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REVIEW

Effectiveness of vitamin D supplementation in managing urinary incontinence and overactive bladder: A systematic review and meta-analysis

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Summary *Background: Urinary incontinence (UI) and overactive bladder (OAB) are common lower urinary tract symptoms that significantly impact quality of life. Conventional pharmacologic treatments are often associated with side effects and limited efficacy, highlighting the need for alternative therapies. Vitamin D, known for its role in muscle function and its presence in the receptors of the bladder and prostate, has been proposed as a potential non-invasive intervention. This study aimed to evaluate the effectiveness of vitamin D supplementation in the management of UI and OAB.*

Methods: A systematic review and meta-analysis were conducted in accordance with the PRISMA guidelines. Twelve studies (six RCTs and six cohort studies) were included. Study quality was assessed using the Newcastle-Ottawa Scale (NOS) and the Cochrane Risk of Bias Tool. Statistical analysis was conducted using Review Manager 5.4. Standardized mean differences (SMDs) and risk ratios (RRs) were used to compare outcomes. A meta-analysis was performed using a random-effects model, which was applied due to heterogeneity, as assessed by the I^2 statistic. Sensitivity analysis was performed using the leave-one-out method.

Results: No significant difference was found between the vitamin D and control groups in improving UI scales (SMD = -1.04; 95% CI: -2.35 to 0.27, p = 0.12) with an I^2 of 94%. There were no significant effects on the risk of OAB (RR = 1.03, p = 0.16) or UI (RR = 0.88, p = 0.59), nor on UI improvement or worsening. The sensitivity analysis revealed that excluding one unusual study resulted in more consistent results and confirmed similar patterns.

Conclusions: I No substantial advantage of vitamin D was observed in UI or OAB patients compared to the control groups.

KEY WORDS: *Vitamin D; Urinary incontinence; Overactive bladder.*

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INTRODUCTION

Lower urinary tract symptoms (LUTS), including urgency, frequent urination, *urinary incontinence* (UI), and nocturia, whether occurring individually or as part of a syndrome known as *overactive bladder* (OAB), are prevalent and distressing conditions that affect millions of individuals worldwide (1-3). Epidemiological studies reveal that these symptoms impact 12% to 18% of community-dwelling men, with incidence increasing with age (2-4).

Initial therapies for UI and OAB include non-invasive behavioral approaches and/or pharmacological treatments, tailored to the patient's goals and preferences. Pharmacologic interventions are frequently commenced for particular OAB symptoms, such as urgency (with or without UI), frequency, and nocturia. However, recent findings indicate that pharmaceutical interventions, including anticholinergic bladder relaxants, are frequently abandoned due to unpleasant side effects or perceived ineffectiveness (4). Moreover, growing concerns have emerged regarding their potential long-term adverse effects on cognitive function (5). As a result, there is a clear need to develop alternative strategies that promote prevention and early intervention, particularly for men affected by UI and OAB. Vitamin D supplementation has been proposed as a simple and potentially effective strategy for alleviating LUTS, especially storage problems associated with OAB. Vitamin D receptors are present in the detrusor muscle of the bladder and the prostate (6, 7), and vitamin D administration may enhance smooth and skeletal muscle performance while decreasing prostate growth (8, 9). Thus, vitamin D may contribute to improved bladder control by directly enhancing detrusor smooth muscle activity and reducing the sensation of urgency.

However, the relationship between vitamin D and UI remains unclear, as research findings have been contradictory.

Vitamin D is a lipophilic molecule mostly acquired by solar exposure or dietary consumption. Vitamin D attaches to vitamin D-binding protein in the body and is metabolized to *25-hydroxyvitamin D* [25(OH)D] by 25-hydroxylase in the liver; its concentration is typically utilized to evaluate an individual's vitamin D status. In primary cultures of satellite cells, 1,25-dihydroxyvitamin D3 was observed to enhance myogenic differentiation and myotube formation by elevating the expression of myogenic regulatory proteins, including myogenin (10).
The research conducted by van der *Meijden et al.* (11) further demonstrated that higher levels of vitamin D support the differentiation and maturation of skeletal muscle cells, leading to increased myotube fiber diameter and enhanced muscle performance. These findings suggest a potential novel approach for treating UI. However, the relationship between vitamin D levels and urinary symptoms remains unclear, with studies showing conflicting results. Therefore, this systematic review aims to evaluate the effectiveness of vitamin D supplementation in the management of OAB and UI.

Methods

Study design
The systematic review adhered to the *Preferred Reporting Items for Systematic Reviews and Meta-Analyses* (PRISMA) guidelines (12).
The Prospero registration number was given to the protocol of this systematic review [CRD420251107352].

Definition of inclusion criteria and targeted outcomes
The inclusion criteria focused on studies evaluating the effectiveness of vitamin D supplementation in managing *overactive bladder* (OAB) and *urinary incontinence* (UI). Eligible study designs included *randomized controlled trials* (RCTs) and cohort studies. The review was guided by the PICO framework, where the population consisted of patients with OAB or UI, the intervention involved vitamin D supplementation, and the comparator included placebo, no intervention, or lower doses of vitamin D, where applicable. The outcomes of interest were efficacy measures, particularly improvements in urinary symptoms.
Studies were excluded if they presented insufficient or unclear outcome data, or if they were laboratory-based studies, posters, study protocols, case studies, case series, case reports, abstract-only publications, reviews, or articles not published in English.

Search strategy
A comprehensive search for systematic reviews was conducted across the following electronic databases for articles published from inception to March 2025: *PubMed*, *Cochrane Library*, *Scopus*, and *Web of Science*. The search strategy employed a combination of keywords and *Medical Subject Headings* (MeSH) related to the PICO framework. Terms such as "*Urinary incontinence*", "*Overactive bladder*", and "*Vitamin D*" were combined using Boolean operators (AND/OR) to capture relevant studies. Filters were applied to include only English-language studies from the last 10 years and focus on specific study types, such as clinical trials, RCTs, and retrospective studies, ensuring relevance to the research question. Additionally, reference lists of relevant articles were reviewed to ensure thorough coverage of the available evidence.

Screening and extraction
Initially, articles with irrelevant titles were excluded. In the subsequent phase, both the full text and abstracts of papers were meticulously reviewed to determine their compliance with the inclusion criteria. To streamline the process, titles and abstracts were organized and screened using EndNote version 8, and duplicate records were removed. The titles and abstracts were independently screened by two reviewers, followed by a full-text assessment based on predefined inclusion and exclusion criteria. Full-text articles meeting the inclusion criteria undergo further assessment. Baseline characteristics and outcome data were extracted in Excel sheets. Any differences of opinion were resolved by consensus or by referring them to a senior author.

Quality assessment
The *Newcastle-Ottawa Scale* (NOS) was used for non-randomized studies, including retrospective or prospective cohort designs. Scores were interpreted as low quality if they received 0-3 stars, moderate quality if they received 4-6 stars, and high quality if they received 7-9 stars (13).
For *randomized controlled trials* (RCTs), the Cochrane Risk of Bias Tool was used. This tool systematically evaluated various domains of bias, including selection bias, performance bias, detection bias, attrition bias, and reporting bias. Each study was carefully reviewed to determine whether the authors had implemented adequate measures to minimize these biases.

Statistical analysis
The statistical analysis was done using Review Manager 5.4 software. We compared the continuous outcomes using the *standardized mean difference* (SMD), given the difference in measurement scales. We compared the dichotomous data using the *risk ratio* (RR). Heterogeneity was assessed using I^2, with a p-value of 0.05. A random-effects model was used to account for the heterogeneity among the outcomes. Sensitivity analysis using the leave-one-out method was used to resolve the heterogeneity. All the steps were done at 95% *confidence intervals* (CI), and p-values were considered significant if they were less than or equal to 0.05.

Results

Search results
The searching process resulted in a total of 221 articles from the included databases. These encompassed 123 duplicates, so we conducted title and abstract screening on the remaining 98 articles.
In this phase, 81 articles were excluded, and 17 were included for full-text screening, resulting in 12 articles

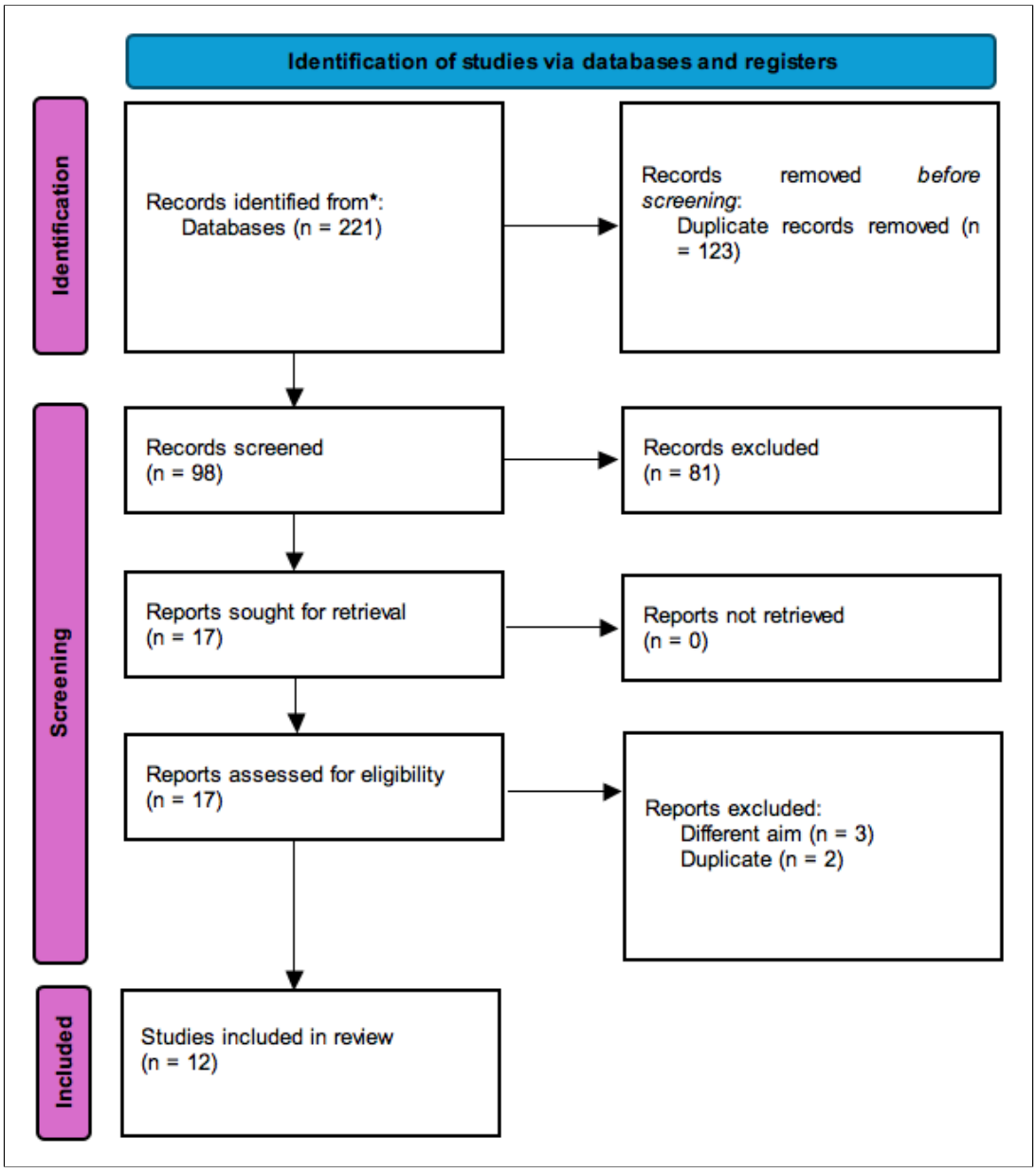

Figure 1. *PRISMA flow diagram of searching and screening processes.*

being selected for the current systematic review and meta-analysis (Figure 1).

Results of quality assessment

The quality of the six included cohort studies was assessed using NOS, which evaluates studies based on three domains: selection of study groups (maximum four stars), comparability of groups (maximum two stars), and ascertainment of either the exposure or outcome (maximum three stars). Three studies - *Vaughan (2021)*, *Markland (2020)*, and *Vaughan (2022)* - received the highest overall rating of 9 stars, indicating strong methodological quality across all domains. These studies achieved full scores in selection and outcome/exposure, and were rated with two stars in comparability, suggesting robust control of confounding variables. *Özçift* and *Micoogullari (2022)* and *Yoo (2018)* scored seven stars each, reflecting slightly lower quality due to limited comparability and fewer stars in the outcome domain.

Aydogmus (2023) received the lowest rating of 5 stars, with limited strength in both selection and comparability domains. Overall, the majority of studies included in the review demonstrated moderate to high methodological quality, with careful selection and adequate outcome assessment; however, variation in the control for confounding was noted (Table 1).

The risk of bias across the six included RCTs was evaluated using the Cochrane Risk of Bias tool, covering seven domains: random sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, incomplete outcome data, selective reporting, and other bias. *Shahraki (2022)* demonstrated the highest methodological rigor, with a low risk of bias across all domains, indicating strong internal validity. *Markland (2023)* and *Markland (2022)*, although showing

Table 1.
The NOS quality assessment for non-randomized studies.

Studies	Selection	Comparability	Exposure/Outcome	Overall star rating
Aydogmus 2023 (1)	**	*	**	5
Vaughan 2021 (2)	****	**	***	9
Markland 2020 (3)	****	**	***	9
Özçift and Micoogullari 2022 (4)	****	*	**	7
Yoo 2018 (5)	***	**	**	7
Vaughan 2022 (6)	****	**	***	9

Table 2.
The Cochrane risk of bias assessment for RCT.

Study	Random sequence generation	Allocation concealment	Blinding of participants and personnel	Blinding of outcome assessment	Incomplete outcome data	Selective reporting	Other bias
Arjmand 2023 (7)	Low	Unclear	Unclear	Unclear	Low	Low	Low
Markland 2023 (8)	Low	Low	Low	Low	Low	High	High
Shahraki 2022 (9)	Low	Low	Low	Low	Low	Low	Low
Markland 2019 (10)	Low	Unclear	Low	Low	Low	Low	Low
Oberg 2017 (11)	Unclear	Unclear	Unclear	High	Low	Low	Unclear
Markland 2022 (12)	Low	Low	Low	Low	Low	High	High

low risk in most categories, exhibited high risk of bias in selective reporting and other biases, potentially affecting the reliability of their outcomes. *Markland (2019)* showed a low risk in most areas, but allocation concealment was unclear, which slightly weakened its overall robustness. *Arjmand (2023)* had unclear risk in three domains – allocation concealment, blinding of participants and personnel, and outcome assessment – raising concerns about potential performance and detection bias.
The *Oberg (2017)* study had multiple areas of concern, including unclear randomization, allocation, and performance blinding, as well as a high risk of bias in outcome assessment, indicating a greater potential for bias. Overall, while several studies were methodologically sound, a few showed risks, particularly in blinding and reporting, that should be considered when interpreting their findings (Table 2).

Baseline characteristics
The baseline characteristics of the included studies reveal a diverse representation of populations across various countries and age groups, focusing on the relationship between vitamin D supplementation and UI or OAB symptoms. Six studies were RCTs and six were cohort studies. Study populations ranged from children [mean age 7.71 years (14)] to older adults [mean age 71.6 years (15)], with sample sizes varying widely from small randomized controlled trials [e.g., 30 participants per arm (16)] to large cohort studies [e.g., 59355 participants (17)]. Most studies focused on women, with several targeting postmenopausal women or those with specific UI subtypes, while a few included men (18, 19). The interventions involved varying doses and forms of vitamin D, from low daily doses to high-dose regimens such as 50,000 IU weekly (20) or a single intramuscular dose of 200,000 IU (21).
Control groups primarily received placebos, no intervention, or lower doses of vitamin D. Collectively, the baseline characteristics underscore substantial heterogeneity in study design, intervention protocols, control group, and target demographics (Table 3).

Statistical analysis
No significant difference was observed between vitamin D and the control groups regarding the effect on UI scales with SMD = -1.04 (95% CI: -2.35, 0.27, p = 0.12) and I^2 = 94%, p < 0.00001 (Figure 2).
No significant difference was observed between vitamin D and controls regarding the risk of OAB (RR: 1.03; 95% CI: 0.99 to 1.07, p = 0.16, and I2 = 45%, p = 0.16) and UI (RR: 0.88; 95% CI: 0.57 to 1.37, p = 0.59, and I^2 = 93%, p < 0.00001) (Figures 3, 4).
No significant difference was observed between vitamin D and control in UI improvement (RR: 1.57, 0.31, 7.78, p = 0.58, and I^2 = 76%, p = 0.04) or worsening (RR: 1.37; 95%CI: 0.82, 2.3, p = 0.23, and I^2 = 96%, p < 0.00001) (Figures 5, 6).

Sensitivity analysis
Sensitivity analysis using the leave-one-out method revealed that removing Shahraki 2022 (4) (high control values) resolved the heterogeneity in the UI scales, with SMD = -0.34 (95% CI: -0.9, 0.21, p = 0.23) and I^2 = 55%, p = 0.14. (Figure 7).

Table 3.
Baseline characteristics of the included studies.

Study ID	Study design	Population	Country	Study period	Intervention	Control	Sample size		Mean Age, (SD)		Male, n (%)		Dose of Vitamin D
							Intervention	Control	Intervention	Control	Intervention	Control	
Arjmand 2023 (7)	RCT	Postmenopausal women with urgency urinary incontinence	Iran	2019-2020	Vitamin D	Placebo	45	45	58 (5)	57 (5)	0 (0)	0 (0)	Vitamin D3 (50,000 IU) tablets weekly for 8 weeks
Aydogmus 2023 (1)	Cohort	Postpartum urinary incontinence	Belgium	NR	Vitamin D	Pelvic floor muscle training group	29	28	27.8 (5.9)	27.4 (4.6)	0 (0)	0 (0)	1200 IU daily vitamin D for 12 weeks
Markland 2023 (8)	RCT	Older men with overactive bladder and urinary incontinence symptoms	USA	Between November 2011 and March 2014	Vitamin D	Placebo	2823	2830	68 (7)	68 (7)	2823 (100)	2830 (100)	Vitamin D3 2000 IU
Shahraki 2022 (9)	RCT	Premenopausal women with stress urinary incontinence and vitamin D insufficiency	Iran	2020 and 2021	Vitamin D	Placebo	30	30	44.53 (2.5)	44.23 (2.4)	0 (0)	0 (0)	5000 IU vitamin D weekly for 3 months
Markland 2019 (10)	RCT	Women with urgency urinary incontinence	USA	From 2013-2017	Vitamin D	Placebo	28	28	61.4 (7.1)	59.5 (9.2)	0 (0)	0 (0)	Weekly oral 50,000 IU vitamin D3 for 12 weeks
Vaughan 2021 (NHS-I) (2)	Cohort	Women with urinary incontinence	USA	2004-2012	>=1000 IU vitamin D intake	0-<200 IU vitamin D intake	2213	3063	71.6 (6.78)	70.72 (7)	0 (0)	0 (0)	0-200 IU or >=1000 IU daily vitamin D intake
Vaughan 2021 (NHS-II) (2)	Cohort	Women with urinary incontinence	USA	2005-2013	>=1000 IU vitamin D intake	0-<200 IU vitamin D intake	1082	2669	52.97 (4.09)	50.53 (4.53)	0 (0)	0 (0)	0-200 IU or >=1000 IU daily vitamin D intake
Markland 2020 (NHS-I) (3)	Cohort	Women with urgency urinary incontinence	USA	2004-2012	>=1000 IU vitamin D intake	0-<200 IU vitamin D intake	3912	6472	68 (7)	67 (7)	0 (0)	0 (0)	0-200 IU or >=1000 IU daily vitamin D intake
Markland 2020 (NHS-II) (3)	Cohort	Women with urgency urinary incontinence	USA	2005-2013	>=1000 IU vitamin D intake	0-<200 IU vitamin D intake	2956	7555	52 (4)	49 (5)	0 (0)	0 (0)	0-200 IU or >=1000 IU daily vitamin D intake
Oberg 2017 (11)	RCT	Postmenopausal women with lower urinary tract symptoms	Norway	2007-2010	High dose vitamin D	Standard dose vitamin D	134	139	62.8 (7.5)	63.4 (6.9)	0 (0)	0 (0)	20000 IU daily in the high dose group and 400 IU of vitamin D3 twice daily in the standard dose group
Özçift and Micoogullari 2022 (4)	Cohort	Children with overactive bladder related urinary incontinence	Turkey	Between May 2017 and July 2021	Vitamin D	NA	34	NA	7.71 (2.66)	NA	16 (48)	NA	Oral vitamin D3 2000 IU/day was pres cribed for 8 weeks
Yoo 2018 (5)	Cohort	Men with lower urinary tract symptoms	Korea	Between March 2014 and April 2017	Vitamin D	NA	255	NA	59.4 (11.4)	NA	255 (100)	NA	Intramuscular injection of 200000 IU in a single dose
Vaughan 2022 (6)	Cohort	Women from mid-life through older ages with overactive bladder	USA	NR	Vitamin D (>=1000 IU)	No vitamin D	36789	22566	67 (6.5)	67 (6.9)	0 (0)	0 (0)	>=1000 IU
Markland 2022 (12)	RCT	Older women with urinary incontinence	USA	2011 to 2018	Vitamin D	Placebo	5213	5222	70 (7)	70 (7)	0 (0)	0 (0)	2000 IU/day

NA: not applicable; RCT: Randomized controlled trial.

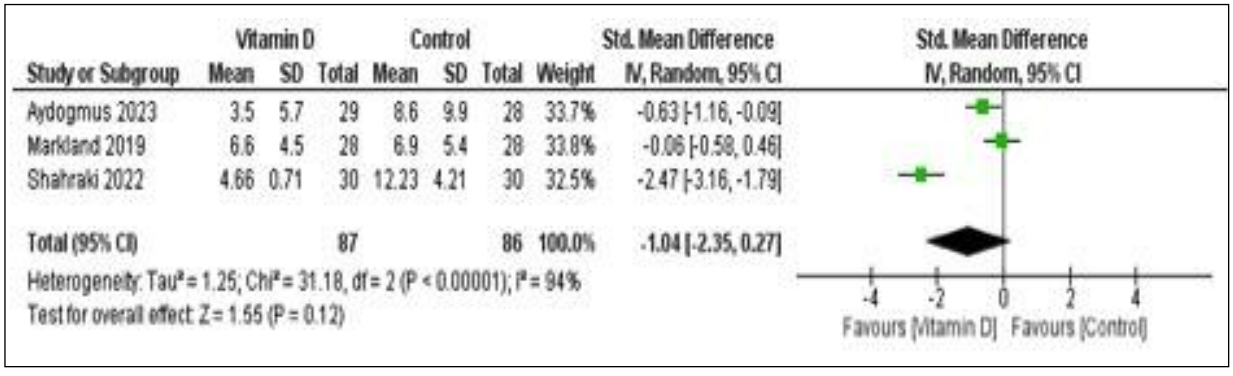

Figure 2.
Comparison between vitamin D and controls in their effect on urinary incontinence scales.

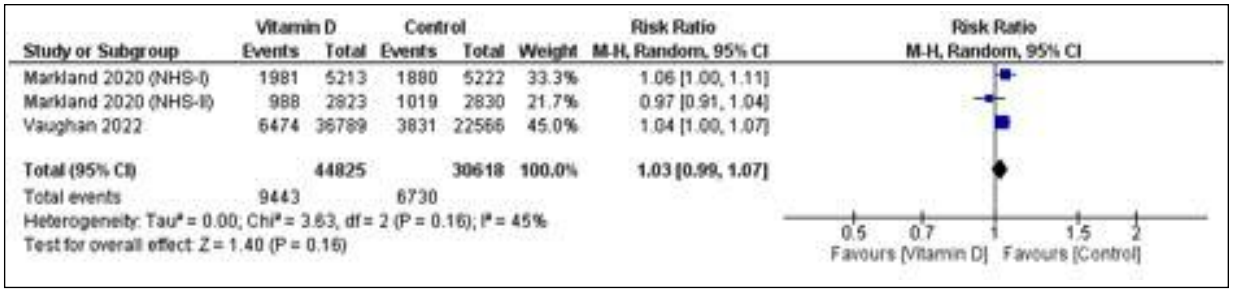

Figure 3. *Comparison between vitamin D and controls in the risk of overactive bladder.*

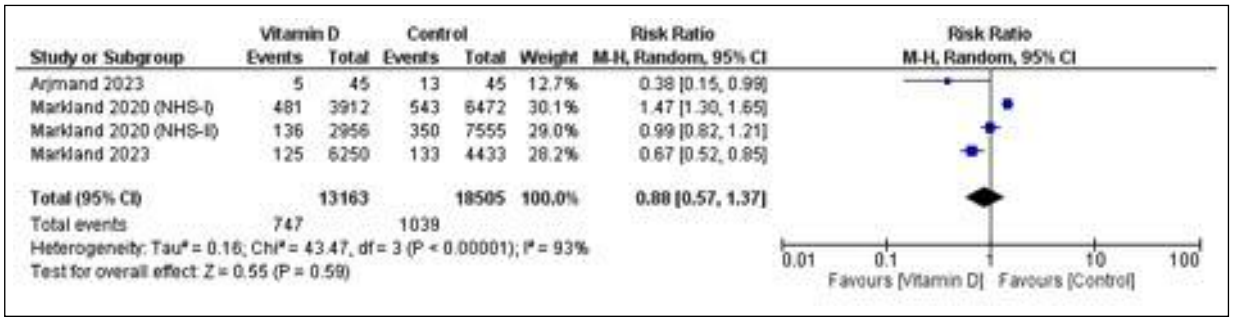

Figure 4. *Comparison between vitamin D and controls in the risk of urinary incontinence.*

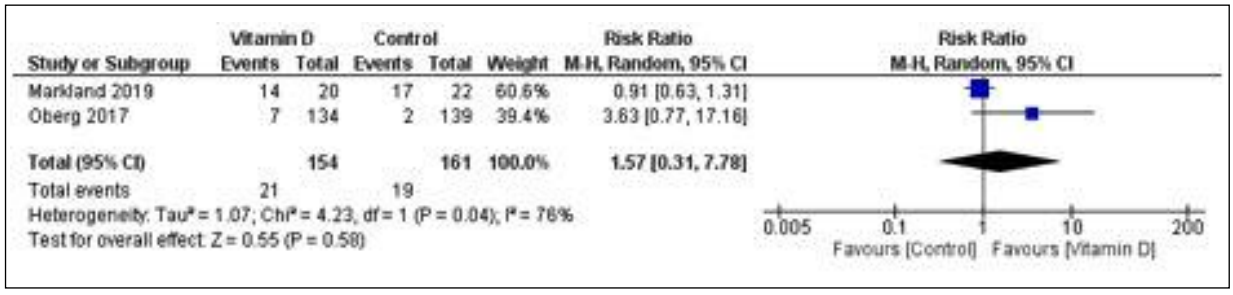

Figure 5. *Comparison between vitamin D and controls in urinary incontinence improvement.*

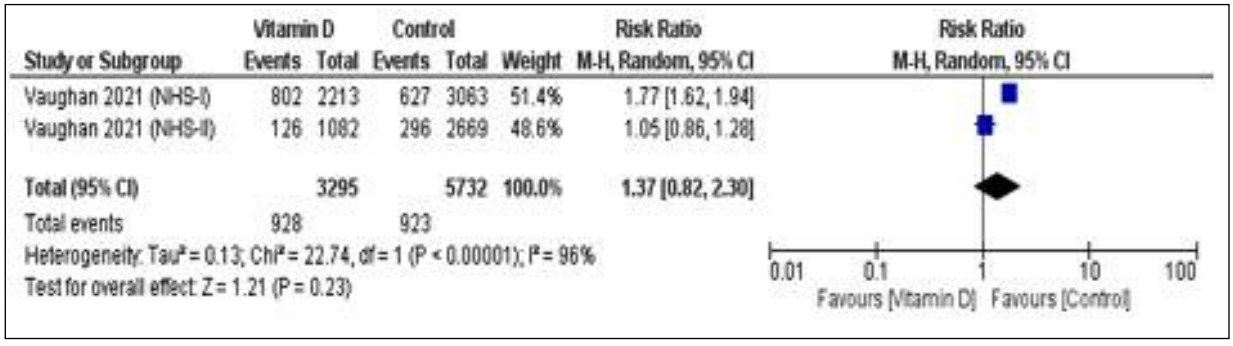

Figure 6. *Comparison between vitamin D and controls in urinary incontinence worsening.*

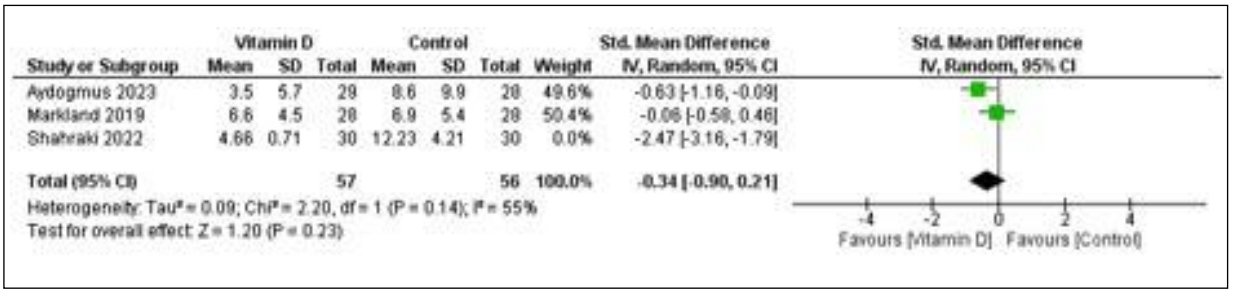

Figure 7. *Leave-one-out analysis of the comparison between vitamin D and controls in their effect on urinary.*

Discussion

Summary of findings

This systematic review and meta-analysis examined the potential effect of vitamin D supplementation in alleviating symptoms of UI and OAB. The study encompassed a diverse population, including children, postpartum women, postmenopausal women, and elderly individuals of both genders. This demonstrated the diversity of the impacted groups. In the comparison of vitamin D supplementation against a placebo or other control circumstances for its effect on urinary symptoms, no statistically significant changes were observed. Nonetheless, an examination of scores before and during therapy revealed a persistent tendency toward enhancement among the intervention groups. The analysis of risk ratios did not demonstrate that vitamin D supplementation significantly decreased or increased the likelihood of developing UI or OAB. The comparisons of the improvement or worsening of symptoms revealed no significant differences between the vitamin D group and the control group. Nonetheless, considerable variability existed among the studies, likely because of the extensive range of dosages, methods of administration, study populations, baseline vitamin D levels, and procedures employed to assess outcomes. Sensitivity analysis elucidated the conclusions by highlighting which studies exerted a disproportionate influence on the outcomes and the variations among them. The research indicates that vitamin D supplementation may not consistently outperform control therapies across all parameters.

Clinical implications and investigation with current literature

Current evidence does not support routine vitamin D screening or supplementation solely for UI/OAB in the general older adult population. Major trials (e.g., VITAL ancillary studies) found no improvement in OAB or UI prevalence/incidence with vitamin D3 2000 IU/day over several years (8, 12). However, vitamin D deficiency is common in certain high-risk groups (e.g., older adults with pelvic floor disorders, pregnant/postpartum women, and children with OAB (4, 13). In these subpopulations, clinicians might consider checking vitamin D levels. Several observational studies and a systematic review and meta-analysis reported associations between low vitamin D and worse *lower urinary tract symptoms* (LUTS)/UI (5, 14-16). For example, pregnant women in late gestation with vitamin D deficiency had higher UI prevalence and severity (13). In children with OAB, deficiency was far more common than in healthy controls (4). Thus, assessing vitamin D status is reasonable in treatment-refractory UI/OAB, particularly if other deficiency risk factors are present (e.g., limited sun exposure, malabsorption, darker skin) (4, 13). A previous systematic review by *Bapir et al.* (17) also evaluated treatments for urge incontinence in postmenopausal women and identified limited but suggestive evidence for vitamin D efficacy in selected cases. For patients with confirmed vitamin D deficiency and symptoms of UI/OAB, supplementation may be considered as an adjunct. Small trials suggest benefits in specific contexts: for example, in premenopausal women with stress UI and vitamin D insufficiency, 8-12 weeks of high-dose vitamin D3 (5,000 IU weekly) significantly reduced leakage scores vs placebo (9). In children with OAB, an 8-week regimen of vitamin D3 2,400 IU/day, combined with standard urotherapy, resulted in greater improvements in voiding frequency, urgency, nocturia, and quality of life compared to urotherapy alone(18). Similarly, postpartum women with UI who received vitamin D replacement showed greater increases in pelvic floor strength (Oxford score) and larger decreases in incontinence questionnaire scores than those doing pelvic-floor exercises alone (1). In sum, when deficiency is documented, supplementation (often at higher-than-routine doses) might improve symptoms. Nevertheless, vitamin D should not replace guideline-based UI/OAB care (such as behavioral therapy, pelvic floor training, and pharmacotherapy) but can be an adjunct for patients with deficiency. Adequate dietary calcium and monitoring of serum 25(OH)D are advised if high-dose regimens are used.

Regarding the dosing of vitamin D, typical large trials used moderate doses (e.g. 2000 IU/day), which did not improve UI/OAB (8, 12). In contrast, trials that reported benefit used higher dosing. One RCT administered 5,000 IU of vitamin D3 once weekly for 3 months to premenopausal women (9). The pediatric trial used 2,400 IU daily for 8 weeks (18). These regimens quickly raised 25(OH)D levels above 30 ng/mL. Thus, when considering vitamin D therapy for UI/OAB, clinicians might aim for a serum 25(OH)D level in the sufficient range (≥ 30 ng/mL) using adequate dosing; treatment durations in studies have ranged from 8 weeks to 5 years. However, the optimal dose and duration remain uncertain. Careful monitoring is warranted to avoid hypervitaminosis D.

Strengths and limitations

This review provides a comprehensive synthesis of available RCTs and cohort studies evaluating the impact of vitamin D supplementation on UI and OAB. A key strength lies in the inclusion of diverse populations spanning multiple age groups, from children to older adults, and various clinical subtypes of UI. Additionally, the employment of sensitivity analyses, including leave-one-out testing, strengthened the robustness of findings and helped identify sources of heterogeneity across studies. This systematic approach enables a more accurate interpretation of both between-group and within-group effects of vitamin D supplementation.

The findings are limited by significant heterogeneity across included studies in terms of population demographics, vitamin D dosages, treatment durations, baseline vitamin D status, and outcome assessment tools. Many studies had small sample sizes or short follow-up periods, which may reduce statistical power and limit the generalizability of results. The meta-analysis included both randomized and observational studies, which, while increasing data breadth, introduces potential biases such as confounding and selection bias. Moreover, few studies have stratified participants based on baseline vitamin D levels, making it difficult to isolate the effects of repletion in individuals with deficient versus sufficient levels.

Recommendations

The findings of this review suggest that while vitamin D supplementation does not consistently demonstrate superiority over control interventions for UI or OAB. Clinicians should consider assessing vitamin D status in individuals presenting with persistent or treatment-resistant UI or OAB, especially among high-risk groups such as postmenopausal women, older adults, postpartum women, and children with OAB. These populations are more likely to exhibit vitamin D insufficiency, which may influence pelvic floor muscle function and bladder detrusor activity. Vitamin D supplementation may be used as an adjunct to standard UI/OAB management in patients with confirmed deficiency. Although its use should not replace evidence-based first-line treatments such as pelvic floor muscle training, bladder retraining, or pharmacologic therapy, supplementation may help enhance therapeutic outcomes. Higher-dose regimens, such as weekly or daily supplementation for short durations, appear to be more effective in improving urinary symptoms than low-dose maintenance therapy. However, individualization and monitoring are essential to prevent hypervitaminosis D. For researchers, future clinical trials should adopt standardized definitions of UI and OAB, utilize validated outcome measures, and stratify participants according to baseline serum vitamin D levels. Longer follow-up durations and adequately powered sample sizes are necessary to evaluate the sustained effects of supplementation. Studies should also focus on identifying specific subgroups, such as those with stress incontinence, postpartum incontinence, or pediatric OAB, that may benefit most from vitamin D therapy.

Declarations

Ethical approval and consent for participate: *The Prospero registration number was given to the protocol of this systematic review [CRD420251107352].*

Consent for publication: *Not applicable.*

Availability of data and material: *The data supporting this study's findings are available from the corresponding author upon reasonable request.*

Competing interests: *The authors declare no competing interest.*

Funding: *None.*

Authors' contributions: *S.T. Alshahrani: protocol development, manuscript writing, manuscript review. N. Alamri: protocol development, manuscript writing, manuscript review. M.D. Asiri: data collection and manuscript review. M.O. Albabtain: data analysis, manuscript writing. R. Alwadai: data collection and manuscript review. H.M. Assiri: data collection and manuscript review. S. Alghamdi: manuscript review, editing, and senior author. A.T. Alshahrani: data collection and manuscript review., M.J. Bosily: data collection and manuscript review. H. Munyif: data collection and manuscript review. O. Safar: protocol development, manuscript writing, editing, manuscript review, and senior author.*

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Conclusions

The results of this meta-analysis reveal that vitamin D supplementation does not produce a statistically significant improvement in UI or OAB symptoms when compared directly with control groups. No meaningful differences were found in the risk of developing UI or OAB, nor in the likelihood of symptom improvement or worsening between intervention and control arms. The included studies exhibited considerable heterogeneity in terms of populations, dosing regimens, and outcome measures, which likely contributed to inconsistent findings across the analyses. Sensitivity analyses helped identify specific studies that disproportionately influenced the overall heterogeneity. Further high-quality, targeted research is needed to determine which patient subgroups are most likely to benefit and to establish optimal dosing strategies.

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