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Research Article

Dietary intake of vitamin D in adult outpatients with different degrees of obesity coming from an urban community

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Abstract

The aim of the present study was to investigate in-depth the dietary intake of vitamin D of subjects with different BMI in relation to serum vitamin D status. The survey covered 264 individuals, aged 19 to 60 years. Vitamin D deficiency was found in 33.3% of the participants and 40.2% showed evidence of insufficient vitamin D intake. It was established that the daily average dietary intake of vitamin D among the whole group of subjects was 6.6 μg/day (women – 5.6 μg/day, men – 10.4 μg/day). We found significant correlations between daily average dietary intake of vitamin D and weight, % body fat, fat mass, visceral fat (in women), muscle and fat-free mass, and height-adjusted indices: fat mass index and fat-free mass index, total body water and some metabolic variables (basal insulin and high sensitivity C-reactive protein). The survey revealed that the dietary intake of vitamin D of the respondents was insufficient.

Keywords

nutrition, nutritional intake, obesity, overweight, vitamin D

Introduction

Currently, the majority of European countries are continuously updating their recommendations concerning the dietary intake of vitamin D (Doets et al. 2008; EFSA 2010). In the period 2010–2014 the European Food Safety Authority (EFSA) published dietary reference values (DRVs) for breast-fed infants and small children in the European Union (EFSA 2012), as well as some opinions concerning adults' vitamin D intake (EFSA 2010, 2012, 2013, 2014). Nevertheless the recommendations for vitamin D intake varied significantly among the individual countries. According to the competent authorities recommendations for dietary intake of 10–25 μg/day vitamin D were sufficient to maintain the blood serum levels above 25 nmol/l, but that might not be adequate to sustain the greater part of the population over the greater value of 50 nmol/l in winter without appropriate sun exposure in summer (Cashman et al. 2008).

The usual daily dietary intake of vitamin D contributes to a smaller extent compared with exposure to UVB from sunlight to achieve the average annual levels of 25(OH)D. According to Holick (2004) 90% of the necessary amount of vitamin D is provided as a result from sunlight exposure (Holick 2004). Currently the intake model is changing and among many populations the

exogenous vitamin D sources, in dietary regimes and in supplements as a total are far from negligible, especially in winter in areas with greater latitude, as well as for individuals with minimal sunlight exposure because of various reasons (O'Mahony et al. 2011; Cashman and Kiely 2014). Nevertheless, even with a balanced and varied dietary regime it might be difficult to achieve recommended vitamin intake levels. The food sources of vitamin D are restricted. The most popular food sources are fat fish and eggs and small amounts of vitamin D are supplied by meat. Other dietary sources of vitamin D are the fortified foods (most frequently milk and dairy products, margarine and spreads, and some cereals), as well as food supplements containing vitamin D.

The great differences in the published data referring to the population vitamin D status and to daily average dietary intake of the vitamin make direct international comparisons hard and non- precise, because of methodological differences associated with the characteristics of the involved populations, the study design, the variety of involved patients and pre-set limits, methodology of collecting the information about the dietary intake, different data bases for food composition etc. (Uusitalo et al. 2011; Spiro and Buttriss 2014). Thus the availability of national data for the dietary intake of vitamin D in a total and selected population is particularly important and is a contribution provided by this survey. Very few researchers have studied the determinants of vitamin D serum levels using a set of variables covering in parallel dietary intake, socio-demographic data, anthropometrical data and biochemical indicators.

The aim of the present survey was to study comprehensively the dietary intake of vitamin D among individuals who had normal body weight and who were overweight related to the status of serum vitamin D.

Material and methods

The designed observational transversal survey engaged 264 individuals from Sofia city, aged 19–60 years of age. The sample was not representative for the capital of the country and included 109 (41.3%) men and 155 (58.9%) women aged 19–60 years of age, distributed in the following age groups: 19 – <30 (42 persons) and 30 – <60 (222 persons) consistent with the stipulations of Ordinance № 1/2018 for the physiological norms for the Bulgarian population nutrition. Of them 72 individuals had normal body weight and formed the control group (BMI – 18.5 to 24.9 kg/m^2); 65 had overweight (BMI – 25.0–29.9 kg/m^2) and 127 were obese (BMI over 30.0 kg/m^2).

All participants in the study cooperated in taking down their full anamnesis and medical history, and they underwent a physical examination. The dietary status was assessed through anthropometric characteristics – anthropometric indicators and indexes and Tanita 420 BC MA analyzer was used to determine the body composition by professional bioelectric impedance.

The nutrition assessment was made through 24–h recall and food frequency questionnaire (FFQ). It was assessed in the winter months of 2014 and 2015. The used methods were 24-hour recall – capturing the dietary intake during a preceding day (Black 2000). The dietary intake (amount of consumed foods, energy and nutrients intake) of the involved individuals was evaluated for two non-sequential days including one working day and one day off in the week. The respondents' active interview was used to determine the amount of consumed foods through kitchen measures or measurement, presence of vitamins and/or minerals supplementation. The collected data were processed through computer software for assessment of the dietary intake, implementing a database containing the chemical composition of Bulgarian foods and beverages.

Results

The daily average dietary intake of vitamin D of the examined individuals differentiated by age, sex and nutritional status is presented in Table 1. The daily average intake of vitamin D among all groups of examined persons was below the recommended dietary intake of 15 μg/day with the smallest value of 5.5 μg/day recorded among women aged 30–<60 (Ministry of Health 2018). The rate of the average daily intake of vitamin D showed a downwards shift in all groups with intake medians respectively from 36.8% to 44.5% of the mean levels. The cause of the insufficient dietary intake of the vitamin was the traditionally low fish and fish products consumption and the lack of vitamin D-fortified foods in Bulgaria (Ministry of Health 2006).

The nutritional status distribution of the studied individuals showed that the average daily vitamin D intake of persons with normal weight (7.6 μg/day) was higher than the average daily vitamin D intake of overweight (6.6 μg/day) and obese individuals (6.0 μg/day). No statistically significant difference, though, was found between vitamin D intake of subjects with normal (7.6 μg/day) and above-normal weight (6.2 μg/day), ($p > 0.05$). It was established that the relative rate of individuals with average daily vitamin D intake below the recommended average daily intake – 15 μg/day was higher in all studied groups suggesting that about 85% of the individuals had daily intake lower than the recommended by the Ordinance for physiological limits for population nutrition (Table 1) (Ministry of Health 2018).

Table 2 lists the results for the relative rate of individuals (%) with average daily intake of vitamin D (μg/day) distributed by age, sex, BMI and a set of intervals of dietary intake of vitamin D including also the lower reference nutrient intake (LRNI) value and EAR for vitamin D of 10 μg/day (according to the value set by the Institute of Medicine (IOM)). The relative rate of individuals whose vitamin D intake values were smaller than 10 μg/day and who were respectively at possible risk for vitamin D deficiency was 80.6%. The distribution of the subjects depending on their nutritional status showed that 83.4%

Table 1. Average daily intake of vitamin D (μg/day) of the investigated individuals and relative rate (%) of the persons with average daily vitamin D intake (μg/day) below/over the recommended dietary intake distributed by age, sex and BMI.

Sex	Age (years)	Anthropometrical status	Number	Vitamin D (μkg/day)			Vitamin D (%)	
				Average value	SD	Median	<15 μg	>15 μg
M	**19–<30**	Normal	8	10.6	13.8	4.1	75.0	25.0
		Overweight	0	0.0	0.0	0.0	0.0	0.0
		Obesity	6	17.1	15.0	10.3	66.7	33.3
		Total	14	13.4	14.2	5.1	71.4	28.6
	30–<60	Normal	11	6.6	6.4	4.9	81.8	18.2
		Overweight	22	8.7	11.1	.3	72.7	27.3
		Obesity	62	7.0	10.2	3.3	83.9	16.1
		Total	95	7.4	10.0	3.3	81.1	18.9
F	**19–<30**	Normal	22	6.3	9.1	2.1	86.4	13.6
		Overweight	3	1.2	1.4	.6	100.0	0.0
		Obesity	3	5.9	7.3	2.4	100.0	0.0
		Total	28	5.7	8.5	2.1	89.3	10.7
	30–<60	Normal	31	8.2	11.4	2.6	74.2	25.8
		Overweight	40	5.8	7.0	2.6	87.5	12.5
		Obesity	56	3.8	5.2	1.8	94.6	5.4
		Total	127	5.5	7.8	2.2	87.4	12.6
Total M, F	**19–<30**	Normal	30	7.5	10.5	3.6	83.3	16.7
		Overweight	3	1.2	1.4	.6	100.0	0.0
		Obesity	9	13.4	13.6	10.3	77.8	22.2
		Total	42	8.3	11.1	3.7	83.3	16.7
	30–<60	Normal	42	7.8	10.2	2.9	76.2	23.8
		Overweight	62	6.8	8.7	2.6	82.3	17.7
		Obesity	118	5.5	8.4	2.5	89.0	11.0
		Total	222	6.3	8.8	2.6	84.7	15.3
	Total (19–<60)	Normal	72	7.6	10.3	3.2	79.2	20.8
		Overweight	65	6.6	8.6	2.5	83.1	16.9
		Obesity	127	6.0	9.0	2.6	88.2	11.8
		Total	264	6.6	9.2	2.6	84.5	15.5

Table 2. Rate (%) of individuals with average daily intake of vitamin D (μkg/day) distributed by age, sex, BMI and intervals of dietary intake of vitamin D.

Vitamin D (μg/day)	Normal			Overweight			Obesity			Total		
	M	F	M, F	M	F	M, F	M	F	M, F	M	F	M, F
%	Total – 19–60 years of age											
0–2.49	21.1	50.9	43.1	54.5	46.5	49.2	38.2	61.0	48.8	38.5	53.5	47.3
2.5–5	42.1	20.8	26.4	13.6	20.9	18.5	27.9	18.6	23.6	27.5	20.0	23.1
5.01–10	15.8	5.7	8.3	4.5	14.0	10.8	13.2	8.5	11.0	11.9	9.0	10.2
>10	21.1	22.6	22.2	27.3	18.6	21.5	20.6	11.9	16.5	22.0	17.4	19.3

of the obese persons, 78.5% of the overweight and 77.8% of the people with normal body weight were at risk of vitamin B deficiency. The highest percentage rate of individuals at possible risk of deficient vitamin D intake was found among obese men (88.1%).

The rate of individuals with low dietary intake of vitamin D or intake in the interval 0–2.49 μg/day was the highest among those classified as overweight (49.2%) and obese (48.8%). The obese persons also provided the lowest percentage rate of persons with dietary intake of vitamin D over 10 μg/day (16.5%).

Spearman's correlation coefficients revealing the relationship between the levels of daily average dietary intake of vitamin D and the anthropometric and metabolic indicators are listed in Table 3. Correlations were found between the daily average dietary intake of vitamin D and body composition indexes – fat mass (% and kg), fat-free and muscle mass (kg), water content (% and kg), and the strength of the relationship increased with the increasing of BMI of the examined persons. For obese people, the weight and waist circumference also were related to the daily average dietary intake of vitamin D.

The additional regression analysis with the Curve Estimation procedure demonstrated weak to moderate correlation between the daily average dietary intake of vitamin D and the percentage rate of the fat mass (Compound model; $R = 0.2$, $p = 0.001$); visceral fat mass (in women) (Compound model; $R = 0.167$, $p = 0.036$), as well as with the height-adjusted indexes fat mass index (FMI) (Compound model; $R = 0.134$; $p = 0.031$) and fat free mass index

Table 3. Relationship between the daily average dietary intake of vitamin D and anthropometric indicators, indexes of body composition, metabolic and biochemical indexes in the examined individuals differentiated by sex and BMI (Spearman's coefficients).

Indicator	Total	Male	Female	Normal bw	Above norms bw (overweight and obesity)	Overweight	Obesity (I, II, III grade.)
Vitamin D (nmol/l)	0.119	0.080	0.150	0.150	0.080	0.076	0.077
Age (years)	-0.094	-0.072	-0.107	-0.029	-0.093	0.062	-0.161
Weight (kg)	0.04	0.030	-0.110	0.068	0.126	0.227	**0.175***
Height (cm))	**0.153***	0.120	0.037	0.059	**0.194****	0.167	**0.211***
Waist circumference	-0.006	-0.019	-0.131	-0.104	0.097	0.193	0.125
Waist circumference/height	-0.06	-0.055	-0.139	-0.152	0.010	0.099	0.011
Systolic arterial pressure (mmHg)	-0.029	0.037	**-0.177***	-0.008	0.009	-0.017	0.035
Diastolic arterial pressure (mmHg)	-0.06	0.001	**-0.216****	-0.179	0.029	0.065	0.034
Fat mass (%)	**-0.155***	-0.053	**-0.161***	-0.070	**-0.172***	-0.137	**-0.186***
Fat mass (kg)	-0.075	-0.020	-0.133	-0.045	-0.042	-0.042	-0.030
Fat-free mass (kg)	**0.134***	0.078	-0.040	0.090	**0.208****	0.226	**0.241****
Muscle mass (kg)	**0.141***	0.102	-0.041	0.088	**0.219****	0.226	**0.256****
Water content (%)	**0.132***	0.089	-0.048	0.092	**0.212****	0.219	**0.258****
Water content (kg)	**0.133***	-0.004	**0.164***	0.073	0.130	0.111	0.135
Bone mass (kg)	**0.141***	0.099	-0.031	0.110	**0.212****	0.211	**0.253****
Visceral muscle mass	-0.014	-0.058	-0.157	-0.064	0.064	0.171	0.083
BMI (kg/m2)	-0.023	-0.004	-0.120	0.064	0.037	0.194	0.069
Blood sugar (mmol/l)	0.019	-0.004	-0.046	0.041	0.046	0.037	0.055
TC (mmol/l)	-0.023	0.008	-0.051	0.065	-0.045	0.046	-0.082
TT (mmol/l)	0.023	0.046	-0.143	-0.136	0.089	0.065	0.120
LDL (mmol/l)	-0.006	-0.011	0.098	0.025	-0.151	-0.213	-0.134
HDL (mmol/l)	0.046	0.062	-0.002	0.132	0.044	0.108	0.016
Ratio LDL/HDL	0.069	0.097	-0.037	0.106	0.140	0.251	0.112
Ratio TCHOL/HDL	0.047	0.081	-0.076	0.047	0.134	**0.284***	0.094

** P < 0.01; * P < 0.05.

(FFMI) (Power model, R = 0.122, p = 0.042) as a total for the whole studied sample, and with the basal levels of immunoreactive insulin (IRI-0') in the whole group (S-model; R = 0.187, p = 0.045) and the group with overweight (S-model; R = 0.209, p = 0.024), and with the chronic inflammation marker – hs- CRP for the whole group (Cubic model; R = 0.33, p = 0.013), male group (Quadratic model; R = 0.394, p = 0.018) and the overweight group (Cubic model; R = 0.331; p = 0.013). Statistically significant, though weak correlation was found between the daily average dietary intake of vitamin D and serum levels of vitamin D (25(OH)D), as a total for the whole group of respondents (Power model; R = 0.14, p = 0.02), the female group (Compound model; R = 0.173, p = 0.031) and the overweight group (Power model, R = 0.158; p < 0.027). The established correlations, though weak, suggested a relationship between dietary vitamin D intake and the indicators characterizing visceral obesity – BMM, IRI0' and hs-CRP.

Discussion

A comprehensive survey was conducted on the dietary intake of vitamin D among individuals of normal weight and those overweight related to the status of serum vitamin D. It was established that the daily average intake of vitamin D of the whole sample was 6.6 μg/day (the female group – 5.6 μg/day and the male group respectively – 10.4 μg/day). In the groups distributed by BMI it was found that the daily average vitamin D intake of individuals with normal weight was 7.6 μg/day, while the overweight persons reported 6.6 μg/day, and those with obesity – 6.0 μg/day. The comparison of the average values for daily vitamin D intake calculated in our study and the available data from dietary surveys among other European populations revealed that the vitamin D intake was lower than the recommended vitamin D intake among all age groups, confirmed by all available surveys. The survey of Freisling et al. involving individuals, aged 35–74 years from 10 countries: Greece, Spain, Italy, France, Germany, the Netherlands, United Kingdom, Denmark, Sweden and Norway found an average daily intake of vitamin D from 4.8 μg/day for men and 3.3 μg/day for women, though with substantial differences between the individual countries (EFSA 2010; Freisling et al. 2010). The report of EFSA also confirmed significant fluctuations of the daily average dietary intake of vitamin D only in 14 European countries, varying from 1.1 μg/day (Spain, women, 18–64 years of age) up to 8.2 μg/day (Finland, men, 25–74 years of age) (EFSA 2012).

The available literature data referring to the dietary intake of vitamin D and its relationship with metabolic indexes and deviations in body composition are scarce (Troev 2012). A small-scale study engaging 30 teenagers compared some cardio metabolic factors and body composition indexes in relation to the intake and serum levels of vitamin D (Campos et al. 2015). The authors outlined that there was a strong negative correlation between the established daily vitamin D intake and the tissue plasminogen activator inhibitor-1

(PAI-1), as well as the vascular cell adhesion molecules (VCAM-1). The increasing of the daily intake of vitamin D has triggered improvements in the body composition and reduction of visceral fat tissue. This study confirmed the relationship established by us between the dietary intake of vitamin D and some of the body composition indexes – weight (kg), fat mass (kg and %), visceral fat mass (in women), muscle mass (kg) and fat free mass (kg), and with the height adjusted indexes FMI and FFMI and the cardio metabolic risk factors as basal insulin level (IRI0') and hs-CRP. Kamycheva et al. revealed a difference in the average daily vitamin D intake vs. BMI in adults. The study showed the presence of an inverse relationship between BMI and the daily average vitamin D intake in both the correlation and the regression analyses (Kamycheva et al. 2003). The authors outlined a statistical model claiming that the intake of the recommended amount of vitamin D would reduce the BMI by almost 0.20 kg/m^2 in men and by 0.25 kg/m^2 in women of all age groups that would have a significant effect on cardiovascular and metabolic risk factors. The multiregression analysis implemented in our study established that only the percentage rate of fat mass of all body composition indexes had a predictive value in relation to the dietary vitamin D intake.

Conclusion

The daily average intake of vitamin D in all studied groups of the sample was below the recommended dietary intake of 15 μkg/day and the women aged 30–59 produced the lowest value of 5.5 μg/day. The daily average vitamin D intake of individuals with normal weight (7.6 μg/day) was higher than the daily average vitamin D intake of individuals who were overweight (6.6 μg/day.) and obese (6.0 μg/day.). A high percentage rate of individuals at possible risk for vitamin D deficiency was established (80.6% of the respondents had daily average vitamin D intake below EAR), and the percentage rate of obese men was the highest (88.1%) (2). Individuals with vitamin D deficiency reported the lowest dietary vitamin D intake – 5.8 μg/day as an average. Male gender, higher education, young age (30-) and normal BMI (up to 25.0 kg/m^2) were the factors predefining the higher dietary intake of vitamin D. Significant, weak to moderate correlations were established between the daily average dietary intake of vitamin D and body weight, fat mass (kg and %), visceral fat mass (for women), muscle and fat free mass, as well as with the height-adjusted indices: FMI and FFMI, water content (kg and %). Weak to moderate correlation was detected between the daily average dietary intake of vitamin D and the basal levels of immunoreactive insulin – IRI-0' (in the whole sample, in the female and overweight group), with the marker of chronic inflammation – hs-CRP (in the whole sample, male group and overweight group). Weak, but significant was the correlation between the daily average dietary intake of vitamin D and vitamin D serum levels (25(OH)D), established in the whole sample, the female group and overweight group.

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