COMPARISON OF VARIOUS DIETARY PARAMETERS INTAKE AND THEIR RELATIONSHIP WITH VITAMIN D LEVEL AMONG THE ADULT MALES AND FEMALES OF CHANDIGARH, INDIA

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Abstract

Background: The vitamin D concentration within the human body is influenced by a multitude of factors, among which dietary intake plays a significant role. **Aims and Objectives:** The objective of the present study is to analyze the sex difference in the intake of various dietary parameters and to find their correlation with the vitamin D levels among the adult males and females of Chandigarh, India. There is a paucity of data regarding this study on the adult population of Chandigarh, India. **Materials and Methods**: The sample included 627 participants (332 males and 295 females) of ages ranging between 30 and 70 years. Vitamin D level was estimated by employing the chemiluminescence immunoassay method, and all the participants were divided into three categories of Vitamin D level, i.e., normal range (>30–100 ng/ml), insufficiency (21–29 ng/ml), and deficiency (0–20 ng/ml) as per the Endocrine Society Guidelines (2011). A 24-hour dietary intake for three consecutive days was performed to evaluate the intake of energy, protein, fat, calcium, and iron among adult males and females. **Results:** The mean values of the daily intake of the males for all the dietary parameters were significantly higher than those of the females. Vitamin D level in the males lying in vitamin D insufficient category was positively and significantly associated with energy intake($r=0.188$, $p<0.05$). Dietary intake of fat was positively and significantly associated with vitamin D level in females ($r = 0.346$, $p<0.01$) present in the vitamin D normal category. **Conclusion**: Energy intake was positively and significantly associated with the vitamin D level among the males present in the insufficient category of vitamin D. Dietary intake of fat was found to be positively and significantly associated with the vitamin D level among the females present in the normal category of vitamin D. Nutritional strategies that address malnutrition are necessary to make food systems healthier and more environmentally sustainable.

Keywords: deficiency, vitamin D, energy intake, fat intake

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Introduction:

Vitamin D occurs in two main forms: vitamin D_3 (cholecalciferol) and vitamin D_2 (ergocalciferol). Vitamin D_3 is found in animal foods like fatty fish, egg yolks, and milk. Vitamin D_2, however, is mostly found in plant foods like yeast, mushrooms, and foods that have been supplemented. [1,2]. Endogenous synthesis from 7-dehydrocholesterol in the epidermis of the skin following exposure to UV (ultraviolet) B radiation with wavelengths between 290 and 315 nm is a significant source of vitamin D for humans[3]. The most active metabolite of Vitamin D is 1,25-dihydroxycholecalciferol ($1,25(OH)_2D_3$). It is the result of two stages of hydroxylation of 25-hydroxycholecalciferol ($25(OH)D_3$) in the liver and position 1 α hydroxylation in the kidney and other organs[4-6]. The various organs and tissues of human body are affected by vitamin D in its active form. The pleiotropic effect of vitamin D affects the immune, cardiovascular, and nervous systems in addition to the calcium-phosphorus metabolism [7].

Especially in industrialized nations, vitamin D deficiency is still widely prevalent[8]. The use of UV filters, increased atmospheric pollution, excessive skin pigmentation, and the aging of the global population are likely the root causes of deficiency [9]. Additionally, it is important to analyze the vitamin D concentration while taking into account variables like seasonality and lifestyle influences [10,11]. As a result, a properly balanced diet and supplementation now play the primary role in meeting the vitamin D requirement due to a decline in endogenous synthesis of vitamin D_3. It is important to remember that a balanced diet can likely only meet the requirement in 20% of cases [12]. Dietary sources of vitamin D include foods and supplements; therefore, "total vitamin D intake" reflects the combined contribution of foods and supplements. There are some naturally occurring sources of vitamin D in the diet. These include fatty fish, fish liver oil, and egg yolks. However, some foods are fortified with vitamin D. After vitamin D was recognized as important in preventing rickets in the 1920s [13], fortification of some foods with vitamin D was introduced on a voluntary basis. The relationship between vitamin D concentration and diet has been investigated in many studies [14-18]. The present study aims at analyzing the daily dietary intake of energy, protein , fat, calcium and iron of males and females lying in the three categories of vitamin D level and its correlation with the vitamin D levels. There is a paucity of data regarding this type of study on the adult population of Chandigarh, India.

Material and Methods:

The present study was conducted with the objective to assess the association of the Vitamin D levels with the other biochemical parameters among the adult males and females of Chandigarh, India, which is the capital of states named Punjab and Haryana. In the present cross-sectional study, a random sampling procedure was adopted to select 332 males and 295 females, with age ranging between 30 and 70 years. Before initiating data collection, all the participants were informed about the nature as well as purpose of the study, and their verbal informed consent was also obtained. Union territory of Chandigarh comprised the city of Chandigarh and a number of adjoining villages. The data were collected from different sectors of Chandigarh city, excluding rural areas. Data collection was carried out from December 2017 to March 2019 from various parts of union territory of Chandigarh. The sample size was calculated applying the formula ($n = Z\alpha 2 \times p \times q/d2$) with 95% of confidence interval and 5% probability of type 1 error[19]. If the prevalence of deficiency was assumed to be 40%, using the aforementioned formula, the estimated sample size would be 590. On the basis of inclusion and exclusion criteria, a sample of 627 participants was selected.

To evaluate the approximate quantity of dietary intake of all the subjects a 24-hour dietary recall method for three consecutive days was performed. The amounts of food consumed was estimated by using standardized spoons, glasses and bowls for measurement of the foodstuffs. Additional information on frequency (ate 2 times /day or 3 times / day) and type (vegetarian / non-vegetarian/ ovatarian), intake of seasonal / non-seasonal fruits were also recorded. Nutritive value tables for Indian foods were employed to assess nutrient intake[20]. The dietary assessment of intake of total energy, protein, fat, calcium and iron was calculated. Informed consent was taken from each participant, and ethical clearance for conducting the study was obtained from the Institutional Ethical Committee.

For the estimation of the Vitamin D of the participants, chemiluminescence immunoassay (CLIA) method was adopted. Blood samples were collected by a trained technician. The samples were transported to the laboratory in cool packs and were stored at −20°C. Serum 25 (OH) Vitamin D level was estimated by CLIA technique (Beckman dxi 600) in the laboratory. Vitamin D level was stratified into three categories, i.e., normal range (>30–100 ng/ml), Vitamin D insufficiency (21–29 ng/ml), and Vitamin D deficiency (0–20 ng/ml) [21].

Exclusion criteria: Subjects having any chronic liver disease, prolonged illness, history of medication with corticosteroids, hormone replacement therapy, pregnancy and any record/history of surgery were excluded from the study.

Statistical analysis

The collected data were analysed by employing Statistical Package for the Social Sciences (SPSS) version 21.0 (SPSS Inc.). Sex difference for the various parameters were calculated using the t-test. Correlation was calculated by using SPSS. The level of significance for all analysis was set at $P < 0 \cdot 05$ and a confidence interval of 95%.

Results:

Table 1 depicts the descriptive statistics of dietary intake among the adult males and females of Chandigarh. In the normal category of vitamin D level, the mean value of the daily energy intake of the males (1997.34 Kcal) was found to be significantly higher as compared to their female counterparts (1794.42 Kcal). The difference between the mean values for this variable between both the sexes was statistically significant as evident from the t-value. In the insufficient category of vitamin D level, the mean value of the daily energy intake of the males was 2110.07 Kcal, which was significantly higher than the females 1843.88 Kcal, t-value presents statistically significant sex difference for this variable. In the deficient category of vitamin D level, the mean value of the daily energy intake of the males (2196.22 Kcal) was found to be significantly higher as compared to their females counterparts (1949.22 Kcal). The sex difference between the mean values of both the Vitamin D Deficient (VDD) groups was found to be significant as evident from the t-value. It has been observed that there is a lower dietary intake of energy in all three categories of vitamin D than the recommended dietary allowances of the Indian Council of Medical Research(ICMR) in males and females, respectively.

The mean value of the daily protein intake for the males present in normal vitamin D category was 38.6 g/d which was significantly higher than their age matched female counterparts (34.62 g/d). In Vitamin D insufficient(VDI) category, the mean value of the dietary intake of protein for the males was 40.08 g/d which was significantly higher than the mean value of females (36.31 g/d). The mean value of the dietary protein intake for the males in Vitamin D deficient category (42.33 g/d) was significantly higher than the females (38.38 g/d). The difference between both the sexes for the protein intake was found to be statistically significant for vitamin D normal (t-value 8.754**), Vitamin D Insufficient (VDI) (t-value 7.206**) and Vitamin D Deficient(VDD) categories respectively (t-value 53.179**). Males and females in the present study demonstrated lower dietary intakes of protein in all three categories of vitamin D than the recommended dietary allowances of the ICMR for males and females, respectively.

The mean values of the fat intake through diet for the vitamin D normal males and females were 12.72 g/d and 11.71 g/d respectively. In Vitamin D insufficient category, the mean values of the fat intake in males and females were 14.11 g/d and 13.2 g/d respectively. The mean values of the fat intake for the vitamin D deficient males and females were14.78 g/d and 13.78 g/d respectively. t-value exhibited statistically significant sex difference in vitamin D normal (7.899**), vitamin D insufficient (2.516*) and vitamin D deficient categories (24.432**). The dietary intake of fat in all three categories of vitamin D was found to be lower than the recommended dietary allowances of the ICMR for males and females, respectively.

The daily calcium intake of the males in normal Vitamin D category (301.41 vs 275.38 mg/day), VDI (313.8 vs 277.1 mg/day) and VDD (322.3 vs 295.71 mg/day) was significantly higher than their female counterparts as evident from table 1. The difference between the mean values of both sexes was reported to be significant, as found by the t-value. The intake of calcium in all three categories of vitamin D was lower than the recommended dietary allowances of the ICMR in males and females, respectively.

In males, the daily intake of the iron for the Vitamin D normal males was 17.18 mg/day, which was significantly higher than their female counterparts (16.24 mg/day) as observed by their t-value (2.095**). Vitamin D insufficient category also exhibited significantly higher daily intake of the iron through diet among males (18.58 mg/day) as compared to females (16.28 mg/day). The daily intake of the iron through diet for the Vitamin D deficient males and females was found to be 19.34 mg/day and 17.34 mg/day respectively. t-value (14.843**) demonstrated statistically significant sex difference in VDD category also. There was a lower dietary intake of iron in all three categories of vitamin D than the recommended dietary allowances of the Indian Council of Medical Research (ICMR) in males and females, respectively.

Table 1. Descriptive statistics of dietary intake among the adult males and females of Chandigarh.

VITAMIN D RANGE	ENERGY (Kcal) Mean±S.D	t-value	PROTEIN (g/d) Mean±S.D	t-value	FAT (g/d) Mean±S.D	t-value	CALCIUM (mg/day) Mean±S.D	t-value	IRON (mg/day) Mean±S.D	t-value
NORMAL		305.646**		8.754**		7.899**		38.685**		2.095**
MALES	1997.34±4.03		38.6±3.24		12.72±0.74		301.41±4.76		17.18±2.35	
FEMALES	1794.42±4.72		34.62±2.38		11.71±0.94		275.38±3.57		16.24±3.63	
INSUFFICIENT		118.423**		7.206**		2.516*		44.536**		3.836**
MALES	2110.07±13.68		40.08±2.65		14.11±2.13		313.8±4.65		18.58±3.53	
FEMALES	1843.88±6.69		36.31±3.52		13.2±1.47		277.1±4.16		16.28±2.42	
DEFICIENT		369.168**		53.179**		24.432**		101.037**		14.843**
MALES	2196.22±2.05		42.33±0.62		14.78±0.47		322.3±3.05		19.34±1.08	
FEMALES	1949.22±6.35		38.38±0.57		13.78±0.22		295.71±1.37		17.34±1.06	

Level of significance p<0.05*, p<0.01**, p<0.001**

Table 2. Karl Pearson correlation coefficient (r) of dietary intake of adult males with the different categories of vitamin D levels

Parameters	Vitamin D Normal		Vitamin D Insufficient (VDI)		Vitamin D Deficient (VDD)		Total	
	r	**p**	**r**	**p**	**r**	**p**	**r**	**p**
Energy (Kcal)	r=0.072	p=0.450	r=0.188*	p=0.035	r=-0.047	p=0.648	r=-0.891**	p=0.0001
Protein (g/d)	r=0.121	p=0.208	r=-0.119	p=0.184	r=-0.099	p=0.341	r=-0.446**	p=0.0001
Fat (g/d)	r=-0.173	p=0.069	r=0.096	p=0.284	r= 0.021	p=0.842	r=-0.451**	p=0.0001
Calcium (mg/day)	r=-0.122	p=0.203	r=0.163	p=0.068	r=0.010	p=0.926	r=-0.799**	p=0.0001
Iron (mg/day)	r=0.099	p=0.302	r=-0.20	p=0.821	r=-0.102	p=0.324	r=-0.271**	p=0.0001

Level of significance p<0.05*, p<0.01**, p<0.001**, VDI= Vitamin D insufficient, VDD= Vitamin D deficient

Karl Pearson correlation coefficient (r) for different categories of Vitamin D levels with the various dietary intake parameters of the males is documented in Table 2. Energy intake presented a positive association with vitamin D normal (r=0.072) and VDI males (r=0.188*), while a negative and non-significant correlation was notice in VDD males(r= -0.047). Protein intake demonstrated a positive and non-significant (r=0.121) association in vitamin D normal males, whereas it showed a negative and non-significant correlation with VDI (r= -0.119) and VDD (r= -0.099) males. Fat intake presented a negative and non-significant association with normal Vitamin D level (r = -0.173), whereas a positive and non-significant correlation was noted with vitamin D insufficient (r=0.096) and vitamin D deficient (r = 0.021) males. In all the categories of Vitamin D i.e., normal (r=-0.122), insufficient(r=0.163) and deficient (r=0.010), there was no significant association reported between the vitamin D level and dietary intake of calcium. There was no significant association reported between the vitamin D level and dietary intake of iron among the vitamin D normal (r=0.099), insufficient (r=-0.020) and deficient (r=-0.102) males.

Table 3. Karl Pearson correlation coefficient (r) of dietary intake of adult females with the different categories vitamin D levels

Parameters	Vitamin D Normal		Vitamin D Insufficient(VDI)		Vitamin D Deficient(VDD)		Total	
	r	**p**	**r**	**p**	**r**	**p**	**r**	**p**
Energy(Kcal)	r=-0.021	p=0.866	r=0.093	p=0.568	r=0.092	p=0.213	r=-0.924**	p=.0001
Protein(g/d)	r=-0.105	p=0.393	r=-0.019	p=0.908	r=-0.133	p=0.069	r=-0.647**	p=0.0001
Fat(g/d)	r= 0.346**	p=0.004	r= 0.250	p=0.119	r= -0.031	p=0.677	r= -0.706**	p=0.0001
Calcium(mg/day)	r=0.050	p=0.684	r=0.003	p=0.986	r=-0.012	p=0.875	r=-0.846**	p=0.0001
Iron(mg/day)	r=0.100	p=0.419	r=-.028	p=0.864	r=0.103	p=0.162	r=-0.187**	p=0.001

Level of significance p<0.05*, p<0.01**, p<0.001**, VDI= Vitamin D insufficient, VDD= Vitamin D deficient

Karl Pearson correlation coefficient (r) for different categories of Vitamin D levels with the various dietary intake of the females is documented in Table 3. In the case of Vitamin D normal (r=-0.021), insufficient (r=0.093) and deficient (r=0.092) category of females, there was no significant association reported between the vitamin D level and daily intake of energy. In the case of normal(r=-0.105), insufficient(r=-0.019) and deficient(r=-0.133) categories of females, no significant association was reported between the vitamin D level and protein intake. The vitamin D level was found to be associated significantly and positively associated with the dietary intake of fat for the vitamin D normal females(r=0.346**) whereas in case of the vitamin D insufficient (r= 0.250) and deficient (r=-0.031) females there was no significant association reported. Females in normal (r=0.050), insufficient (r=0.003) and deficient (r=-0.012) categories of the vitamin D were reported to have no significant association between daily intake of calcium with the vitamin D. There was no significant association reported between the vitamin D level and dietary intake of iron among the vitamin D normal (r=0.100), insufficient (r=-.028) and deficient (r=0.103) females.

Discussion:

Vitamin D is a fat-soluble vitamin with an important contribution in human physiology. In our present study, males exhibited significantly higher dietary intake of energy than their females counterparts in all the three categories of vitamin D i.e. vitamin D normal (1997.34 Kcal vs 1794.42 Kcal) , VDI (2110.07 Kcal vs 1843.88 Kcal) and VDD (2196.22 Kcal vs 1949.22). These findings are in agreement with the study conducted on Caucasian population[22], in which it was observed that intake of energy among males was higher than their female counterparts. A study on Indian population reported that Indians residing in both the urban as well as rural settings were having lesser average calorie consumption than the recommended value [23]. Zargar reported that there was no significant difference for energy intake values in males from different occupations in his study on residents of Kashmir which included 64 adult men and 28 adult non-pregnant/non-lactating women. They reported that the dietary intake of energy for farmers was 11676±564 (kJ), for Government employees 12019±677(kJ),for household individuals 11899±367(kJ),for medical professionals 11778±380 (kJ) and for students it was found to be 11641±588 (kJ)[24].

In the present study protein intake was significantly higher in males than their female counterparts in all the three categories of vitamin D level i.e. vitamin D normal (38.6 g/d vs 34.62 g/d), VDI (40.08g/d vs36.31 g/d) and VDD (42.33g/d vs 38.38g/d). A study conducted by the Zargar reported no statistically significant difference with respect to protein intake among the population of Kashmir[24]. They stated that protein intake from diet by the farmer was 54.1±5.2(g/day), for Government employees 55.5±5(g/day), for individuals in the household 50.1±7.4(g/day),for medical professionals 53.6±7.2(g/day) and for students the dietary protein intake was 51.6±7.3(g/day)[24].

In the present study dietary intake of iron was significantly higher in males than their female counterparts in all the three categories of vitamin D level i.e. vitamin D normal (17.18 mg/day vs 16.24 mg/day), VDI (18.58mg/day vs16. 28mg/day) and VDD (19.34mg/day vs17.34mg/day). The dietary intake of iron was positively associated with the vitamin D normal males. Females present in vitamin D normal and deficient categories of vitamin D exhibited positive correlation between the iron intake and vitamin D level. These observations were in agreement with several earlier studies [25-28]. A report of Balanco suggested a positive association between 25-hydroxy vitamin D and transferrin saturation among the Spanish VDD and VDI women [26]. The best marker of vitamin D status is 25-dihydroxy vitamin D, while transferrin saturation is the marker of the supply of iron to tissues.

A report of Malczewska evaluated whether vitamin D deficiency were associated with reduced iron status on healthy female athletes. They found that the percentage of iron deficiency (ID) was more (32%) in the VDD category than in the normal vitamin D group (11%) [29]. Previous researchers attributed an increase in hepcidin concentration due to the surge in some cytokines (IL-6 or IL-1B) for impairment of iron availability as well as its absorption by an individual with insufficient level of vitamin D [30,31]. In the present study the values of the iron intake were found to be lower than the RDA values thereby indicating the deficiencies of both micronutrients i.e. iron and vitamin D in the Chandigarh population. Regarding iron intake, the Recommended Dietary Allowance as given by ICMR are not easily achieved by either men or women. Therefore, the obtained results may indicate a possible association between vitamin D and iron status, although the nature of this relationship and the underlying mechanism remains ambiguous.

In our study the dietary intake of the fat was higher in Vitamin D normal (12.72g/d vs11.71g/d), VDI (14.11g/d vs 13.2g/d) and VDD (14.78g/d vs 13.78g/d) males than the females, although their mean values were lower than the recommended dietary allowance. Fat was negatively associated with males in Vitamin D normal category and, whereas a positive relationship was seen with VDI as well as VDD category. A study conducted by Bolesławska revealed a significant association between the high dietary fat intake and the vitamin D levels. They stated that both males and females having the high dietary intake of the fat were having higher concentration of the vitamin D levels as compared to those who were not having the high intake of the fat through diet and were consuming the Eastern European diet. Plasma $25(OH)D_3$ concentration was found to be significantly higher in individuals on the Low Carbohydrate High Fat diet (LCHF). This may be due to the higher consumption of products rich in vitamin D_3 in the LCHF group than in the Eastern European group, while the consumption of vitamin D_2 rich products were at similar level [32]. In contrary to the findings of present study Dawson reported that fat content in the diet has no relationship with the vitamin D uptake in the body which was different from our present study [33].

In the present study the calcium intake of males was higher in vitamin D normal (301.41mg/day vs 275.38 mg/day), VDI (313.8mg/day vs 277.1mg/day) and VDD (322.3mg/day vs 295.71 mg/day) categories than their female counterparts. The calcium intake was lower than the recommended dietary allowance of ICMR in both the sexes. A study performed by Gallaghar on the Caucasian females described that the dietary intake of calcium was not associated with the vitamin D levels [34]. In an intervention study of Berlin to examine the effect of calcium intake on the level of serum 25- hydroxyvitamin D_3 of the normal adults found that with supplementation of 2000 mg ca/d for forty two days had resulted in the lowering of serum $1,25(OH)_2D$ concentrations by 20% and increasing serum 25(OH)D concentrations by 30% [35].Harinarayan observed that in south Indian population, there was an inadequate dietary intake of the calcium which was very lower than the RDA issued by the ICMR which was similar to our present study[36].

The major cereals consumed in the adult population of Chandigarh was rice, rather than ragi and wheat, which has lower phytate levels. Even the carbohydrate portion was occasionally replaced by sweets containing milk and its products. Intake of coated cereals (rich in phytates) by the adult population retards the absorption of calcium from the gut. The other source of calcium was from leafy vegetables. Besides this, it has been shown in the study that the calculated values for all nutrients are significantly higher than the analytical values. Hence, an individual with a calculated low intake of calcium with a background diet containing foods high in phytates, as in our study, may be more calcium deficient than calculated from dietary intake data[37].

Conclusion:

Energy intake was positively and significantly associated with the vitamin D level among the males present in the insufficient category of vitamin D. Dietary intake of fat was found to be positively and significantly associated with the vitamin D level among the females present in the normal category of vitamin D. In the present study, dietary intake of energy, protein, fat, calcium, and iron were higher in males than their female counterparts in all three categories of vitamin D. Their mean values were lower than the recommended dietary allowance of the ICMR for both sexes. The recommended dietary allowances suggested by the ICMR are indicative of a healthy and sustainable diet. Based on consumption data analysis, it is clear that Indian diets across the urban-rural split, geographies, and economic levels depart greatly from this reference diet and are not good for people or the environment. Unhealthy diets are important causes of India's persistently high levels of under nutrition (including micronutrient deficiencies) as well as its growing levels of overweight and obesity. India now produces far too much rice, sugarcane, and coarse grains, as well as far too few pulses, fruits, and vegetables. Large environmental footprints are left by rice and sugarcane. Both require a lot of water. Additionally, wet rice fields release methane, a potent greenhouse gas. Additionally, rice farmers in several Indian states burn rice waste, which releases carbon dioxide and particulates that seriously pollute the air. The switch in planting patterns to coarse grains and pulses would improve the nutritional quality and environmental sustainability of India's food systems. Public health and nutrition strategies that address malnutrition are necessary to make food systems healthier and more environmentally sustainable. It also calls for policies in the areas of agriculture, commerce, and consumer education that may address the availability, acceptability, and affordability of more nutritious food alternatives.

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Conflicts of interest
There are no conflicts of interest.

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