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Vitamin D Status in Women with Different Clothing Styles and its Correlation with their Dietary Intake

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Abstract: ***Introduction**: Vitamin D is a fat-soluble vitamin that plays an important role in bone metabolism. Deficiency of vitamin D has been found to increase globally with the passing years. Many Indian women cover their bodies for religious and cultural reasons limiting the skin's exposure to sunlight and therefore its ability to synthesize vitamin D is affected. This study aims to compare vitamin D status in non-hijabi, hijabi and niqabi (veiled) women from Mumbai and to correlate it with their dietary intake of vitamin D. **Methods**: 150 females, 50 in each group (Groups: 1. Non-hijabi, 2. Hijabi, 3. Niqabi) aged 18 to 45 years were selected for serum vitamin D blood test. Data was collected from each woman by administering a case report form, food frequency questionnaire (FFQ) and 24 hour dietary recall. **Results**: The mean values of serum 25(OH)D in group 1, 2 and 3 were 14.62 ng/ml, 18.11 ng/ml, and 18.62 ng/ml, respectively. The highest intake of vitamin D3 calculated via food frequency questionnaire was in group 3 (0.83 µg/day), then in group 2 (0.52 µg/day) and least in group 1 (0.41 µg/day). The association of dietary intake with serum 25(OH)D status showed a statistically significant difference in the intake of vitamin D3 calculated from both 24 hour diet recall(p = 0.025) and food frequency questionnaire(p = 0.000) amongst those who had serum 25(OH)D deficiency, insufficiency and sufficiency. **Conclusion**: Hypovitaminosis D status is alarmingly high in all the three groups irrespective of the clothing styles – non hijabi, hijabi and niqabi. Therefore, the clothing style of females should not be used as a pretext for the diagnosis of vitamin D deficiency. It can also be concluded that there is a notable importance of dietary intake of vitamin D3 in maintaining sufficient vitamin D status. Along with sunlight exposure, it is important to consume supplements and foods rich in vitamin D to maintain adequate vitamin D status.*

Keywords: Serum Vitamin D, Vitamin D deficiency, Dietary Vitamin D intake, Females, Hijab, Clothing, Women, Niqab

1. Introduction

Vitamin D is a fat-soluble vitamin and a hormone precursor that plays an important role in bone metabolism. Prevalence of vitamin D deficiency (VDD) is reported worldwide, both in countries which are sunshine deficient and sunshine sufficient [1]. Various studies showed poor vitamin D status irrespective of age, sex, and geography [2]. It has been proven that vitamin D not only helps to maintain bone health but it's deficiency is independently associated with chronic pathological conditions such as coronary heart disease, type 2 diabetes, cancer, autoimmune diseases and various inflammatory disorders and also increases the risk of mortality in the population [3].

In countries with abundant sunlight, it is considered that children and adults would be obtaining adequate quantity of this sunshine vitamin. However, in India which is one of the most sun-drenched countries of the world, vitamin D deficiency is an epidemic similar to what has been observed in countries in the Middle East and South America[4].

It is important to obtain adequate amount of vitamin D either from diet or from adequate exposure of the skin to sunlight. The term "vitamin D" includes either compounds vitamin D3 (cholecalciferol) or vitamin D2 (ergocalciferol). On exposure to sunlight, vitamin D3 is produced in the skin and is derived from 7-dehydrocholesterol by ultraviolet irradiation of the skin and it is also found in animal food sources e.g., fatty fish (e.g., salmon, mackerel and tuna) cod liver oil, milk, etc whereas Vitamin D2 is found in vegetal sources like sun-exposed yeast and mushrooms. Vitamin D deficiency is considered to be a result of inadequate sun exposure or inadequate intake of the vitamin over time.

South Asian countries like India, Pakistan, Bangladesh as well as Middle Eastern countries are known to cover skin extensively due to religious or cultural reasons. The prevalence of vitamin D deficiency is 70% –100% in the general population and it prevails in epidemic proportions all over the Indian subcontinent [5]. The fortification of widely consumed food items such as dairy products with vitamin D is rare in India. In India, the socioreligious and cultural practices do not facilitate adequate sun exposure, thereby negating potential benefits of plentiful sunshine. Many Indian women cover their bodies for religious and cultural reasons limiting the skin's exposure to sunlight and therefore its ability to synthesize vitamin D is affected. Especially among women different clothing styles range from covering the whole body including the hands and face (Niqab) to styles that cover the body except hands and face (Hijab) to western type dressing styles. It is important to compare the vitamin D status in females with these different dressing styles. Some studies have shown that even intensive sun exposure does not ensure vitamin D adequacy [6].

Apart from inadequate sunlight exposure, deficiency can occur if the person doesn't consume the recommended levels of the vitamin over time. Thus it is important to know the dietary intake of vitamin D. The present study is one of the few studies in the existing literature to evaluate dietary intake of vitamin D in relation to clothing style and to assess its effect on vitamin D status. Vitamin D status is often defined by serum levels of 25(OH)D as follows: vitamin D deficiency, 25(OH)D < 20 ng/ml; vitamin D insufficiency, 25(OH)D of 21–29 ng/ml; sufficiency, 25(OH)D 30-100 ng/ml; and toxicity, >150 ng/ml [9].

Objectives of the study

- To compare serum vitamin D levels in hijabi, niqabi and non-hijabi females aged 18 to 45 years and to study its association with their respective clothing styles.
- To assess the dietary intake of vitamin D
- To study the correlation between dietary intake of vitamin D and serum vitamin D levels.

2. Materials and Methods

A cross sectional study was conducted to investigate vitamin D status in 150 females. This study recruited healthy, premenopausal females aged 18 – 45 years. Subjects were assigned to three groups (n=50 per group) on the basis of the clothing style of the participants:

Group 1 (Non hijabi group)
It included female participants who reported wearing Western-style clothing and Indian dress (Salwar Kameez or Saree).

Group 2 (Hijabi group)
It included female participants who reported that they wear the hijab/scarf covering the head with their face and hands exposed.

Group 3 (Niqabi group)
It included female participants who reported that they wear a black veil/niqab which covered their face.

Ethical Committee Approval
Ethical approval was obtained from Inter System Biomedica Ethics Committee (ISBEC) for the study.

Inclusion criteria
Women with different dressing styles i.e. hijabi, niqabi, non-hijabi aged 18-45 years willing to participate in the study from Mumbai and had the same dress style for at least the preceding 6 months were included in the study.

Exclusion criteria
Patients who had consumed vitamin D or calcium supplements or had taken vitamin D injections within last 3 months, or consumed medications known to influence bone metabolism were excluded from the study.

Sample Collection
Venous blood samples were collected from each subject after acquiring a written informed consent from them and samples were sent to a laboratory for subsequent analysis of serum 25(OH)D.

Laboratory Analysis
Serum 25-hydroxyvitamin D (25-OH Vitamin D) concentration was measured via Fully Automated Chemi Luminescent Immuno Assay.

Data Collection
Data was collected from each woman by giving a structured questionnaire to collect information from the participants. The questionnaire consisted of the following:

Demographic Information
It included clothing style, age, date of birth, occupation or designation, qualification.

Diet History
It included eating habits, consumption of vitamin D supplements/ calcium supplements, total number of family members for whom food was cooked.

Medical History
Diagnosed illness, any bone related disorder, medications consumed for any bone disorders, vitamin D status in past.

Anthropometry
Height, weight was measured and Body Mass Index (BMI) of the subjects was calculated.

Nutrient Intake Assessment:
a) 24 hr home dietary recall
24 hour dietary recall was used to assess the nutrient intakes of foods and nutrients
b) Calcium and vitamin D food frequency questionnaire

A validated food frequency questionnaire which was adapted according to the purpose of the study was used [19]. The food frequency questionnaire was adjusted to reflect the local food items known to contain vitamin D and calcium consumed in the city.

Statistical Analysis
The data was analysed using Statistical Package for Social Sciences (SPSS) software (version 25, SPSS Inc., Chicago, IL, USA). One-way Anova, Karl Pearson's correlation co-efficient and multiple regression was done to analyse the data.

3. Results

This study examines the vitamin D status in women focusing on the role of their dress style, and their vitamin D dietary intake. We focused on young, healthy females aged 18 - 45 years in this study to control for other factors besides clothing style, such as menopausal status, that may cause discrepancies in vitamin 25(OH)D status.

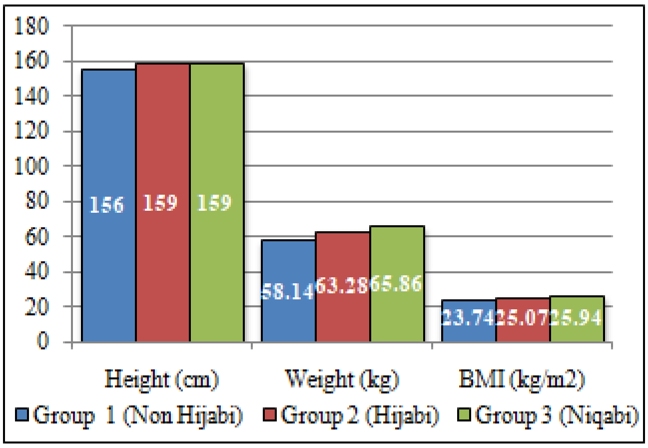


Figure 1: Anthropometric Measurements

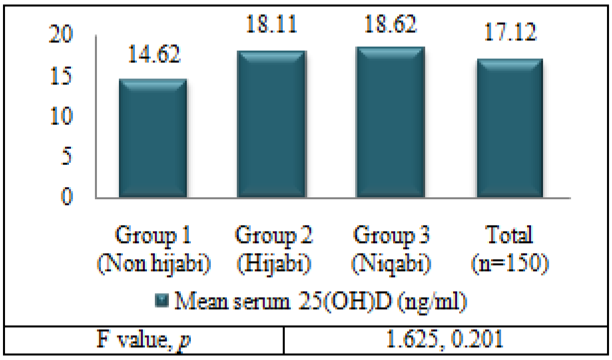
Anthropometric Measurements

The mean height, weight, BMI of the study participants shown in figure 1 were 158 ± 0.51 cm, 62.43 ± 11.99 kg and 24.91 ± 4.88 respectively. Body Mass Index is a simple index of weight-for-height that is commonly used to classify overweight and obesity in adults. Though BMI is a measure of excess weight rather than excess fatness of the body, it can be effectively used as a screening tool for the population. According to the WHO classification of BMI, the mean BMI of 24.91 ± 4.88 kg/m^2 in the present study was in the category of normal [7]. There was no significant difference in BMI of the three groups and thus the there was no influence of BMI of the participants on serum 25(OH)D levels for the three groups. It has been observed that higher BMI levels were associated with lower vitamin D levels [8].

Biochemical measurements

Serum 25-hydroxyvitamin D

Levels of serum 25(OH)D were compared among three groups – non hijabi, hijabi and niqabi.



Data presented as mean ± SD

Figure 2: Mean values of serum 25(OH)D in groups according to clothing styles

Table 2: Mean dietary intake of Macronutrients

Nutrients	Group 1 (Non-hijabi)	Group 2 (Hijabi)	Group 3 (Niqabi)	Total	F value	*p*
Energy (kcal)	1439 ± 426	1533 ± 433	1476 ± 315	1483 ± 394	0.727	0.485
Protein (g)	38.04 ±13.78	44.05 ±19.87	40.21 ± 9.31	40.77 ± 15.07	2.069	0.130
Carbohydrate (g)	189.63 ± 63.85	193.59 ±50.44	196.22 ± 54.23	193.14 ± 56.14	0.172	0.842
Fat (g)	49.53 ± 19.56	54.61 ± 23.22	49.82 ± 13.64	51.32 ± 19.23	1.101	0.335

Data presented as mean ± SD.

Table 3: Mean dietary intake of Micronutrients

Nutrients	Group 1	Group 2	Group 3	Total	F value	*p*
Mean dietary intake calculated via 24 hour diet recall						
Calcium (mg)	457.63 ± 217.85	437.53 ±167.89	492.55 ± 202.82	462.57 ± 197.30	0.995	0.372
Phosphorus (mg)	460.74 ± 162.39	514.85 ± 215.01	474.70 ± 115.12	483.43 ± 169.60	1.379	0.255
Vitamin D3 (µg)	0.59 ± 0.93	0.75 ± 0.92	0.41 ± 0.75	0.57 ± 0.86	1.189	0.31
Ergocalciferol D2 (µg)	29.87 ± 18.95	26.26 ± 10.13	27.53 ± 9.37	27.89 ± 13.53	0.913	0.404
Mean dietary intake calculated via food frequency questionnaire (FFQ)						
Calcium (mg)	490.91 ± 283.02	442.79 ± 226.16	510.29 ± 313.46	481.33 ± 276.20	0.789	0.456
Vitamin D3 µg)	0.41 ± 0.40	0.52 ± 0.48	0.83 ± 0.89	0.59 ± 0.65	4.814	0.01
Ergocalciferol D2 (µg)	21.96 ± 9.35	21.95 ± 8.96	22.03 ± 8.25	21.98 ± 8.80	0.001	0.999

Data presented as mean ± SD.

Figure 2 shows mean 25(OH)D levels 14.62 ± 14.37 ng/ml, 18.11 ± 11.79 ng/ml, 18.62 ± 9.67 ng/ml in groups 1, 2 and 3 respectively. Analysis of variance indicated that mean of 25(OH)D did not differ significantly between groups according to clothing styles (p=0.201).

In the study by Mishal et al., there were no significant differences among any of the groups of women with a mean 25(OH)D levels of 19.3±9.35 ng/ml [10]. This could be explained by the lack of sunshine in winter, as our study was conducted in the winter season which minimizes influences of different dress styles in that season.

The mean 25(OH)D level of the entire study group was 17.12 ± 12.15 ng/ml. Also the mean 25(OH)D levels of the three groups was in the mild hypovitaminosis D range (11 – 20 ng/ml).

Dietary intake

The average intake of macronutrients – energy, protein, carbohydrates and fats and micronutrients – vitamin D3, ergocalciferol(D2), calcium and phosphorus was calculated via 24 hour dietary recall. A validated food frequency questionnaire was administered to calculate vitamin D3, ergocalciferol(D2) and calcium by determining the

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frequency (per month, week or day) with which subjects consumed each item on the list.

In table 2 and table 3, the mean intake of macronutrients and micronutrients calculated via 24 hour dietary recall did not differ significantly between groups according to clothing styles. However, analysis of variance (ANOVA) indicated that intake of Vitamin D3 calculated via food frequency questionnaire (FFQ) differed significantly between groups according to clothing styles (p = 0.010). Post hoc analysis using Bonferroni test showed that vitamin D3 intake differed significantly between group 1(non- hijabi) and group 3 (niqabi) (p=0.012). The highest intake of vitamin D3 calculated via FFQ was in group 3 (0.83 µg/day), then in group 2 (0.52 µg/day) and least in group 1 (0.41 µg/day).

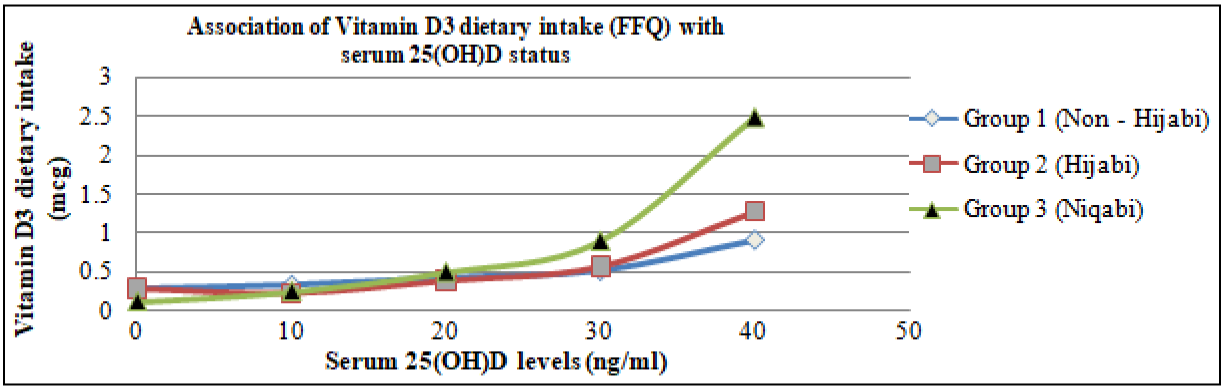

Figure 3: Association of Vitamin D3 dietary intake (FFQ) with serum 25(OH)D status

Table 4: Pearson's correlation between dietary intake of micronutrients and serum vitamin D level

	Serum Vitamin D level (ng/ml)							
	Group 1 (Non-hijabi)		Group 2 (Hijabi)		Group 3 (Niqabi)		Total	
	r	*p*	r	*p*	r	*p*	r	*p*
Micronutrients per day calculated via 24 hour diet recall								
Calcium (mg)	0.046	0.749	0.082	0.570	-0.095	0.510	0.021	0.798
Phosphorus (mg)	0.236	0.100	0.198	0.168	0.136	0.347	0.204	0.012
Vitamin D3 (mcg)	0.735**	0.001	0.449*	0.017	0.370*	0.037	0.505**	0.000
Ergocalciferol D2 (µg)	0.187	0.193	0.128	0.375	0.079	0.588	0.132	0.106
Calcium and Vitamin D per day calculated via food frequency questionnaire (FFQ)								
Calcium (mg)	-0.026	0.858	0.069	0.633	-0.208	0.148	-0.056	0.497
Vitamin D3 (µg)	0.398*	0.013	0.638**	0.000	0.665**	0.000	0.511**	0.000
Ergocalciferol D2 (µg)	0.202	0.160	0.000	0.998	0.070	0.631	0.100	0.221
**Pearson's correlation is significant at the 0.01 level *Pearson's correlation is significant at the 0.05 level								

In the association of dietary intake with serum 25(OH)D status, there was a statistically significant difference in the intake of vitamin D3 calculated from both 24 hour diet recall(p = 0.025) and FFQ(p = 0.000) amongst those who had serum 25(OH)D deficiency, insufficiency and sufficiency.

In those subjects who had sufficient serum 25(OH)D levels there was a higher intake of vitamin D3 as compared to insufficient and deficient subjects. In Figure 3, it can be observed that serum 25(OH)D concentrations were significantly lower in individuals with less vitamin D3 intake and increased with increasing dietary intake of vitamin D3.

Table 4 shows that Pearson's correlation between serum 25(OH)D level and dietary intake of micronutrients - phosphorus, calcium, vitamin D3, ergocalciferol, showed a statistically significant correlation only between serum 25(OH)D level and vitamin D3 calculated from both food frequency questionnaire and 24 hour dietary recall in all the three groups. Mean vitamin D3 intake calculated via food frequency questionnaire in group 3 was the highest, which was followed by group 2 and the lowest intake was in group 1.This suggests that the increased mean serum 25(OH)D levels in group 3 and group 2 as compared to group 1 can be due to the increased dietary intake in group 3, then in group 2 and least in group 1.

Multiple Regression

Multiple regression was used to see the effect of various predictors which included different clothing styles, phosphorus, calcium, vitamin D3, ergocalciferol intake calculated from food frequency questionnaire and 24 hour diet recall on serum 25(OH)D level. The overall model to explain the serum vitamin D status (ng/ml) with both FFQ and 24 hour diet recall was significant,

R^2 = 0.372, Adjusted R^2 = 0.340, F = 11.736, p<0.05 for food frequency questionnaire

R^2 = 0.397, Adjusted R^2 = 0.345, F = 7.683, p<0.05 for 24 hours diet recall

Vitamin D3 (p = 0.000) and ergocalciferol (D2) (p = 0.001) calculated via food frequency questionnaire and Vitamin D3 (p = 0.000) and ergocalciferol (D2) (p = 0.003) calculated via 24 hour diet recall were associated with higher serum vitamin D concentrations, p<0.05.

There was no significant relationship between serum 25(OH)D concentrations and clothing styles - non hijabi (p= 0.435), hijabi (0.466) and niqabi (p= 0.211). No significant relationship was observed with calcium (p= 0.734) and phosphorus intake (p= 0.682) from 24 hour diet recall. Also there was no significant relationship in the second regression model which included calcium from food frequency questionnaire along with different clothing styles- non hijabi (p= 0.705), hijabi (0.784) niqabi (p= 0.644).

Table 5: Multiple regression

Significant relationship with serum 25(OH)D		Non-Significant relationship with serum 25(OH)D	
Food frequency questionnaire	24 hour diet recall	Food frequency questionnaire	24 hour diet recall
Vitamin D3 (p = 0.000)	Vitamin D3 (p = 0.000)	1. Non hijabi (p= 0.705)	1. Non hijabi (p= 0.435)
Ergocalciferol (D2) (p = 0.001)	Ergocalciferol (D2) (p = 0.003)	2. Hijabi (p=0.784)	2. Hijabi (p=0.466)
		3. Niqabi (p= 0.644)	3. Niqabi (p= 0.211)
		4. Calcium (p= 0.521)	4. Calcium (p= 0.734)
			5. Phosphorus (p= 0.682)

4. Discussion

Vitamin D is known to play a vital role in bone health. Vitamin D deficiency therefore plays an important role in osteoporosis and other bone ailments [3]. Vitamin D levels are influenced by several factors, including age, ethnicity, exposure to UVB radiation, diet, body mass index (BMI), daily calcium intake, sunscreen use, and clothing style [11]. The body requires 10-15 minutes of exposure to solar UVB radiation between 10 am and 2 pm at least 2 to 3 times per week to synthesize adequate vitamin D levels [12]. For cultural or religious reasons, the women in India wear covered clothing including styles that cover the face (niqab), covered but face and hands exposed (hijab), or dressed in Indian/Western style.

In our study, all the groups had vitamin D deficiency and there was no significant difference in serum 25(OH)D levels across the three groups. A similar study by Al-Yatama et al. in Kuwait concluded that serum 25(OH)D levels were not significantly different across the three groups despite the observed elevation in bone turnover markers and majority of participants in all three groups exhibited vitamin D deficiency [13]. A study conducted in Bangladesh to evaluate the vitamin D status in veiled and non veiled Bangladeshi women also showed that hypovitaminosis D was common in both veiled and unveiled women but with marginal and insignificant differences between the two groups [14]. In our study it can be observed that a suboptimal level of serum 25(OH)D was present in the three groups with the highest level in group 3 irrespective of having a fully covered clothing style. Also the highest intake of vitamin D3 calculated via FFQ was in group 3 (0.83 μg/day), then in group 2 (0.52 μg/day) and least in group 1 (0.41 μg/day), this could be the reason of higher serum 25(OH)D level in group 3. However, WHO/FAO suggests at least 5 mcg/day dietary intake of vitamin D3 to maintain optimal levels, but in all the three groups there was suboptimal intake of vitamin D3 which resulted in deficient serum 25(OH)D levels in our study group [15]. A similar study done by Pasco et al. in Australia on 861 women showed a median intake of 1.2 μg/day vitamin D3 and this study group also had suboptimal level of serum 25(OH)D due to inadequate intake. In the study done by Pasco et al., it concluded that the contribution of vitamin D from dietary sources appeared to be insignificant during summer. However, during winter vitamin D status was influenced by dietary intake [16]. As our study was also conducted in winter, this could be the reason of effect of dietary intake of vitamin D3 on serum 25(OH)D status. In a study by van der Wielen et al., despite having enough sunlight, the prevalence of hypovitaminosis D was up to 83% in elderly Greek women compared with only 18% of the elderly population in Norway. A high intake of fish, vitamin D fortification of food, and vitamin D supplementation was the reason for vitamin D adequacy in Norway [17]. In a study conducted in central Sweden (latitude 60°) during winter, serum 25(OH)D concentrations increased by 25.5 nmol/L with 2–3 servings (130 g/wk) fatty fish/wk, by 6.2 nmol/L with the daily intake of 300 g vitamin D–fortified reduced-fat dairy products, by 11.0 nmol/L with regular use of vitamin D supplements [18]. This shows that subjects with adequate vitamin D3 dietary intake have higher vitamin D levels despite their very low sunlight exposure.

The limitation of this study is that as the participation in the study involved blood withdrawal, a limited sample size of 50 volunteers from each group was analyzed. Therefore, the results of our study should be interpreted with caution, and larger sample sizes are required in future studies to unravel the effect of dietary intake and clothing style on vitamin D status. As our study was carried out during winter-time, it is important to know the effect of dietary intake of vitamin D on vitamin D status during summer time as past researches have shown variation in vitamin D levels between both seasons.

The study was conducted on premenopausal females aged 18-45 years; vitamin D status in postmenopausal females should also be assessed as menopause may cause discrepancies in vitamin D status. Also one of the limitations of the present study is that men were not examined in this study for their Vitamin D status.

5. Conclusion

Vitamin D deficiency and borderline vitamin D status were prevalent in different groups of adult premenopausal women aged 18 – 45 years and they were equally at risk of developing vitamin D deficiency. Hypovitaminosis D was alarmingly high in all the three groups irrespective of the clothing styles – non hijabi, hijabi and niqabi. Therefore, the clothing style of females should not be used as a pretext for the diagnosis before other probable factors are being examined or considered. The results indicated that hypovitaminosis D could be an important public health problem in adult women of Mumbai. It can also be concluded that there is a notable importance of dietary intake of vitamin D3 in maintaining sufficient serum 25(OH)D status.

A comprehensive programme to prevent vitamin D deficiency in women is recommended. Strategies may include improved dietary supplies of calcium and vitamin D, extensive awareness of the importance of sunlight exposure and improved judicious exposure to sunlight. In this case high intake of vitamin D and calcium rich food as well as inclusion of a food-fortification programme could be suggested. The topic of vitamin D deficiency should be integrated in the popular broadcasting media as well as newspapers could play an important role in this aspect.

6. Recommendations

A study carried out in summer-time to see the seasonal variation of vitamin D status in women is needed in order to plan long term solutions to alleviate this problem. There is also a window of opportunity to develop new recipes with vitamin D rich foods that can become a part of regular diet. Similarly, long term intervention studies using vitamin D rich diets need to be conducted for better understanding of the effect of dietary intake of vitamin D on serum vitamin D status. Public health practitioners, dietitians and nutritionists should advise people in this part of the world, especially women to take precautionary measures by finding ways and means for more outdoor lifestyles, within the framework of their religious and cultural commitments, and to seek oral vitamin D supplementation. Fortification of dairy products and other suitable food items should be one of the concerns of health policy makers.

7. Acknowledgments

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