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Brief report

25-hydroxyvitamin D is differentially associated with calcium intakes of Northern, Central, and Southern European adolescents: Results from the HELENA study

Cristina Julian M.Sc. [a,b,c], Marcela González-Gross Ph.D. [c,d], Christina Breidenassel Ph.D. [d,e], Theodora Mouratidou Ph.D. [a], Germán Vicente-Rodriguez Ph.D. [a,b,c], Luis Gracia-Marco Ph.D. [f], Marika Ferrari Ph.D. [g], Kurt Widhalm Ph.D. [h], Dénes Molnár Ph.D. [i], Anthony Kafatos Ph.D. [j], Frederic Gottrand Ph.D. [k], Yannis Manios Ph.D. [l], Alejandro de la O B.Sc. [m], Mathilde Kersting Ph.D. [n], Stefaan De Henauw Ph.D. [o], Marc J. Gunter Ph.D. [p], Luis A. Moreno Ph.D. [a,b,c,q], Inge Huybrechts Ph.D. [p,*], on behalf of the HELENA Study Group**

[a] Growth, Exercise, Nutrition and Development Research Group, Faculty of Health Science, University of Zaragoza, Zaragoza, Spain
[b] Instituto Agroalimentario de Aragón (IA2), Universidad de Zaragoza, Zaragoza, Spain
[c] Centro de Investigación Biomédica en Red de Fisiopatología de la Obesidad y Nutrición (CIBERObn), Universidad de Zaragoza, Zaragoza, Spain
[d] ImFine Research Group, Department of Health and Human Performance, Faculty of Physical Activity and Sport Sciences–INEF, Technical University of Madrid, Madrid, Spain
[e] Department of Nutrition and Food Science, University of Bonn, Germany
[f] Children's Health and Exercise Research Centre, College of Life and Environmental Sciences, Sport and Health Sciences, University of Exeter, Exeter, United Kingdom
[g] Crea-Council for Agricultural Research and Economics, Rome
[h] Department of Pediatrics, Medical University of Vienna, Vienna, Austria
[i] Department of Paediatrics, Medical Faculty—University of Pécs, Pécs, Hungary
[j] Preventive Medicine & Nutrition Unit, University of Crete School of Medicine, Heraklion, Crete, Greece
[k] CHU Lille, University Lille 2, Lille, France
[l] Department of Nutrition and Dietetics, School of Health Science and Education, Harokopio University, Athens, Greece
[m] Department of Medical Physiology School of Medicine, Granada University, Granada
[n] Research Institute of Child Nutrition, Rheinische Friedrich-Wilhelms-University Bonn, Dortmund, Germany
[o] Faculty of Medicine and Health Sciences, Department of Public Health, Ghent University, Ghent, Belgium
[p] International Agency for Research on Cancer, Lyon, France
[q] Instituto de Investigación Sanitaria Aragón (IIS Aragón), Zaragoza, Spain

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ABSTRACT

Objectives: Adolescents in the European Union (EU) exhibit a higher prevalence of vitamin D (VitD) deficiency than other age groups. The degree to which sunlight exposure 25-hydroxyvitamin D [25(OH)D] concentrations depends on a variety of factors, including diet. Nevertheless, the relationship between calcium and VitD intake and 25(OH)D concentrations has not been previously studied among adolescents living in different EU countries and consequently in different latitudes. Therefore, the aim of this study was to examine whether calcium and VitD intakes are differentially associated with 25(OH)D in adolescents from northern, central and southern EU countries.

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LAM and IH had joint last authorship.

* Corresponding author. Tel.: ++33 (0) 4 72 73 81 48; fax: ++33 (0) 4 72 73 83 61.
E-mail address: huybrechtsi@iarc.fr (I. Huybrechts).
** Supplemental material for list of committee members.

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Methods: The present analysis included 178 adolescents from northern EU countries, 251 from central EU countries, and 212 from southern EU countries (ages 12.5–17.5 y). Mixed model linear regression analyses stratified by geographic location were used to verify associations between calcium and VitD intake and 25(OH)D concentrations. Age, Tanner stage, seasonality, energy intake, and supplement use were entered as covariates.
Results: Only the calcium intake of central EU adolescents was positively associated with 25(OH)D ($\alpha = 0.005$; 95% confidence interval, 0.007–0.028).
Conclusions: Further longitudinal studies should confirm these observations, as this could be important for future public health interventions aiming to increase 25(OH)D concentrations in adolescents.

Introduction

Adolescents in the European Union (EU) exhibit a higher prevalence of vitamin D (VitD) deficiency than other age groups [1,2]. Such deficiency contributes to a higher risk for metabolic bone diseases and potentially other, nonskeletal, chronic diseases later in life. Hence, cost-effective public health VitD strategies are of great public health importance [1].

25-Hydroxyvitamin D [25(OH)D] is principally acquired through sunlight exposure; ultraviolet-B radiation activates the cutaneous synthesis of previtamin D_3 in the skin [3]. The degree to which sunlight exposure increases 25(OH)D concentrations depends on a variety of factors: latitude, season, air pollution, sunscreen use, skin pigmentation, age, liver and kidney disease, and medication use; however, the role of diet on 25(OH)D status is still being debated [1].

VitD from dietary sources has been associated with 25(OH)D concentrations, especially during the winter months. In adults, for every unit increase in VitD intake, 25(OH)D could increase by 1 nmol/L (summer and autumn) and 3.1 nmol/L (winter and spring) [4]. Calcium intake reduces circulating concentrations of calcitriol, which subsequently raises serum 25(OH)D concentrations and modulates the relationship between parathormone and 25(OH)D [5].

Nevertheless, the relationship between calcium and VitD intake and 25(OH)D concentrations appears not to have been previously studied among adolescents living in different EU countries and consequently in different latitudes. Therefore, the aim of this study was to examine whether calcium and VitD intakes are differentially associated with 25(OH)D in adolescents from northern, central, and southern EU countries.

Material and methods

Study design

A subsample of 641 healthy adolescents (344 girls) ages 12.5 to 17.5 y from the HELENA-CSS (Healthy Lifestyle in Europe by Nutrition in Adolescence Cross-Sectional Study) who were not taking any medication, did not present any acute infection the week before the examination, provided data on two nonconsecutive 24-h dietary recalls, and participated in blood sampling were included for the purpose of this study. The sample included 178 adolescents from northern EU cities (Dortmund, Germany and Stockholm, Sweden), 251 from central EU cities (Ghent, Belgium; Lille, France; and Vienna, Austria), and 212 from southern EU cities (Athens and Heraklion, Greece; Rome, Italy; and Zaragoza, Spain). The study was performed following the ethical guidelines of the Declaration of Helsinki 1964, the Good Clinical Practice rules and the legislation about clinical research in humans in each of the participating countries. The protocol was approved by the Human Research Review Committees of the institutions involved. All study participants and their parents provided a signed informed consent form.

Dietary assessment

Trained dietitians assisted adolescents in completing two nonconsecutive 24-h recalls that included weekdays and weekend days. The 24-h recalls were collected via the computer-based HELENA-Dietary Intake Assessment Tool [6]. The German Nutrient Database was used to analyze the dietary data because it is an adequate tool for estimating nutrient intake in European adolescents [7]. The Multiple Source Method was used to estimate the usual dietary intake of nutrients and foods [8]. Adolescents were asked about micronutrient supplement usage and were classified into two groups: supplement and nonsupplement users.

Specimen collection and biochemical analyses

Fasting blood samples were collected by venipuncture at school between 0800 and 1000, between October 2006 and June 2007 [9]. Blood was collected in EDTA tubes and transported at room temperature within 24 h to the central Institut für Ernährungs- und Lebensmittelwissenschaften laboratory. Blood samples were centrifuged at 3500*g* for 15 min at 4°C and the supernatant stored

Table 1
Descriptive characteristics of northern, central, and southern EU adolescents (N = 641)

	Northern EU adolescents (n = 178)	Central EU adolescents (n = 251)	Southern EU adolescents (n = 212)	*P* value (ANOVA)*
Age, y	14.6 ± 1.2	15.0 ± 1.1	14.5 ± 1.2	<0.001
Girls, n (%)	81 (45.5)	146 (58.2)	117 (55.2)	0.030
Tanner stage				<0.001
Tanner I, n (%)	0 (0)	2 (0.8)	3 (1.4)	
Tanner II, n (%)	26 (15)	8 (3.2)	15 (7.1)	
Tanner III, n (%)	68 (39.3)	25 (10)	56 (26.7)	
Tanner IV, n (%)	74 (42.8)	133 (53.4)	83 (39.5)	
Tanner V, n (%)	5 (2.9)	81 (32.5)	53 (25.2)	
Supplement users, n (%)	38 (21.3)	27 (11.1)	15 (7.2)	**<0.001**
Energy intake, kcal/d	2120.6 ± 764.5	2333.5 ± 907.4	2117.7 ± 693.9	**0.004**
25(OH)D, nmol/L	53.0 ± 21.1	56.6 ± 26.6	69.1 ± 20.5	**<0.001**
Vit D intakes, μg/d	1.8 ± 0.9	1.8 ± 0.9	2.2 ± 1.3	**<0.001**
Calcium intakes, mg/d	870.8 ± 515.2	625.0 ± 582.4	867.3 ± 344.5	0.527

25(OH)D, 25-hydroxyvitamin D; ANOVA, analysis of variance; EU, European Union; VitD, vitamin D
Values are percentages for categorical variables; means ± SD for continuous variables
* Significant differences between northern, central, and southern EU countries are represented in bold.