p-values < 0.05). In boys, obesity increased the odds of vitamin D deficiency (adjusted odds ratio, 95% confidence interval: 1.57, 1.08–2.27) (31).

15. A cross-sectional study aimed to evaluate the prevalence of vitamin D deficiency and its associated factors in 477 southern Iranian children aged 9-18 years. The results showed that 81.3% of subjects were 25(OH)D deficient. The 25(OH)D concentration was associated with BMI ($r = -0.1$, $p= 0.02$), pubertal status ($r = -0.08$, $p = 0.04$), and sun exposure ($r = 0.10$, $p = 0.04$). In multiple regression analysis, after adjusting for confounding factors, age and puberty were found to be independently associated with 25(OH)D concentration ($p = 0.008$ and $p = 0.006$, respectively). There was a significant correlation between exercise and 25(OH)D concentration after adjustment for BMI ($p = 0.01$) or fat mass index ($p = 0.02$). This indicates that 25(OH)D deficiency is highly prevalent among children in southern Iran and is related to insufficient sun exposure, low physical activity, advancing age, and the pubertal stage (32).

16. A cross-sectional study aimed to evaluate the prevalence of vitamin D deficiency, variations in bone turnover markers, and the influencing factors among 444 adolescents in Tehran. The results indicated that vitamin D deficiency was prevalent among adolescents, with only 22.4% of students having normal serum vitamin D levels. Vitamin D insufficiency was found in 34.2% of students, while vitamin D deficiency was present in 43.3%. Serum levels of vitamin D, osteocalcin, CTX (C-terminal telopeptide of type I collagen), and bone-specific alkaline phosphatase were significantly higher in boys across all ages. Additionally, serum levels of 25(OH) vitamin D positively influenced bone turnover markers and exhibited a negative correlation with parathyroid hormone (PTH) (33).

17. A cross-sectional study aimed to determine the epidemiology of vitamin D deficiency in 124 subjects aged 10-18 years in Minoodar district in Qazvin. The results showed that the mean vitamin D level was 12.15±7.20 ng/dL. The minimum vitamin D level was 1.08 ng/dL, and the maximum was 26.80 ng/dL. Vitamin D levels in females were significantly lower than in males. None of the study subjects had vitamin D sufficiency. All females and 81% of males had vitamin D deficiency. Vitamin D deficiency in females was significantly higher than in males (34).

18. A cross-sectional study aimed to evaluate the vitamin D status in 513 healthy six-year-old children in Isfahan. The results showed that vitamin D serum level was < 20 ng/ml in 3% of cases and < 33 ng/ml in 26% of cases. Sunlight exposure and daily intake of vitamin D had significant effects on serum levels of vitamin D. This study confirmed the high

prevalence of vitamin D deficiency in children (35).

19. A cross-sectional study aimed to evaluate the prevalence of vitamin D deficiency in 318 Isfahani high school students in 2004. The results indicated that the prevalence of vitamin D deficiency, defined as 25-OHD levels <20 ng/ml, was 46.2% among all subjects, with 72.1% in females and 18.3% in males. Additionally, vitamin D deficiency was approximately four times more prevalent in female students compared to males ($p<0.05$) (36).

20. A cross-sectional study aimed to evaluate the status of vitamin D in pregnant women and newborns. The results indicated that 66.8% of mothers and 93.3% of newborns had vitamin D deficiency (defined as less than 35 nmol). Furthermore, vitamin D levels were significantly lower in infants whose mothers were vitamin D deficient compared to those whose mothers were not ($p< 0.01$) (37).

21. A cross-sectional study aimed to evaluate the vitamin D3 status in 235 children under 15 years admitted to Urmia Hospital. The results showed that 75 children (31.9%) had a severe deficiency, 54 (23%) had a mild deficiency, and 106 (45.1%) were normal. Considering age groups, the level of vitamin D in the toddler group (0-5 years) was higher than in children (5-10), and adolescents (11-15). There was a significant difference between the two groups. In terms of seasonal variation, the highest levels of vitamin D were observed in autumn, while the lowest levels occurred in spring, and this difference was statistically significant ($p < 0.05$). The results of this study demonstrate a high prevalence of mild to severe vitamin D deficiency among children under the age of 15 (38).

22. A cross-sectional study aimed to determine the prevalence of vitamin D deficiency and its relationship with overall and abdominal obesity in 216 adolescent girls. The results showed that the mean serum 25(OH)D was 7.26±2.81 ng/ml, and 100% of subjects had vitamin D insufficiency. There was a significant inverse correlation between serum 25(OH)D and waist circumference (WC) ($r = -0.112$, $p = 0.047$) (39).

23. A cross-sectional study aimed to assess vitamin D status among 1,111 primary school children in Tehran during the fall and winter of 2007-2008. The results showed that the prevalence of vitamin D deficiency was 91.7%, which was higher in girls than in boys according to both criteria used. Serum levels of 25(OH)D were inversely correlated with intact parathyroid hormone (iPTH) ($r = -0.154$, $p< 0.001$) (40).

24. A descriptive cross-sectional study aimed to investigate the prevalence of vitamin D and zinc deficiency among 3,380 adolescents aged 10 to 19 in Mashhad. The results showed that 11.4% of subjects had vitamin D deficiency, 51.9% had insufficient vitamin D, and 36.7% had normal vitamin D levels. The prevalence of vitamin D and zinc deficiency was higher in female adolescents than in male adolescents ($p < 0.001$). The study results indicated that the low level of zinc in the studied adolescents was not a risk factor for vitamin D deficiency (41).

25. A cross-sectional study aimed to determine the serum levels of vitamin D and the factors affecting these levels in 389 infants aged 2 to 6 years in Kermanshah. The results indicated that 8.7% of the infants had severe vitamin D deficiency, while 49.1% were insufficient, and 42.2% had normal levels of vitamin D. The highest mean serum vitamin D levels were observed during the summer, and there was a significant relationship between serum vitamin D levels and factors such as age, height, weight, and exposure to sunlight ($p < 0.05$) (42).

26. A cross-sectional study involving 420 adolescents aged 10-16 years aimed to investigate the prevalence and determine a cut-off point for vitamin D deficiency in Arak, Iran. The results indicated that when considering 25(OH) vitamin D levels as indicative of vitamin D deficiency, 84% of the students were found to be deficient (99.1% of girls and 66.5% of boys) (p=0.001). The scatter diagram revealed three cut-off points for vitamin D deficiency at 25(OH) vitamin D levels of <13, 21, and 33 ng/ml. This suggests that vitamin D deficiency is more prevalent among girls and increases with weight (p=0.05) (43).

27. A cross-sectional study aimed to evaluate the prevalence of vitamin D deficiency among 167 female students in secondary school in Yazd. The results showed that 60% of the subjects had vitamin D deficiency (95% CI 52.3-67.5), and 21% suffered from severe deficiency (95% CI 14.8-27.2) (44).

28. A cross-sectional study aimed to investigate the serum concentrations of vitamins A and D in Iranian infants. The results showed that the mean (standard deviation) concentration of vitamin D was 61.3 (31.4) nmol/L. Deficiency was found in 2.8% of infants (defined as <25 nmol/L) and insufficiency in 32.9% (defined as <50 nmol/L). Girls had lower vitamin D concentrations than boys (p=0.006) (45).

29. A cross-sectional study aimed to evaluate the prevalence of vitamin D deficiency and its related factors in 361 children and adolescents in North Khorasan, Iran. The results showed that the prevalence of vitamin D deficiency was 16.1% and insufficiency was 25.2%. Girls exhibited higher levels of vitamin D deficiency (30.6%), and insufficiency (38.7%). Additionally, the mean serum level of 25(OH)D decreased in older age groups (46).

30. A cross-sectional study aimed to evaluate vitamin D status and its association with components of metabolic syndrome in 297 healthy schoolchildren aged 7-11 years. The results showed that the mean serum 25(OH)D concentration was 14.12 ± 8.20 ng/mL (35.3 ± 20.5 nmol/L). Ninety-six percent of children had low serum 25(OH)D levels; 31.0% were deficient, and 65.0% had insufficient levels of 25(OH)D. Vitamin D deficiency was significantly higher in girls (p = 0.00) (47).

31. A cross-sectional study aimed to determine the association between air pollution and vitamin D status in 100 children aged 4 to 10 years in Isfahan. The results indicated that the mean serum level of 25(OH)D was 37.4 (22.5, 81.6) nmol/L. Vitamin D deficiency and insufficiency were identified in 37.9% and 46.3% of the children, respectively. In regions with ample sunlight, air pollution should be considered a contributing factor to hypovitaminosis D (48).

32. A nationwide cross-sectional study aimed to determine the association of serum 25-hydroxy vitamin D (25(OH)D) levels with measures of general and abdominal obesity in 1,090 students aged 10 to 18 across 27 provinces of Iran. The results indicated that the median serum 25(OH)D level was 13.0 ng/mL. Overall, 40% of participants were classified as vitamin D deficient, while 39% had vitamin D insufficiency (49).

33. A cross-sectional study assessed vitamin D status in 384 children and adolescents, examining puberty and obesity effects. Vitamin D deficiency affected 49%, significantly higher in females (33.1% vs. 15.9% in males, p<0.001). Obese children had lower mean vitamin D levels than non-obese (p<0.001). Females showed significantly lower levels than males only at Tanner stage II (12.3±9.0 vs. 19.6±16.6 ng/ml, p=0.005) (50).

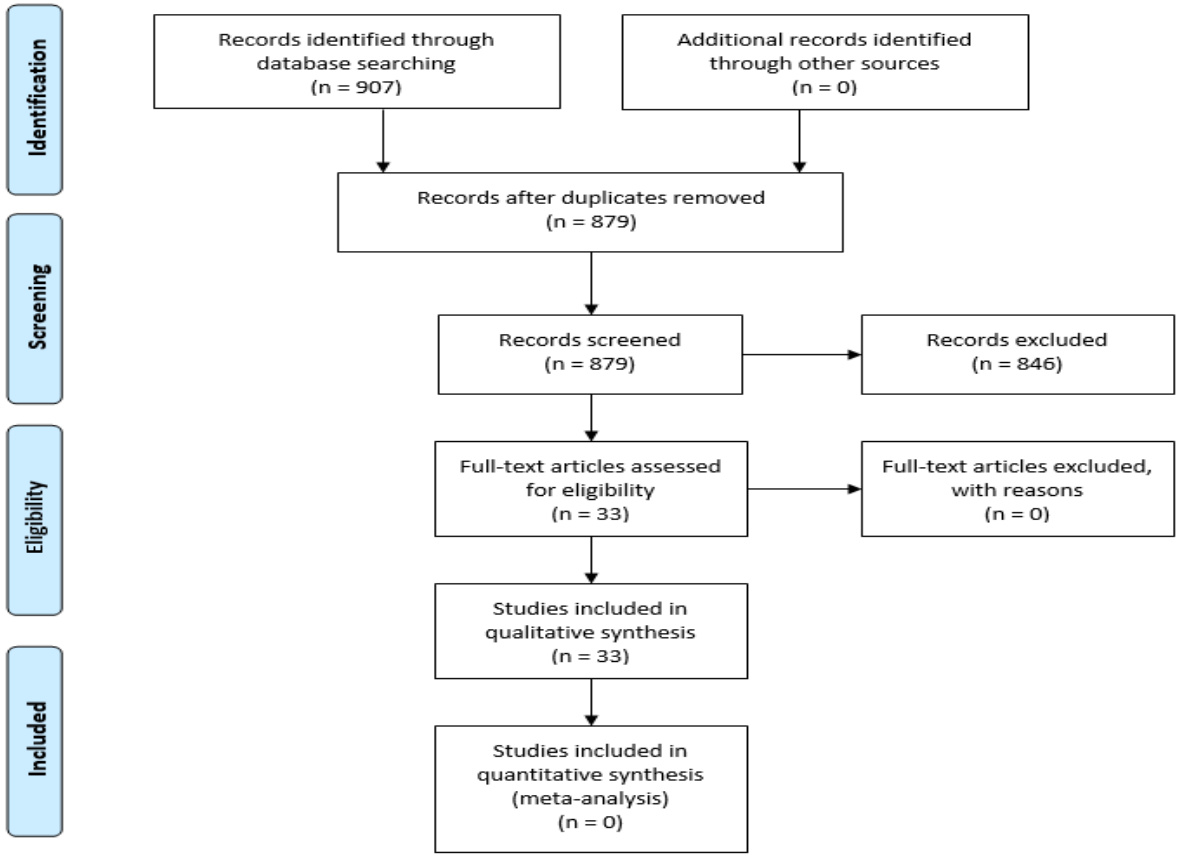

Fig.1: PRISMA Flowchart.

Tabale-1: The general characteristics of included studies (n=33).

Author, Year, Reference	Target population	Setting	Sample size	Age	Gender	Main results
Qorbani et al., 2021, (19)	children and adolescents	30 provinces of Iran	2596	7-18	MF	The children aged 7 to 12 years have significantly higher serum 25-hydroxyvitamin D concentrations than adolescents aged 13 to 18 years ($p < 0.05$)
Mohammadian et al., 2014, (20)	children	Gorgan	215	2-7	MF	85.6% of subjects had vitamin D deficiency.
Zahedi-Rad et al., 2015, (21)	children	Tehran	257	9-12	MF	The mean serum 25(OH)D concentration was 21.9 ± 15.6 nmol/L, with significantly higher concentrations in boys than in girls.
Ataie-Jafari et al., 2015, (22)	school students	27 provinces of Iran	1095	10-18	MF	40% of subjects were vitamin D deficient, and 39% had vitamin D insufficiency.
Zardast et al., 2015, (23)	children	Birjand	238	--	--	Vitamin D levels in the subjects ranged from a minimum of 4.3 ng/dL to a maximum of 63.1 ng/dL, with a mean value of 15.4 ± 8.1 ng/dL.
Aghapour et al., 2023, (24)	general population	National	27 interviews with stakeholders		MF	The prevalence of Vitamin D deficiency (VDD) in Iran is notably high among different age groups. Specifically, it is reported at 23.3% among infants, 76% among adolescents, and 59.1% among adults.
Namazi et al., 2021, (25)	children and adolescents	30 provinces of Iran	2596	8-18	MF	Approximately 70% of Iranian children and adolescents had serum levels of vitamin D lower than 30 ng/mL.
Nozari et al., 2021, (26)	children and adolescents	Babol city	807	1-16	MF	25.27% of the children were deficient in 25(OH)D, and 59.1% were insufficient.

Rabbani et al., 2009, (27)	children and adolescents	Tehran	963	7-18	MF	The prevalence of vitamin D insufficiency was 53.6% in girls and 11.3% in boys.
Ebrahimi et al., 2014, (28)	children and adolescents	Shahroud	1047	11-20	MF	Junior high school students had significantly lower levels of vitamin D (11.3±7.9 vs. 16.3±9.6 ng/mL).
Kelishadi et al., 2016, (29)	adolescents	27 provinces of Iran	1095	10-18	MF	Vitamin D deficiency was documented in 40% of participants, including 40.7% of boys and 39.3% of girls.
Esmaeili et al., 2019, (30)	general population		7504	6-65	MF	The prevalence rates of vitamin D deficiency are 56.3% in girls and 11.3% in boys aged 6 to 18 years.
Babaniamansour et al., 2019, (13)	children	Tehran	288	1-6	MF	The prevalence of vitamin D deficiency was 51%, while 4.51% had severe deficiency (level of vitamin D < 10 ng/mL).
Rastad et al., 2021, (31)	children and adolescents	30 provinces of Iran	2596	7-18	MF	The prevalence of vitamin D deficiency in Iranian children and adolescents is 71.1%, with no significant difference between boys (72.0%) and girls (70.1%).
Saki et al., 2017, (32)	children and adolescents	Fars Province,	477	9-18	MF	81.3% of subjects were deficient in 25(OH)D.
Larijani et al., 2016, (33)	adolescents	Tehran	444	<14	MF	Vitamin D insufficiency was reported in 34.2% of students, while vitamin D deficiency was found in 43.3% of them.
Ghanei et al., 2015, (34)	children	Minoodar district in Qazvin	124	10-18	MF	All females and 81% of males had vitamin D deficiency.
Ardestani et al., 2010, (35)	children	Isfahan city	513	6	MF	Vitamin D serum levels were found to be less than 20 ng/ml in 3% of cases and less than 33 ng/ml in 26% of cases.
Moussavi et al., 2005, (36)	adolescents	Isfahan city	318	14-18	MF	The prevalence of vitamin D deficiency among all subjects was 46.2%, with 72.1% in females and 18.3% in males.
Maghbooli et al., 2006, (37)	mothers and their infants	Karaj city	154	--	MF	66.8% of mothers and 93.3% of newborns had vitamin D deficiency (less than 35 nmol).
Rezaiee Golmisheh et al., 2018, (38)	children and adolescents	Urmia Hospital	235	<15	MF	31.9% of subjects had severe deficiency, 23% had mild deficiency, and 45.1% were in normal status.
Karimi-Hasanabad et al., 2015, (39)	adolescents	Boukan	216	14-17	F	All subjects exhibited vitamin D insufficiency.
Neyestani et al., 2012, (40)	children	Tehran	1111	9-12	MF	The prevalence of vitamin D deficiency was 91.7%, which was higher in girls than in boys according to both criteria used.
Shafaei et al., 2023, (41)	children and adolescents	Mashhad	3380	10-19	MF	11.4% of subjects had vitamin D deficiency, while 51.9% had insufficient vitamin D levels. The prevalence of vitamin D and zinc deficiencies was higher in female adolescents compared to male adolescents ($p < 0.001$).
Hemmati et al., 2019, (42)	children	Kermanshah	389	2-6	MF	8.7% of infants had severe deficiency, while 49.1% and 42.2% had insufficient and normal levels of vitamin D, respectively.
Talaei et al., 2011, (43)	adolescents	Mashhad	420	10-16	MF	84% of the students were vitamin D deficient, with 99.1% of girls and 66.5% of boys affected (p=0.001).
Shakiba et al., 2009, (44)	adolescents	Yazd city	167	12-16	F	60% of subjects suffered from vitamin D deficiency, and 21% of those affected experienced severe deficiency.
Olang et al., 2011, (45)	infants	all regions of Iran	7112	1-2	MF	Vitamin D deficiency was found in 2.8% of infants (with levels <25 nmol/L), and insufficiency was identified in 32.9% (with levels <50 nmol/L).

Shakeri et al., 2014, (46)	children and adolescents	Bojnurd city	361	7-18	MF	The prevalence of vitamin D deficiency was reported at 16.1%, while the rate of insufficiency was 25.2%.
Mellati et al., 2015, (47)	children	Zanjan city	297	7-11	MF	96% of children had low serum 25(OH)D levels; 31.0% were deficient, and 65.0% had insufficient levels of 25(OH)D.
Kelishadi et al., 2014, (48)	children	Isfahan city	100	4-10	MF	Vitamin D deficiency and insufficiency were detected in 37.9% and 46.3% of children, respectively.
Jari et al., 2015, (49)	children and adolescents	27 provinces in Iran	1090	10-18	MF	Overall, 40% of participants were vitamin D deficient, and 39% were vitamin D insufficient.
Saneifard et al., 2021, (50)	children and adolescents	Tehran	384	7-16	MF	Vitamin D deficiency was identified in 49% of the study participants, with a significantly higher prevalence in females (33.1%) compared to males (15.9%, $p < 0.001$).

M: male, F: female, 25(OH) D: 25-hydroxyvitamin D.

4- DISCUSSION

This systematic review aimed to investigate the prevalence of vitamin D deficiency and the associated factors in Iranian children and adolescents. The results indicated that the prevalence of vitamin D deficiency and insufficiency in children and adolescents was 47.35% (range: 3-91.7%), and 55.6% (range: 11.3-100%), respectively. The prevalence of vitamin D deficiency in infants was estimated to be 51% (range: 2.8-93.3%), with mean values ranging from 61.3±31.4 ng/dL. The findings of this systematic review highlight a significant prevalence of vitamin D deficiency and insufficiency among Iranian children and adolescents.

In the current review, a serum level of 25(OH)D below 20 ng/ml (50 nmol/L) was considered indicative of vitamin D deficiency, based on a report by the Institute of Medicine. A 25(OH)D level between 20 ng/ml and 30 ng/ml was classified as vitamin D insufficiency. The results indicate that the prevalence of vitamin D deficiency is notably high, particularly among females. For instance, one study showed that all females and 81% of males exhibited some level of deficiency, with the deficiency rate among female students being approximately four times greater than that of their male counterparts (34). Another study reported that 46.2% of all subjects had vitamin D deficiency, with 72.1% in females and 18.3% in males, indicating that females were significantly more affected ($p < 0.05$) (36). Additionally, a study of 167 female students in Yazd found that 60% had vitamin D deficiency, with 21% experiencing severe deficiency (44).

A separate study involving 384 children and adolescents evaluated vitamin D status and analyzed the influence of puberty and obesity on its levels. The findings revealed that 49% of the participants were vitamin D-deficient, with a significant gender disparity: 33.1% of females were deficient compared to 15.9% of males ($p < 0.001$) (50). These findings highlight the urgent need for public health interventions addressing vitamin D deficiency, particularly among females.

Based on the current review, the prevalence of vitamin D deficiency among infants is a significant concern, with estimates indicating that approximately 51% of infants are affected, ranging from 2.8% to 93.3%. Evidence suggests that vitamin D deficiency in infancy is linked to various health risks, including rickets and other growth-related issues (51-53). Therefore, the high prevalence of vitamin D deficiency among infants necessitates ongoing monitoring and intervention strategies to ensure adequate vitamin D levels for healthy growth and development.

Vitamin D plays a crucial role in bone growth and metabolism, and its deficiency can lead to significant health issues, particularly during embryonic development and childhood. In Iran, the prevalence of vitamin D deficiency is alarmingly high, affecting different demographic groups in various ways (19, 21, 22, 26, 30, 52). A systematic review in 2018 showed that the prevalence of vitamin D deficiency in Iranian boys and girls was 35% and 61%, respectively. The overall prevalence of vitamin D insufficiency among Iranian children and adolescents is 31% (9).

A systematic review and meta-analysis conducted in Iran in 2018 showed that the prevalence of Vitamin D deficiency was 35% for boys (95% confidence interval [CI]: 34–37), and 61% for girls (95% CI: 60–63). In addition, the overall prevalence of vitamin D insufficiency among Iranian children and adolescents was 31% (95% CI: 30–31) (9). This systematic review indicates a concerning increase in the prevalence of vitamin D deficiency among children and adolescents compared to previous years. These statistics underscore a significant public health issue, as vitamin D deficiency can result in various health complications, including bone diseases such as rickets, autoimmune disorders, and other chronic conditions (13, 54). The findings suggest a need for targeted interventions to address vitamin D deficiency in this demographic across Iran.

The high prevalence of vitamin D deficiency in Iran is attributable to several interrelated factors:

- **Limited Sunlight Exposure**: Cultural practices in Iran significantly restrict sun exposure, which is crucial for vitamin D synthesis. Many Iranians, particularly women, adhere to clothing norms that limit skin exposure to sunlight. This results in a pronounced deficiency, as traditional clothing often covers most of the skin, inhibiting the natural production of vitamin D through sunlight exposure. The issue is compounded by the fact that even in sunny regions such as Isfahan, cultural restrictions limit direct sunlight exposure, exacerbating the deficiency problem (10, 55, 56).
- **Dietary Habits**: Dietary Habits: The average per capita milk consumption in Iran is approximately 85-90 kilograms, which falls short of the World Health Organization’s recommendation of at least 165 kilograms. This low intake significantly contributes to insufficient dietary vitamin D levels. Furthermore, there is a general lack of significant food sources rich in vitamin D within the typical Iranian diet, which further aggravates the situation (10, 57).
- **Urbanization**: Increased urbanization has led to lifestyle changes that reduce outdoor activities. Many people now spend more time indoors due to work and lifestyle choices, which limits their exposure to sunlight. Additionally, urban environments often suffer from air pollution, which can hinder UV radiation penetration and further diminish vitamin D synthesis (54, 58).
- **Lifestyle Changes**: Various lifestyle factors contribute to the rising rates of vitamin D deficiency in Iran. Increased use of sunscreen, combined with cultural practices that discourage sun exposure, plays a critical role in this issue15. Moreover, dietary insufficiencies related to low consumption of vitamin D-rich foods are prevalent among many Iranians. The shift towards more sedentary lifestyles and reduced outdoor activity due to urbanization significantly contributes to this public health challenge (54, 55, 57, 58).

The findings emphasize the immediate necessity for public health interventions

aimed at addressing vitamin D deficiency, especially in females. Various strategies are proposed to tackle this pressing public health concern:

- **Supplementation Programs:** Encouraging vitamin D and calcium supplementation may help mitigate the risks of deficiency.
- **Dietary Improvements:** Promoting the consumption of vitamin D-rich foods is essential for maintaining optimal health and preventing deficiencies.
- **Public Awareness Campaigns**: It is crucial to increase awareness about the importance of sunlight exposure and dietary sources of vitamin D. This knowledge can significantly improve overall health outcomes in the population (59-63).

By focusing on supplementation programs, improving diet, and increasing public awareness of the importance of vitamin D, health providers can reduce this common problem among children and adolescents.

5- CONCLUSION

The prevalence of vitamin D deficiency and insufficiency among Iranian children and adolescents is a significant public health concern. This review indicated that the prevalence of vitamin D deficiency in this demographic was 47.35%, with a range of 3% to 91.7%. The mean serum vitamin D levels for this group ranged from 7.26±2.817.26±2.81 ng/mL to 23.46±9.30 ng/mL. The prevalence of vitamin D insufficiency was 55.6%, with a range from 11.3% to 100%.

In infants, the prevalence of vitamin D deficiency is estimated to be 51%, with a range from 2.8% to 93.3%. The mean values of vitamin D levels in these infants ranged from 28.3 ± 19.4 ng/mL to 61.3 ± 31.4 ng/mL. In addition, the prevalence of severe vitamin D deficiency is significantly higher in girls compared to boys. Vitamin D plays a crucial role in bone health and overall well-being, particularly in growing children and adolescents. The high rates of deficiency and insufficiency underscore the need for effective public health strategies, including dietary supplementation and increased sun exposure, particularly in populations at risk.

6- CONFLICT OF INTEREST: None.

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