

## INTAKE AND CONTRIBUTION OF FOOD GROUPS TO VITAMIN D INTAKE IN ADULTS WITH OVERWEIGHT AND OBESITY

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### Abstract

The aim of the present study is to investigate the dietary intake of vitamin D in normal-weight and overweight individuals, establishing its correlation with specific food groups.

Two hundred and sixty-four individuals were studied, of which 41.3% men and 58.9% women between 19 and 60 years of age. Nutritional assessment was carried out applying 24-h recall in the months January to April in 2014 and 2015. Nutritional status was assessed by means of anthropometric indicators – anthropometric indicators and indices, whereas weight and body composition were measured by professional bioelectrical impedance using a Tanita 420 BC MA device.

It was established that the average daily intake of vitamin D for the entire group of studied individuals was 6.6 µg/day (women – 5.6 µg/day and men – 10.4 µg/day). Main dietary sources of vitamin D in the diet of adults were meat and meat products, fish and fish products, eggs and milk and dairy products. In the groups based upon BMI category of participants, meat and meat products were found to be the main source of vitamin D in all groups.

Average daily intake of vitamin D has values significantly below the recommended average daily intake. A policy to promote the consumption of foods

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rich in vitamin D in order to reduce the relative share of individuals not meeting the recommendations is required.

**Key words:** vitamin D intake, nutrition, obesity

**Introduction.** Vitamin D is a fat-soluble vitamin with many functions in the body, being crucial for maintaining calcium homeostasis [1–3]. Vitamin D reduces the risk of many chronic diseases, such as cancer, autoimmune diseases, infectious diseases and cardiovascular diseases [4]. A source of vitamin D for the body is both the endogenous synthesis in the skin initiated by exposure to ultraviolet (UV) radiation and the dietary intake through vitamin D-containing foods [4]. Vitamin D synthesis results from the influence of such factors as geographic altitude, use of sun glasses and clothing, time spent outdoors, age, skin colour and environmental pollution [5].

Dietary intake is essential for maintaining the serum concentration of vitamin D – 25(OH)D. Vitamin D has been found in some animal-derived foods, mainly as cholecalciferol (vitamin D3), a highly bioavailable form. Vitamin D is also present in plant-based foods in the form of ergocalciferol (vitamin D2) [6]. Additionally, the intake of vitamin D in the form of supplements should be considered [7].

The aim of the current study is to investigate the dietary intake of vitamin D in normal-weight and overweight individuals and to establish the correlation with specific food groups.

**Material and methods.** In the conducted observational, transversal study 264 individuals from the city of Sofia aged from 19 to 60 years were studied. The sample was not representative for a capital city and included 109 men (41.3%) and 155 women (58.9%) aged 19 to 60 years, divided into the following age groups: 19–<30 years (42 persons) and 30–<60 years, (222 persons). The age groups were created in accordance with Ordinance No.1 on physiological norms for the nutrition of the population in Bulgaria [8]. Seventy-two of the studied participants had normal body weight, as a control group (BMI – 18.5 to 24.9 kg/m<sup>2</sup>); 65 were overweight (BMI – 25.0–29.9 kg/m<sup>2</sup>) and 127 were obese (BMI over 30.0 kg/m<sup>2</sup>).

A comprehensive medical history was obtained, a physical examination was conducted and medical information was collected from all participants. Nutritional status was assessed through anthropometric indicators – anthropometric markers and indices, weight and body composition were measured by professional bioelectrical impedance with a Tanita 420 BC MA device.

Assessment of nutrition was carried out by means of a 24-h recall. Nutrition has been evaluated during the winter season in 2014 and 2015. The method of playback of recent memory sequences of food intake for the previous 24 hours or 24-h recall was used [9]. Dietary intake (amount of food consumed, energy and nutrient intake) of studied individuals was assessed for two non-consecutive days, including one working and one rest day of the week. Applying an active interview of the participants, both the amount of food consumed through kitchen

measures or measurement and the presence of supplementation with vitamins and/or minerals were determined. The processing of the obtained data on the nutrition of all the examined individuals was carried out by means of a computer program designed for the assessment of food intake, using a database in which the chemical composition of Bulgarian foods and drinks had been included. Statistical analyses were done using the SPSS 23.0 statistical package for Windows (SPSS Inc., Chicago, IL, USA).

**Results.** The average daily intake of vitamin D for the entire group of studied individuals was 6.6 µg/day (women – 5.6 µg /day and men – 10.4 µg /day). The average daily intake of vitamin D in all groups of participants in the study was lower than the recommended dietary intake of 15 µg/day, as the established value of 5.5 µg/day in women aged 30–<60 years was the lowest [9]. The insufficient vitamin D dietary intake resulted from the traditionally low consumption of fish and fish products, as well as from the lack of foods fortified with vitamin D in our country [10]. The main food sources of vitamin D in the diet of adults were meat and meat products, fish and fish products, eggs and milk and dairy products (Table 1). Comparison of data obtained in the study performed by age groups showed a tendency to maintain these four food groups in all age groups. The percentage distribution of vitamin D intake from different food groups in normal-weight, overweight and obese participants revealed that the two most important sources of vitamin D were meat and meat products, followed by fish and fish products. Eggs were the third most important source of vitamin D in individuals with normal weight and obesity, whereas in overweight participants milk and dairy products were the third largest source (Table 1).

Spearman's rank correlation coefficients, establishing the relationship between the levels of average daily dietary intake of vitamin D and main indicators of dietary intake (24-h recall) in the studied groups of individuals, differentiated based on sex and anthropometric indices are shown in Tables 2 and 3. For the entire sample mean daily dietary vitamin D intake correlates to a significant extent, weakly to moderately strong, directly proportionally with many of the dietary intake measures, however, for macronutrients there is no reliable association between mean daily vitamin D dietary intake levels and mean daily intake of saturated fatty acids (g and E%), carbohydrates (g), dietary fibre (g) and added sugar (g). However, the significant correlation of the vitamin D with the minerals potassium, magnesium, total iron and selenium, with the B group vitamins and folate (except for B12) has been demonstrated. When subgrouping by sex and BMI, levels of mean daily dietary intake of vitamin D correlate significantly with fewer dietary intake measures examined. In the groups of women, men, and individuals with normal BMI, the number of markers with which mean daily vitamin D dietary intake is significantly correlated remain nearly identical in comparison to those of the entire sample, both in strength and direction of correlation. Differences in men are observed under the following markers, namely,

Table 1

Table 1

T a b l e 2

Correlation between average daily intake of dietary vitamin D and main indicators of dietary intake in study participants differentiated based on sex and anthropometric indices (Spearman's rank coefficients)

| Index<br>(Spearman's<br>rank coefficient) | Total          | Men             | Women          | Normal<br>weight | Excessive<br>weight<br>(overweight<br>and<br>obesity) | Overweight     | Obesity         |
|-------------------------------------------|----------------|-----------------|----------------|------------------|-------------------------------------------------------|----------------|-----------------|
| Protein (g)                               | <b>0.258**</b> | <b>0.221*</b>   | <b>0.223**</b> | <b>0.272*</b>    | <b>0.262**</b>                                        | <b>0.292*</b>  | <b>0.259**</b>  |
| Animal protein<br>(g)                     | <b>0.287**</b> | <b>0.234*</b>   | <b>0.281**</b> | <b>0.325**</b>   | <b>0.286**</b>                                        | <b>0.353**</b> | <b>0.268**</b>  |
| Animal protein<br>(%)                     | <b>0.215**</b> | 0.183           | <b>0.225**</b> | <b>0.269*</b>    | <b>0.206**</b>                                        | <b>0.279*</b>  | 0.172           |
| Fats (g)                                  | <b>0.166**</b> | 0.077           | <b>0.208**</b> | <b>0.257*</b>    | 0.113                                                 | 0.037          | 0.147           |
| Saturated fatty<br>acids (g)              | 0.030          | -0.068          | 0.060          | 0.120            | -0.021                                                | -0.024         | -0.016          |
| Monounsaturated<br>fatty acids (g)        | <b>0.223**</b> | 0.177           | <b>0.220**</b> | <b>0.256*</b>    | <b>0.193**</b>                                        | 0.099          | <b>0.235**</b>  |
| Polyunsaturated<br>fatty acids (g)        | <b>0.209**</b> | 0.108           | <b>0.293**</b> | <b>0.336**</b>   | <b>0.147*</b>                                         | 0.126          | 0.160           |
| Cholesterol (mg)                          | <b>0.226**</b> | 0.178           | <b>0.222**</b> | 0.188            | <b>0.242**</b>                                        | <b>0.249*</b>  | <b>0.250**</b>  |
| Carbohydrates<br>(g)                      | -0.098         | <b>-0.200*</b>  | -0.064         | -0.100           | -0.106                                                | -0.117         | -0.101          |
| Dietary fibre (g)                         | 0.055          | 0.001           | 0.051          | 0.059            | 0.051                                                 | 0.064          | 0.048           |
| Energy (kcal)                             | 0.101          | 0.003           | 0.117          | 0.152            | 0.073                                                 | 0.013          | 0.101           |
| Protein, E%                               | <b>0.221**</b> | <b>0.259**</b>  | 0.155          | 0.198            | <b>0.256**</b>                                        | <b>0.266*</b>  | <b>0.254**</b>  |
| Fats, E%                                  | <b>0.176**</b> | <b>0.212*</b>   | <b>0.183*</b>  | <b>0.346**</b>   | 0.103                                                 | 0.080          | 0.116           |
| Saturated fatty<br>acids, E%              | -0.084         | -0.127          | -0.070         | 0.012            | -0.130                                                | -0.062         | -0.161          |
| Monounsaturated<br>fatty acids, E%        | <b>0.248**</b> | <b>0.340**</b>  | <b>0.201*</b>  | <b>0.322**</b>   | <b>0.208**</b>                                        | 0.162          | <b>0.231**</b>  |
| Polyunsaturated<br>fatty acids, E%        | <b>0.180**</b> | 0.175           | <b>0.239**</b> | <b>0.378**</b>   | 0.115                                                 | 0.169          | 0.092           |
| Carbohydrates,<br>E%                      | <b>0.306**</b> | <b>-0.387**</b> | <b>0.214**</b> | <b>-0.375**</b>  | <b>-0.290**</b>                                       | -0.222         | <b>-0.328**</b> |
| Alcohol, E%                               | 0.095          | 0.155           | -0.042         | 0.032            | 0.121                                                 | 0.037          | 0.157           |

\*\*  $P < 0.01$ ; \*  $P < 0.05$

T a b l e 3

Relationship between average daily intake of dietary vitamin D and vitamins and minerals from food intake in the studied individuals, differentiated by sex and anthropometric indices (Spearman coefficients)

| Index<br>(Spearman's<br>rank coefficient) | Total          | Men            | Women          | Normal<br>weight | Excessive<br>weight<br>(overweight<br>and<br>obesity) | Overweight     | Obesity        |
|-------------------------------------------|----------------|----------------|----------------|------------------|-------------------------------------------------------|----------------|----------------|
| Vitamin A (µg PE)                         | 0.071          | 0.087          | 0.031          | −0.029           | 0.131                                                 | 0.183          | 0.107          |
| Vitamin E<br>(mg α TE)                    | 0.106          | 0.072          | 0.094          | 0.119            | 0.110                                                 | 0.145          | 0.099          |
| Vitamin B1(mg)                            | <b>0.130*</b>  | 0.116          | 0.077          | 0.136            | 0.132                                                 | 0.160          | 0.121          |
| Vitamin B2 (mg)                           | <b>0.174**</b> | <b>0.210*</b>  | 0.084          | 0.156            | <b>0.179*</b>                                         | <b>0.247*</b>  | 0.164          |
| Niacin (mg)                               | <b>0.379**</b> | <b>0.369**</b> | <b>0.344**</b> | <b>0.378**</b>   | <b>0.384**</b>                                        | <b>0.451**</b> | <b>0.355**</b> |
| Vitamin B6 (mg)                           | <b>0.271**</b> | <b>0.431**</b> | 0.132          | 0.137            | <b>0.346**</b>                                        | <b>0.449**</b> | <b>0.310**</b> |
| Folate (µg)                               | <b>0.169**</b> | <b>0.210*</b>  | 0.108          | 0.099            | <b>0.202**</b>                                        | 0.172          | <b>0.228*</b>  |
| Vitamin B12 (µg)                          | 0.097          | <b>0.215*</b>  | 0.023          | 0.169            | 0.095                                                 | 0.232          | 0.064          |
| Vitamin C (mg)                            | 0.036          | 0.094          | −0.006         | −0.066           | 0.096                                                 | 0.114          | 0.084          |
| Added sugar (g)                           | −0.073         | −0.104         | −0.057         | −0.014           | −0.099                                                | −0.224         | −0.065         |
| Alcohol (g)                               | <b>0.134*</b>  | 0.171          | −0.016         | 0.085            | <b>0.154*</b>                                         | 0.005          | <b>0.219*</b>  |
| Retinol (µg)                              | 0.016          | 0.016          | −0.005         | −0.088           | 0.087                                                 | −0.041         | 0.171          |
| Beta-Carotene<br>(µg)                     | 0.002          | −0.037         | 0.063          | −0.079           | 0.015                                                 | −0.025         | 0.021          |
| Pantothenic Acid<br>(µg)                  | 0.024          | 0.080          | −0.024         | −0.081           | 0.055                                                 | −0.099         | 0.096          |
| Biotin (mg)                               | 0.074          | 0.164          | 0.037          | 0.043            | 0.077                                                 | −0.134         | 0.126          |
| Na (mg)                                   | −0.004         | −0.113         | −0.005         | −0.107           | 0.048                                                 | 0.068          | 0.051          |
| K (mg)                                    | <b>0.226**</b> | <b>0.259**</b> | <b>0.165*</b>  | 0.194            | <b>0.238**</b>                                        | 0.211          | <b>0.253**</b> |
| Ca (mg)                                   | −0.004         | 0.003          | −0.028         | −0.028           | −0.005                                                | −0.063         | 0.017          |
| P (mg)                                    | <b>0.201**</b> | 0.155          | <b>0.178*</b>  | 0.231            | <b>0.187**</b>                                        | 0.233          | 0.173          |
| Mg (µg)                                   | <b>0.179**</b> | <b>0.197*</b>  | 0.130          | 0.192            | <b>0.164*</b>                                         | 0.128          | <b>0.182*</b>  |
| Fe, total (mg)                            | <b>0.162**</b> | 0.145          | 0.145          | 0.155            | <b>0.158*</b>                                         | <b>0.278*</b>  | 0.124          |
| Fe, heme (mg)                             | 0.097          | 0.066          | 0.045          | 0.047            | 0.128                                                 | 0.186          | 0.104          |
| Cu (µg)                                   | 0.046          | 0.041          | 0.032          | −0.012           | 0.060                                                 | 0.183          | 0.060          |
| Zn (mg)                                   | 0.061          | 0.012          | 0.013          | 0.080            | 0.051                                                 | 0.078          | 0.047          |
| Mn (µg)                                   | 0.070          | 0.080          | −0.008         | 0.039            | 0.081                                                 | −0.055         | 0.124          |
| Se (µg)                                   | <b>0.134*</b>  | <b>0.223*</b>  | 0.063          | 0.099            | <b>0.147*</b>                                         | 0.022          | <b>0.185*</b>  |
| J (µg)                                    | 0.063          | 0.108          | 0.021          | 0.040            | 0.069                                                 | −0.159         | 0.097          |

\*\* $P < 0.01$ ; \* $P < 0.05$

the correlations between the average daily dietary intake of vitamin D and the average daily intake of animal protein (E%), total fat (g), saturated fatty acids, monounsaturated fatty acids, polyunsaturated fatty acids, cholesterol disappear, however, correlations in mean carbohydrate intake (g) and vitamin B12 appear; the correlation with magnesium in women and individuals with a normal BMI disappears, and regarding B group vitamins, the correlation with vitamins B1, B2, B6, folate disappears. In obese individuals, the correlation between the average daily dietary intake of vitamin D with the average intake of animal protein (E%) and total fat (g; E%), monounsaturated fatty acids (g) and polyunsaturated fatty acids (E%), with total iron and vitamins B1 and B2 disappears.

**Discussion.** Comparison of mean daily vitamin D intakes obtained from our study with data from population-based nutrition surveys from other countries in Europe establishes lower intake of vitamin D than the recommended intakes of vitamin D in each age group in all studies [11,12]. The study by FREISLING et al. [13], covering individuals aged 35 to 74 years in 10 countries: Greece, Spain, Italy, France, Germany, the Netherlands, the United Kingdom, Denmark, Sweden and Norway found an average daily vitamin D intake of 4.8 µg/day in men and 3.3 µg/day in women, however, with significant differences in the various countries. The European Food Safety Authority's report also revealed significant variation in average dietary vitamin D intake in 14 European countries, ranging from 1.1 µg/day (Spain, women, 18–64 years) up to 8.2 µg/day (Finland, men, 25–74 years) [14,15].

Foods that make the highest contribution to dietary intakes of vitamin D vary from country to country according to habitual dietary patterns. In Norway, the predominant food sources are fish and fats [17], as is the case in Finland where liquid milk and dairy products also contribute significantly [18]. In the UK, oily fish (24%), followed by meat and meat products (22%) and cereal and cereal products (21%) contribute the highest percentage to average daily vitamin D intake in adults [19]. For Irish adults, meat (30%), fish (12%) and spreads (10%) made the most significant contributions of all food groups [16]. In Spain the main source is fish which accounts for 65% of intake [20].

**Conclusion.** In general, the data proving the ability of vitamin D-fortified foods to improve vitamin D status are convincing. A range of improved foods has been shown to be effective in increased circulating 25(OH)D concentrations without evidence of adverse effects. Further studies and development of such foods are considered justified as they have the potential to provide a tool for dealing with the vitamin D deficiency pandemic.

The average daily vitamin D intake of the studied group of individuals is significantly low compared to the recommended average daily intake. A policy to promote the consumption of foods rich in vitamin D for the purpose of reducing the relative share of persons in Bulgaria who do not meet the recommendations for vitamin D is imperative.

## REFERENCES

- [<sup>1</sup>] HOLICK M. F., N. C. BINKLEY, H. A. BISCHOFF-FERRARI., C. M. GORDON, D. A. HANLEY et al. (2011) Evaluation, treatment, and prevention of vitamin D deficiency: an endocrine society clinical practice guideline, *J. Clin. Endocrinol. Metab.*, **96**, 1911–1930, doi: 10.1210/jc.2011-0385.
- [<sup>2</sup>] AUTIER P., M. BONIOL, C. PIZOT, P. MULLIE (2014) Vitamin D status and ill health: a systematic review, *Lancet Diabetes Endocrinol.*, **2**, 76–89, doi: 10.1016/S2213-8587(13)70165-7.
- [<sup>3</sup>] MOLINA P., J. J. CARRERO, J. BOVER, P. CHAUVEAU, S. MAZZAFERRO et al. (2017) Vitamin D, a modulator of musculoskeletal health in chronic kidney disease, *J. Cachexia Sarcopenia Muscle*, **8**, 686–701. doi: 10.1002/jcsm.12218.
- [<sup>4</sup>] HOLICK M. F. (2007) Vitamin D deficiency, *New Engl. J. Med.*, **375**, 266–281, doi: 10.1056/NEJMr070553.
- [<sup>5</sup>] Scientific Advisory Committee on Nutrition (2018) Vitamin D and health report, <https://www.gov.uk/government/publications/sacn-vitamin-d-and-healthreport>.
- [<sup>6</sup>] DIMAKOPOULOS I., E. MAGRIPLIS, A. V. MITSOPOULOU, D. KARAGEORGOU, I. BAKOGIANNI et al. (2019) HNNHS Contributors, HNNHS Advisory Committee Association of serum vitamin D status with dietary intake and sun exposure in adults, *Clinical Nutrition ESPEN*, **34**, 23–31.
- [<sup>7</sup>] DIMAKOPOULOS I., E. MAGRIPLIS, A. V. MITSOPOULOU, D. KARAGEORGOU, I. BAKOGIANNI et al. (2020) Intake and contribution of food groups to vitamin D intake in a representative sample of adult Greek population, *Nutrition*, **72**, 110641.
- [<sup>8</sup>] Ministry of Health, Ordinance No. 1 on the physiological norms of nutrition of the population (SG issue 11/2018).
- [<sup>9</sup>] MATSUSHITA Y., T. TAKAHASHI, K. ASAH, E. HARASHIMA, H. TAKAHASHI et al. (2021) Validation of improved 24-hour dietary recall using a portable camera among the Japanese population, *Nutrition Journal*, **20**, 68, <https://doi.org/10.1186/s12937-021-00724-2>.
- [<sup>10</sup>] Ministry of Health (2006) Recommendations for healthy eating of the population in Bulgaria 18–65 years, Sofia.
- [<sup>11</sup>] SPIRO A., J. L. BUTTRISS (2014) Vitamin D: an overview of vitamin D status and intake in Europe, *Nutr. Bull.*, **39**, 322–350.
- [<sup>12</sup>] MANIOS Y., G. MOSCHONIS, C. P. LAMBRINOU, K. TSOUTSOULOPOULOU, P. BINOU et al. (2017) A systematic review of vitamin D status in southern European countries, *Eur. J. Nutr.*, **57**, 2001–2036.
- [<sup>13</sup>] FREISLING H., M. T. FAHEY, A. MOSKAL, M. C. OCKÉ, P. FERRARI et al. (2010) Region-specific nutrient intake patterns exhibit a geographical gradient within and between European countries, *The Journal of Nutrition*, **140**, 1280–1286.
- [<sup>14</sup>] EFSA (European Food Safety Authority) (2010) Scientific Opinion on the substantiation of health claims related to vitamin D and normal function of the immune system and inflammatory response, maintenance of normal muscle function and maintenance of normal cardiovascular function pursuant to Article 13(1) of Regulation (EC) No. 1924/2006, *EFSA Journal*, **8**, 1468.
- [<sup>15</sup>] EFSA (European Food Safety Authority) (2012) Scientific opinion on the tolerable upper intake level of vitamin D, *EFSA Journal*, **10**, 2813.

- [<sup>16</sup>] O'MAHONY L., M. STEPIEN, M. J. GIBNEY, A. P. NUGENT, L. BRENNAN (2011) The Potential Role of Vitamin D Enhanced Foods in Improving Vitamin D Status Nutrients, **3**(12), 1023–1041.
- [<sup>17</sup>] CALVO M. S., S. J. WHITING, C. N. BARTON (2005) Vitamin D intake: A global perspective of current status, J. Nutr., **135**, 310–316.
- [<sup>18</sup>] PATURI M., H. TAPANAINEN, H. REINIVUO, P. PIETINEN (2008) The National Findiet 2007 Survey, National Public Health Institute, Helsinki, Finland.
- [<sup>19</sup>] HENDERSON L., K. IRVING, J. GREGORY, C. J. BATES, A. PRENTICE et al. (2003) The National Diet and Nutrition Survey: Adults Aged 19 to 64 Years – Vitamin and Mineral Intake and Urinary Analysis, Office for National Statistics, Newport, UK.
- [<sup>20</sup>] SERRA-MAJEM L., L. RIBAS-BARBA, G. SALVADOR, L. JOVER, B. RAIDO et al. (2007) Trends in energy and nutrient intake and risk of inadequate intakes in Catalonia, Spain (1992–2003), Public Health Nutr., **10**, 1354–1367.

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