

Clothing type and vitamin D status: a systematic review and meta-analysis

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Abstract

Background Inconsistent reports have been made on the link of clothing style to vitamin D deficiency (VDD). However, there is no meta-analysis report on the link. Thus, we pooled the existing empirical evidence on the association of wearing concealing clothing with VDD and serum 25(OH)D level among healthy adult women.

Method PubMed, Embase, Scopus, Web of Sciences, and Google Scholar were searched for studies published until December 15, 2020 on the relation of clothing type with vitamin D status. Odds ratio (OR) and standardized mean difference (SMD) were used to summarize the estimates on the association of concealing clothing with VDD status and 25(OH)D level, respectively. The summary estimates were calculated with random-effects meta-analyses, with heterogeneity assessed by I^2 -metrics and subgroup analyses done by types of clothing and regions of residence.

Result In total, 14 studies with a total of 11,332 individual participants were included. Overall, women who wear concealing clothing were 2.28 times more likely to develop VDD compared with women who do not wear concealing clothing (pooled OR=2.28, 95%CI=1.67, 3.10, $P<0.001$). The summary odds of VDD was 1.36 times higher among women who wear veil hijab compared with women who do not wear veil hijab (95%CI=1.49, 3.59, $P<0.001$). The summary odds of VDD was 2.25 times higher among women who wear long sleeve clothes compared with those who wear short sleeve clothes (95%CI=1.63, 3.11, $P<0.001$). The mean serum 25(OH)D level of women who wear veil hijab was also significantly lower by 6.48 ng/ml (pooled SMD=-6.48, 95%CI= -8.24, -4.73, $P<0.001$).

Conclusion Clothing type, particularly fully concealing clothes like hijab, might be contributing to the burden of VDD. Further studies are warranted to investigate the role and dose of additional VD supplement to compensate the effect of concealing clothing (hijab) on VD status of women.

Background

Vitamin D has become a nutrient of significant concern around the world, drawing the attention of researchers, policymakers, clinicians, and the public at large [1]. Vitamin D deficiency (VDD), usually defined by serum 25(OH)D less than 20 ng/ml, is one of the major public health problems worldwide. VDD has reached a pandemic level and is still rising across all regions and age groups [2]. The last two decades have seen a tremendous increase in the prevalence of VDD, with over a billion people estimated to be VD deficient in 2017 [1]. There is a regional variation in the magnitude of VDD, with the highest estimate in the Middle East region and the lowest estimate in the Scandinavian region [3]. Many nations have recognized the need to address VDD and adopted prevention and control strategies including dietary fortification of VD, despite the level of implementation has been short of making a substantial change with regard to the current state of the problem [1, 4].

VDD is a multifactorial problem, resulting from various factors and through different mechanisms. Currently, there is no consensus as to which specific factor is responsible for the sharp and wide resurgence of VDD over the recent decades. However, the main direct risk factor for VDD is believed to be insufficient exposure to sunlight, followed by inadequate dietary or supplemental VD intake [1, 3]. Lifestyle factors, particularly outdoor activities, physical activity, and clothing type are important underlying factors that determine the level of sun exposure and consequently the development of VD insufficiency and deficiency states. Other factors like obesity and mal-absorptive disorders have also been implicated in the rise of VDD, albeit the evidence is weak and inconclusive [5].

Globally, women bear a disproportionately high burden of VDD [1, 2, 6] due to various factors including a more sun-protective lifestyle than men. Use of sunscreen and sun-protective clothing, both of which known to reduce the amount of UV-B exposure, are more common in women than in men [7, 8]. In regions like the middle east, concealing clothing (hijab) which entails covering most part of the body is prevalent among women due to legal, religious, and cultural factors. Provided that skin production is the single most important natural source of VD and the production depends on sun exposure, it could be easily acknowledged that VDD would be higher in individuals who wear concealing clothing. Studies in western Asia showed a significantly lower serum of 25(OH)D level in Muslim and Jewish women who wear concealing clothing like hijab, niqab, chador, and burqa compared with women who wear western type or less concealing clothing [9-13]. Similar findings were reported in Europe and America [14-16].

Despite the biologically convincing mechanism linking wearing concealing clothing like hijab to VDD, the existing studies are not consistent. There is also a wide variation in the strength of the reported estimates. Some studies reported a null or weak association between clothing type and VD status [17]. On the basis of the inconsistency of the existing evidence and the pandemicity of VDD, some authors have cast doubt on the authenticity of the link of concealing clothing to VDD status [18-20]. To date, there is no meta-analysis report on the association of clothing type with VD status. Thus, we carried out this meta-analysis study with the aim of determining the association of wearing concealing clothing with VDD status and serum 25(OH)D level of apparently healthy adult women.

Methods

This review was conducted following the recommendations of the Meta-analysis of Observational Studies in Epidemiology (MOOSE) [21] and reported following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) [22] guidelines.

Literature search and eligibility criteria

Literature search was done using five databases, PubMed, Embase, Scopus, Web of Sciences, and Google Scholar, for studies published until December 15, 2020. We used a combination of MeSH terms and free texts referring to vitamin D status and clothing type. The terms referring to vitamin D status were 'vitamin D', 'vitamin D status', 'vitamin D deficiency', and '25(OH)D'. The terms referring to clothing type were 'clothing type', 'clothing style', 'clothing', 'dressing style', 'lifestyle', 'concealing clothing', 'unconcealing clothing', 'hijab', 'niqab', 'chador', and 'veil'. A PubMed search strategy, developed using a combination of MeSH terms and free texts, is presented as a sample of the search strategy (Additional file 1). The PubMed search strings were translated into the other databases. Hand searching of the reference list of eligible articles was done. Besides, we also hand-searched articles using the PubMed 'Citing' and 'cited by' links for each eligible article. The search included cross-sectional, longitudinal, cohort, case-control, clinical, and randomized control studies, irrespective of the year and the country of the study. In line with the objective of the study, the search was restricted by age and sex; such that, we included only adult women aged 18 years and above. Articles were excluded on any one of the following conditions: (a) animal studies, (b) language other than English, (c) articles without full text, and (c) qualitative studies, book chapters, symposium and conference proceedings, essays, commentaries, editorials, and case reports, (d) study focused on VD insufficiency rather than VDD, and (e) study done among patients.

Study screening and data extraction

First, the title and abstract of the studies retrieved from database searches were assessed and screened by two evaluators (SHM, SA). Full text reviewing was done by the same two authors to determine whether the studies fulfilled the predefined inclusion criteria. The two reviewers (SHM, SA) worked independently while conducting title, abstract, and full text reviewing. Any disagreement at any stage of the screening and selection process was resolved by discussion. The study screening and selection process, including the specific reasons for inclusion and exclusion, is shown in the PRISMA flow chart (Figure 1). Data extraction was done by SHM, checked by SA. From each study, the following information was abstracted (a) study identification (first author, publication year, title), (b) study characteristics and population (country, sample size, study design, follow up years for longitudinal studies, mean age of participants), (c) clothing type, (d) outcome assessment method, (f) measure of association and reported estimates, and (g) variables used for adjustment. The pre-specified measures of association were standardized mean difference (SMD) in serum 25(OH)D, RR or OR of VDD in women wearing concealing clothing like hijab compared with those not wearing concealing clothing. Whenever a study reported both SMD and RR/OR, we extracted both estimates. For studies that reported both adjusted and unadjusted estimates, we extracted the one adjusted for more covariates. The predefined standardized unit of serum 25(OH)D was ng/ml. Other units like nmol/litre were converted to ng/ml.

Study quality assessment

The quality of the studies included in this work was evaluated using the Newcastle-Ottawa Scale (NOS) for observational studies [23]. The NOS scale allowed evaluating the methodological quality of the included studies in three main domains: selection, comparability, and exposure/outcome. The NOS scales range from none to nine stars. Stars from 0 to 3 represent low quality, 4 to 6 medium quality, and 7 to 9 high quality. The grading was done by two evaluators (SHM, SA), working independently and in duplicate, with disagreement resolved by consensus.

Statistical analysis

Pooled analysis

OR and SMD were used to pool the studies and calculate summary estimates. Thus, two separate meta-analyses were done; one for studies which reported OR and the other for studies which reported SMD. The OR represents the odds of VDD in women wearing concealing clothing compared with women not wearing concealing clothing. The SMD represents the difference in the mean serum of 25(OH)D of women wearing and not wearing concealing clothing. For studies which reported only OR or SMD without 95%CI, we calculated the corresponding 95%CI and standard error (SE) using the reported p-values. When exact p-values were reported, they were directly used for the calculation of 95%CI and SE. If P-values were reported as $P < 0.001$, we assumed $P = 0.001$ to calculate the corresponding 95%CI and SE, and if the study reported $P > 0.05$, we assumed $P = 0.53$ [24]. We aimed to calculate the summary estimates, pooled OR and SMD, with fixed-effects model if there was no significant level of heterogeneity or with DerSimonian-Laird random-effects model if there was a significant level of heterogeneity [25].

Heterogeneity assessment

Heterogeneity between the included studies was evaluated by I^2 -metrics. I^2 refers to the proportion of variance attributable to between studies' heterogeneity. I^2 -values of $< 40\%$, $50-75\%$, and $> 75\%$ refer to low, moderate, and high levels of heterogeneity, respectively [26]. When heterogeneity was high, we conducted further subgroup analyses to identify the sources of heterogeneity and provided estimates by subgroups.

Publication bias and sensitivity analysis

We aimed to evaluate publication bias graphically by visual inspection of asymmetry of funnel plots and statistically by Egger's regression test. Sensitivity analysis was conducted following the leave-one-out and analyze the rest method. We aimed to exclude studies, the exclusion of which resulted in pooled estimates outside the 95% CI of the overall estimate. Statistical significance was determined at $P = 0.05$. All statistical analyses were done using Stata version 15.0 software.

Result

Literature search result

We found 304 studies by searching the five databases and the reference list of the eligible studies. After screening the title and abstract of the retrieved studies, 37 studies were found eligible for full-text review. Full text reviewing of the 37 studies resulted in 14 eligible studies [9-12, 15-17, 27-33]. The process of article screening, selection and review is shown in the PRISMA flowchart (Figure 1). Summary of the main characteristics of the included studies is presented by Table 1. All studies were cross-sectional in design and published from 2000 through 2016. Most of the studies (11/14) were conducted in the middle east region. The sample size of the studies ranged from 55 to 3,462 individuals. In total, the 14 studies [9-12, 15-17, 27, 28, 30-34] included 11,332 unique individuals. The mean age of the study participants was 43.92 years.

Table 1: Summary of characteristics of included studies.

First author (Year)	Country	Design	Sample Size (n)	Mean age	Exposure measure	Outcome measure	Covariates adjusted	Reported estimate	Recalculated	NOS
Gannage-Yared (2000) [28]	Lebanon	CS	217	39.40	Veiled vs unveiled	25(OH)D	Vitamin D intake dwelling, parity	Beta: Veiled Vs. Unveiled: 0.37, SE=0.08, P<0.001 Mean: 5.12 ng/ml, SD=3.57, N=102 (Veiled) Mean: 9.8 ng/ml, SD=6.46, N=115 (Unveiled)	SMD=-6.0489 <-4.68< -3.3111	7
Andersen (2008) [17]	Denmark	CS	115	36.20	Long vs short sleeves	25(OH)D	Vitamin D supplements, Calcium dietary intake, Sun habits, BMI, age	OR: Veiled Vs. Unveiled 3.14, 95%CI=0.912- 10.82	OR=3.141, 0.912-10.82	5
Mallah (2011) [9]	Jordan	CS	201	32.00	Niqab vs western	25(OH)D	None	Mean: Unveiled: 40.0, SD=8.3 Mean: Veiled: 28.5, SD=3.8 nmol/liter; P<0.001	SMD=-4.14 <-3.62<-3.08, P=0	7
Golbahar (2013) [30]	Bahrain	CS	250	33.50	Conservative vs west	25(OH)D	None	RR: Veiled Vs. Unveiled: 1.41, 95%CI=1.02-1.96, P=0.04	OR=1.41 (1.02, 1.96), P=0.04	7
Linus (2012) [16]	USA	CS	2577	42.00	Long vs short sleeves	25(OH)D	BMI, age, gender, season, multivitamin, physical activity, milk consumption, sun sensitivity, income, education	OR: Veiled Vs Unveiled: 2.11, 95%CI=1.48-3.00	OR=OR 2.11 (1.48, 3.00)	8
Halicioglu (2011) [34]	Turkey	CS	258	27.19	Covered vs uncovered	25(OH)D	Age, education, income, weight gain, Milk use, multivitamin use	Beta: Unveiled Vs. Veiled: 3.28, SE=0.65, P<0.0001	SMD=-4.9665 <-3.74< -2.5135, P=<0.001	7
Nichols (2012) [12]	Jordan	CS	2032	31.00	Niqab vs no cover	25(OH)D	Parity, residence	OR: Veiled Vs. Unveiled: 1.87, 95%CI=1.20-2.93, P=0.006	OR=1.87 (1.20 - 2.93)	8
Ates (2016) [33]	Turkey	CS	229	29.49	Covered vs uncovered	25(OH)D	Multivitamin use, season	OR: Veiled Vs. Unveiled: 5.1, 95%CI=2.26-11	OR=5.1 (2.26- 11)	7
Batieha (2011) [32]	Jordan	CS	3462	41.90	Hijab vs western	25(OH)D	Region	OR: Veiled Vs. Unveiled: 1.7, P=0.004 Mean: Hijab: =39.4(20.2) ng/ml, Western: N=183, mean=51.2(27.9)	OR=1.70(1.18- 2.44) SMD=-15.9075 <-11.8< -7.6925	8
Alagöl (2011) [31]	Turkey	CS	48	26.00	Niqab vs western	25(OH)D	None	Mean: West 56, SD=41.3 nmol/liter, Niqab 9 SD=5.7, P<0.001	SMD=-21.40 <-14.78<-8.15, P<0.001	5
Granlund	Sweden	CS	1306	40.44	Long vs	VDD	Origin, fish intake,	OR=3.15, 95%CI=1.09- 9.12	OR=3.15 (1.09-9.12)	8

(2015) [15]					short sleeves		journeys abroad			
Guzel	Turkey	CS	60	24.70	Veiled vs unveiled	25(OH)D VDD	None	Mean: 33.1 (16), 53.9 (SD=27.3 ng/ml), P<0.001	SMD=-32.1232 <-20.8< -9.4768, P<0.001	5
(2001) [11]										
Buyukuslu	Turkey	CS	100	20.90	Covered vs uncovered	25(OH)D VDD	None	Mean: Covered: 21.1 (SD=6.7), 29.7 (SD=3.1) P=0.000 ng/ml	SMD=-10.8195 <-8.6< -6.3805 OR=6.0(2.47- 14.58)	5
(2014) [27]										
Mukamel	Israel	CS	341	32.00	Covered vs uncovered	25(OH)D	None	Mean: Covered:13.5, SD=7.5, Uncovered=18.6 (SD=9.6), P<0.002	SMD=-6.9163 <-5.1< -3.2837	6
(2001) [10]										

NOS=New Castel Ottawa Scale; CS=Cross-sectional; VDD=Vitamin D deficiency; OR= Odds ratio; RR=Relative risk; SE=Standard error; SMD=Standardized mean difference; CI=Confidence interval.

Association of clothing style with VDD

The summary estimate and forest plot of the meta-analysis of the association of concealing clothing with VDD is shown in Figure 2. Overall, wearing concealing clothing was significantly associated with VDD; such that, the odds of VDD in women wearing concealing clothing (hijab) was 2.28 times that of women not wearing concealing clothing (pooled OR = 2.28; 95%CI = 1.67, 3.10; $P < 0.001$). There was a moderate level of heterogeneity between the studies ($I^2 = 60.50\%$, $P = 0.013$). Thus, further subgroup analyses were conducted by clothing styles (result shown in Figure 3). Clothing type remained significantly associated with VDD in all subgroups, with no notable change in the direction as well as the strength of the association. Compared with unveiled clothing, veiled clothing type (hijab) was associated with a significantly higher odds of VDD (pooled OR = 2.31; 95%CI = 1.1.49, 3.59; $P < 0.001$, $I^2 = 74.9\%$). Compared with short sleeve clothing, long sleeve clothing was associated with a significantly higher odds of VDD (pooled OR = 2.25; 95%CI = 1.63, 3.11; $P < 0.001$; $I^2 = 0.0\%$). The result of the sensitivity analysis, presented by Table 2, showed that the summary estimate was not influenced noticeably by any of the studies included. The summary OR ranged from the lowest 2.67 (95%CI = 1.89, 3.45) after excluding Ates et al. [33] to the highest 3.25 (95%CI = 2.23, 4.27) after excluding Golbahar et al. [30]. We did not assess publication bias as there was an inadequate number of studies which underpowered any of the available statistical tests for evaluation of publication bias.

Table 2: Sensitivity analysis of studies on the association of clothing type with VDD.

Study Omitted	Pooled OR	95%CI
Andersen (2008) [17]	2.98	2.05-3.91
Golbahar (2013) [30]	3.25	2.23- 4.27
Linos (2012) [16]	3.15	2.06-4.24
Nichols (2012) [12]	3.18	2.15-4.21
Ates (2016) [33]	2.67	1.89-3.45
Batieha (2011) [32]	3.21	2.15-4.27
Granlund (2015) [15]	2.98	2.04-3.91
Buyukuslu (2014) [27]	2.54	1.84-3.24

VDD=Vitamin D deficiency; OR= Odds ratio; CI=Confidence interval.

Association of clothing type with 25(OH)D

The summary estimate and forest plot of the meta-analysis of the association of wearing concealing clothing (hijab) with mean serum 25(OH)D is shown in Figure 4. Clothing style was significantly associated with mean 25(OH)D. The mean serum VD level of women wearing concealing clothing (hijab) was significantly lower than that of women not wearing hijab by 6.48 ng/ml (pooled SMD = -6.48; 95%CI = -8.24, -4.73; $P < 0.001$). There was a high level of between-studies heterogeneity ($I^2 = 86.7\%$, $P < 0.001$). The result of the sensitivity analysis, presented by Table 3, showed that the summary estimate was not noticeably influenced by any of the studies included. The summary SMD ranged from the lowest -5.75 (95%CI = -7.39, -4.11) after excluding Batieha et al. [32] to the highest -7.54 (95%CI = -9.88, -5.20) after excluding Mallah et al. [9]. We did not assess publication bias as there was an inadequate number of studies which underpowered any of the available statistical tests for evaluation of publication bias.

Table 3: Sensitivity analysis of the association of clothing type with 25(OH)D.

Study Omitted	Pooled SMD	95%CI
Gannage-Yared (2000) [28]	-7.15	-9.34-4.96
Mallah (2011) [9]	-7.54	-9.88-5.20
Halicioglu (2011) [34]	-7.42	-9.69-5.15
Batieha (2011) [32]	-5.75	-7.39-4.11
Alagöl (2011) [31]	-5.92	-7.58-4.26
Guzel (2001) [11]	-6.07	-7.73-4.41
Buyukuslu (2014) [27]	-5.87	-7.57-4.17
Mukamel (2001) [10]	-6.90	-8.94-4.85

SMD=standardized mean difference; CI=Confidence interval.

Discussion

We found that wearing concealing clothing was significantly associated with both VDD status and serum 25(OH)D level of adult women. The likelihood of VDD was more than twice higher among women wearing concealing clothing (hijab) compared with women not wearing concealing clothing. Likewise, mean serum VD level was significantly lower among women wearing concealing clothing (hijab) compared with that of women not wearing concealing clothing.

Our findings were consistent with the reports of most of the existing empirical studies on the association of clothing style with VDD or serum 25(OH)D level. Various studies have shown that the risk of VDD is higher in women with concealing clothing [12, 15, 28, 35]. A review of the lifestyle correlates of VD status showed that serum 25(OH)D level was low among women who wear concealing clothing types like hijab, niqab, and chador [6-8]. However, our finding contradicted with some studies that reported no link between clothing type and VD status. In two studies conducted in the United Arab Emirates, mean serum 25(OH)D level was not significantly different between women wearing hijab and women not wearing hijab [18, 20]. A similar finding was reported in a study done in the Netherlands which showed no significant difference in VD status by clothing style [19].

Notwithstanding the cultural and religious values in some clothing codes, the mechanism linking concealing clothing (hijab) to VD status is largely clear. The importance of optimal sunshine exposure in producing and maintaining normal body VD status is well documented [36]. An important step in the production of VD is the conversion of 7-dehydrocholesterol (the precursor of VD) into pre-vitamin D3. This stage requires ultraviolet irradiation. Thus, anything that interferes with the transmission of UV radiation into the skin could limit the cutaneous synthesis of vitamin D3 and result in a state of VD insufficiency or deficiency [6, 7, 36]. Season, sunscreen use, and clothing type were often mentioned to influence ultraviolet ray penetration and skin's VD production [7, 36].

VD has many functional roles. Serving as both vitamin and pre-hormone, it is believed to influence almost all body tissues. Beyond its traditional role in calcium and phosphate metabolism, evidence has been accumulating on the multiple health benefits of VD [1, 37]. It promotes neuromuscular and immune function, cell growth modulation, and inflammation reduction. Emerging evidence has also linked VD with autoimmune, respiratory, cardiovascular, and metabolic disorders [1, 5]. Thus, promotion of healthy VD level stands an important public health priority [38]. Encouraging adequate dietary or supplementary VD intake and sensible sunshine exposure could improve serum 25(OH)D. Globally, the level of sunshine exposure has been declining from time to time, due to various reasons including changes in working and lifestyle conditions. The proportion of people working outdoor has been decreasing, reducing exposure to sunshine. Besides, there is a growing level of health concern related to sunlight exposure. While some level of sunshine exposure is useful, the risks of cutaneous cancer and cataract have been shown to be higher in individuals more exposed to sunlight [8]. Thus, the promotion of sunshine exposure as a main source of VD seems a less reliable and feasible option in the context of the current lifestyle trend. Instead of sun exposure, VD supplementation and dietary fortification might be a more effective and feasible option to achieve a normal level of VD.

VDD has already become a pandemic problem. It is highly prevalent across all regions, irrespective of clothing style, age, sex, or socioeconomic status. Thus, blanket targeting of VD supplementation stands an important consideration not only to the hijab-wearing women but also to the whole population [1, 38, 39]. The finding of this study only implies that women with less skin exposing clothing type might be more vulnerable to VDD. It also does not mean that hijab-wearing influences all aspects of health negatively. For example, hijab-wearing might reduce the risk of skin cancer due to overexposure to sunlight. Thus, instead of doubting the risk of VDD due to hijab-wearing, it would be more informative to document both the pros and cons of hijab-wearing and outline compensatory strategies. With respect to VD, provided the religious and cultural values of hijab-wearing in some countries, and the less feasibility of sun exposure as an effective source of VD, public encouragement of more dietary or supplementary VD intake might be a more viable option for women wearing hijab. Previous studies showed the need for increasing the dose of VD supplementation to individuals with concealing clothing [40, 41]. In a study among individuals with less sun exposure, normal vitamin D level was maintained with a higher dose of VD supplementation [42]. However, further studies are required to determine the additional VD dose needed to compensate for the effect

of hijab-wearing. Besides, whether the provision of additional VD supplement or VD rich diet mitigates the extra risk associated with hijab-wearing needs further evaluation.

Strengths and limitations

This study is the first meta-analysis report on the association of wearing concealing clothing (hijab) with VDD and serum 25(OH)D level. Thus, it would be contributing to filling the gap in the literature. The work included studies from various regions. The inclusion of multi-national studies would improve the representativeness of the study. The work also had some limitations worthy of mentioning. There was a moderate level of heterogeneity among studies used to estimate the association of hijab-wearing with VDD and a high level of heterogeneity among studies used to estimate the association of hijab-wearing with 25(OH)D. However, subgroup analyses were done; i.e. we provided estimates by clothing type subgroups using the random-effects analysis. The studies included in this work used different ways of measuring clothing type, which might have introduced heterogeneity and undermined the comparability of the studies. Most of the studies included in this work were from middle east countries. The lack of adequate data from the other regions would limit the generalizability of the findings. All studies were cross-sectional in design, making casual inference impossible. There was no uniformity in covariate adjustment across the studies. Thus, the possibility of confounding by a third variable could not be ruled out. The association of wearing concealing clothing with VDD could, for example, be due to underlying conditions like obesity which might influence both clothing style and VD status. As this meta-analysis is focused on only healthy women, further studies are needed to show whether the findings could be extrapolated to other population groups.

Conclusion

Clothing type was significantly linked to VDD status and serum 25(OH)D level of women. The odds of VDD was significantly higher in women who wear concealing clothing like hijab compared with women who did not wear concealing clothing. Mean serum 25(OH)D level was also significantly low in women who wear concealing clothing. Enhancing VD supplementation for women who wear concealing clothing represents a more viable option to address the problem. However, further studies are warranted to determine whether the provision of additional VD supplement reduces the risk of VDD. Besides, the additional VD supplement dose needed to compensate the VD level lowering effect of wearing concealing clothing needs to be determined.

Abbreviations

CI: Confidence interval; ES: Effect size; NOS: Newcastle-Ottawa Scale; OR: Odds ratio; RR: Relative risk; SMD: Standardized mean difference; UV: Ultra-violet light; VD: Vitamin D; VDD: Vitamin D deficiency.

Declarations

Ethics approval and consent to participate

This study is based on extracting data from the existing literature. Relevant standard guidelines for systematic review and meta-analysis were followed.

Consent for publication

Not applicable as the study was based on extracting data from published articles.

Availability of data and materials

All data is included within the manuscript.

Competing interests

The authors declared no competing interests.

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Authors' contribution

SHM conceived, designed and led the study, carried out literature search, performed quality assessment of included studies, analyzed data and wrote the manuscript. SA, MT, AS, AP and AH performed literature search, screening, data extraction and quality assessment as second reviewers,

interpretation of findings, and reviewed the draft manuscript. All the authors read, commented and approved the final manuscript.

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Figures

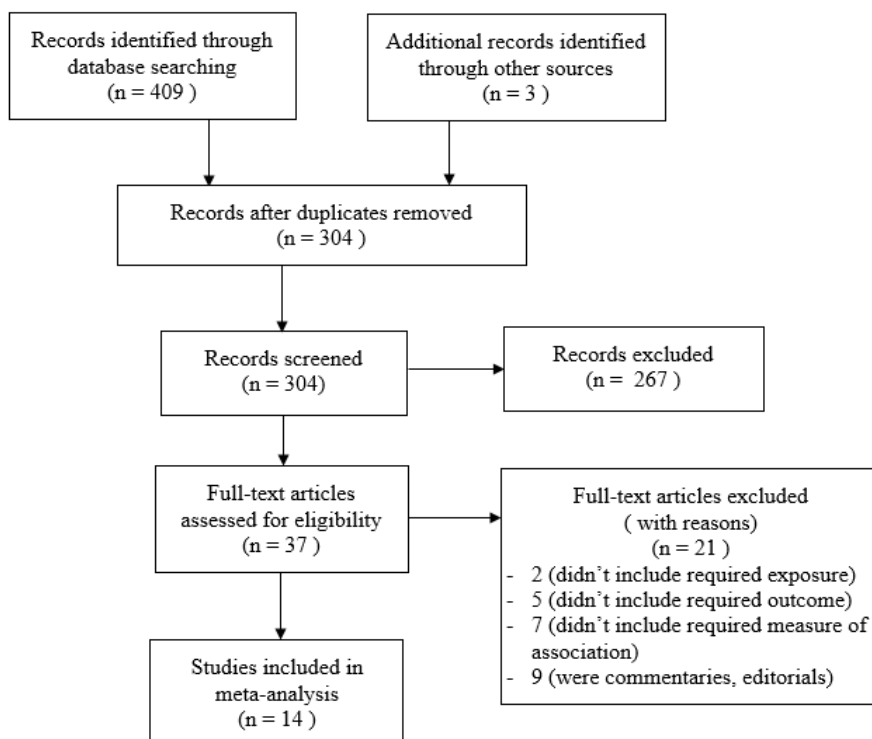


Figure 1

Flow chart of sample selection procedure.

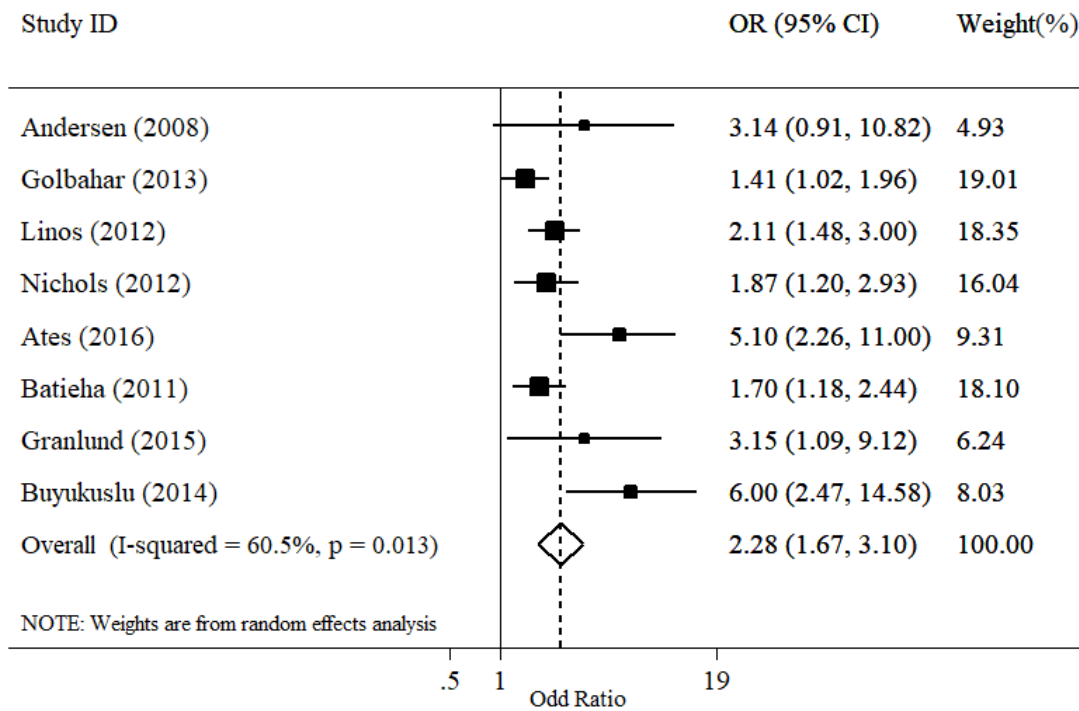


Figure 2

Result of meta-analysis of association of clothing type with VDD.

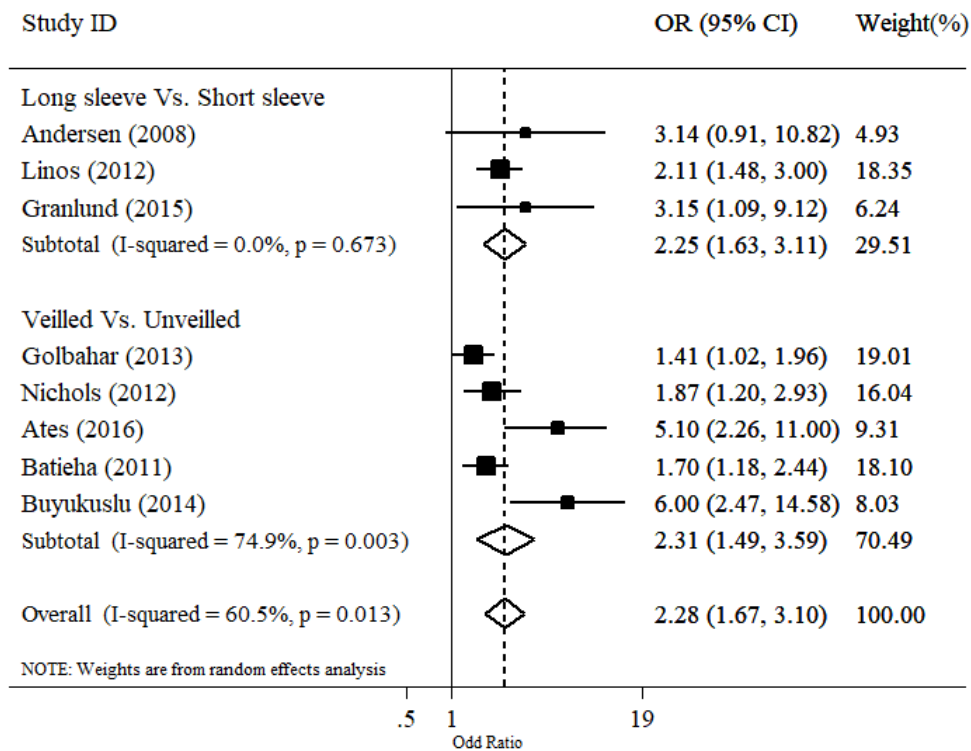


Figure 3
Result of meta-analysis of association of clothing type with VDD, subgroup analysis.

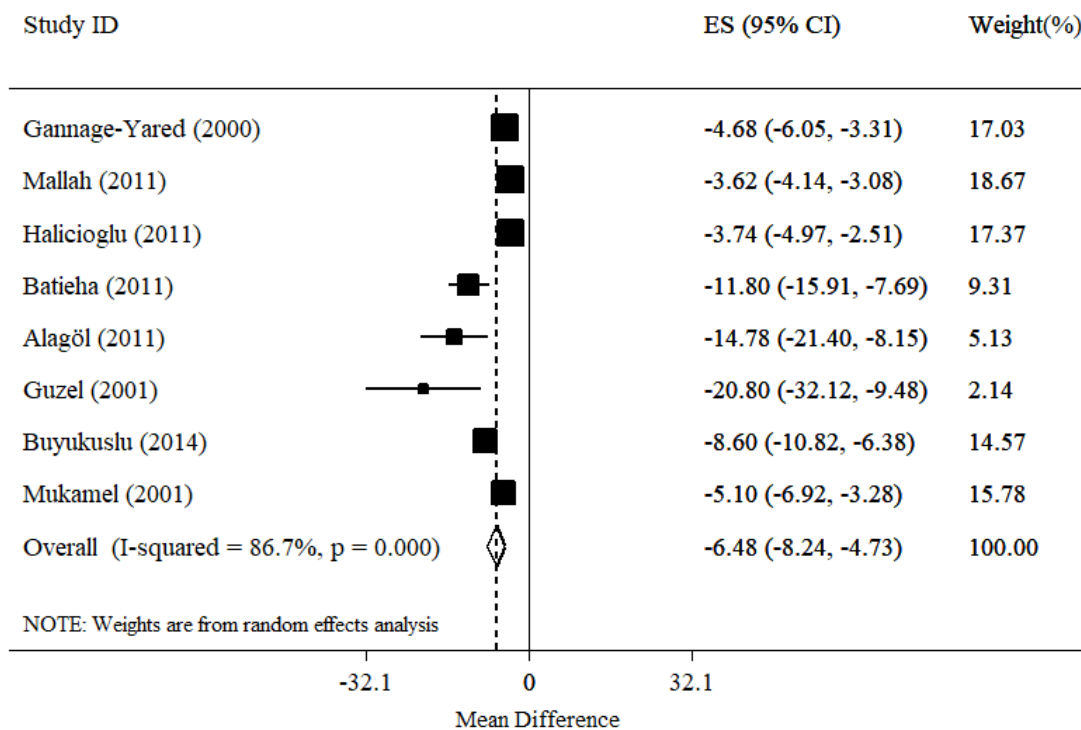


Figure 4
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Result of meta-analysis of association of clothing type with 25(OH)D.

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