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Contribution of sun exposure to the vitamin D dose received by various groups of the Spanish population

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Abstract

Although the harmful effects of excessive exposure to solar ultraviolet (UV) radiation are well known, the recommended dose of UV radiation is beneficial for the synthesis of vitamin D by the skin, in addition to being useful in the treatment of various illnesses and mental problems. Numerous studies have shown that vitamin D performs important functions in the human organism, such as absorbing calcium and phosphorous and contributing to the immune system, among others. Several studies have found that a high percentage of various groups of the Spanish population suffer from vitamin D deficiency, and since very few natural foods contain vitamin D, it was considered important to determine whether groups such as schoolchildren, outdoor workers and athletes, receive enough solar radiation to produce adequate levels of vitamin D in their daily activities. It was found that the amount of vitamin D (in IU) produced by personal effective solar UV doses could exceed the recommended dose of 1000 IU/day in spring and summer, while the winter estimate (about 220 IU/day) is only one quarter of the recommended dose. These results suggest that most people would not receive the

The author wants to express a warm tribute to Dr. Javier Cañada, who passed away in January 2013 after an intense life devoted to teaching and research.

recommended daily vitamin D dose in winter from exposure to solar UV radiation, the main source of vitamin D.

Keywords: ultraviolet radiation, ultraviolet erythemal irradiance, ultraviolet vitamin D irradiance, vitamin D dose.

1. Introduction

The harmful effects of excessive exposure to solar UV radiation are well known, but there are also benefits from UV radiation, since exposing the skin to solar UV radiation can have significant benefits on health and in particular on cardiovascular health (Chen et al., 2010; Weller 2017) and stimulates vitamin D synthesis (Engelsen, 2010; Holick, 2004, 2005, 2007; Holick et al., 2007). An adequate dose of vitamin D seems to be beneficial against multiple sclerosis, cardiovascular disease, autoimmune diseases, infectious diseases and many types of cancers (Garland et al., 2014; Grant et al., 2015; Hossein-Nezhad and Holick, 2013; Juzeniene et al., 2011; McDonnell et al., 2016; Pludowski et al., 2013) in addition to improving human well-being and skeletal health, especially important in growing children. There is also evidence that links suboptimal vitamin-D levels with depressive disorders, although further studies are necessary in this field (Humble, 2010).

"Vitamin D" refers to a group of compounds of which the most important are vitamin D_3 and D_2. The main natural sources of vitamin D (chiefly D_3) comes through UVB irradiation of 7-dehydrocholesterol in the skin, as very few foods contain this vitamin (Holick et al., 2011; Juzeniene et al., 2011). As the vitamin D obtained from the diet and epidermal metabolite are biologically inactive, it has to be activated by hydroxylation in the liver and kidneys. An individual's vitamin D status can be measured in serum by the 25-hydroxyvitamin D (25(OH)D) produced by the liver (Holick, 2007).

Although Spain receives many hours of sunshine every year, a number of studies have found that a high percentage of various groups of the Spanish population suffer from vitamin D deficiency (Cutillas-Marco et al., 2013; Galán et al., 2011; González Molero et al., 2011; Hernández-Ostiz et al., 2016; Mata-Granados et al., 2008; Rodríguez-Rodríguez et al., 2011; Rodríguez-Sangrador et al., 2008). Recent observational studies defined vitamin D deficiency as a 25(OH)D serum level of 50 nmol/L or less, vitamin D sufficiency as 75 nmol/L or higher and vitamin D insufficiency from 50 to 75 nmol/L (Cashman et al., 2016; Garland et. al., 2014; Hossein-Nezhad and Holick, 2013; McDonnell et al., 2016). Mata-Granados et al. (2008) found that 65% of the participants in their study, carried out in spring, showed vitamin D deficiency. In another study on elderly women (53 subjects), Rodríguez-Sangrador et al. (2008) found that vitamin D deficiency affected 80% of the sample in both summer and winter. Rodríguez-Rodríguez et al. (2011) analyzed the vitamin D status of 103 schoolchildren, of whom 51% presented vitamin D deficiency. In Valencia, in a study with 215 patients with melanoma, Hernández-Ostiz et al. (2016) found that 66.5% of the patients had insufficient levels over a period of a year. In a study on a larger sample (1262 participants) over one year, Gonzalez Molero et al. (2011) concluded that one third of the Spanish population could be at risk of vitamin D deficiency. This deficiency in the Spanish population could be due to insufficient exposure to the sun from the use of high-factor sunscreens in summer and warm clothing in winter. Other factors to be taken into account are the age of the individuals, a dark skin pigmentation, and obesity (Binkley et al., 2007; Godar et al., 2011; Hernández-Ostiz et al., 2016; Holick, 2004, 2005, 2007; Ovesen et al., 2003). Some studies also found that the vitamin D content in the Spanish diet was insufficient and concluded that the Spanish population had an inadequate intake (Gonzalez-Rodríguez et al., 2013; Ortega et al., 2012).

Since most of the vitamin D present in our organism comes through UVB irradiation (Holick et al., 2011; Juzeniene et al., 2011), vitamin-D deficiency is associated with low solar UV radiation, which in northern mid-latitudes occurs from October to March (Difffey, 2010; Rhodes et al., 2010; Seckmeyer et al., 2013; Webb et al., 1988; Webb et al., 2010; Webb et al., 2011). Different authors have suggested that there is sufficient UV radiation in the northern mid-latitude winter to produce the required dose of vitamin D, although for this it would be necessary to expose larger areas than the usual exposure at that time of year, hands and face only (Serrano et al., 2017; McKenzie et al., 2009).

Most of the data used in the present study (except those from the ski school) were obtained in the Valencia region on the east coast of Spain (coordinates 0º 22' W, 39º 28 ' N). Due to its geographical situation Valencia has a subtropical Mediterranean climate and receives large UV radiation doses throughout the year. The average annual temperature is 22.8 °C during the day (State Meteorology Agency) with mild winters and long warm to hot summers.

Our aim was thus to estimate whether the dose of UV solar radiation received by several groups of the population of Valencia in their daily activities would be sufficient to produce an adequate dose of vitamin D, assuming that optimal vitamin D levels are easily maintained by a daily intake of 1000 IU of this vitamin (Bischoff-Ferrari et al., 2006; Holick, 2004, 2007; McKenzie et al., 2009). The personal UV erythemal (UVER) dose measurements (in J/m^2) obtained in previous studies for various groups were used to estimate the effective solar UV radiation in the production of vitamin D (UVD) (in J/m^2) applying the factors proposed by Pope et al. (2008). Finally, considering Holick’s guidelines (2002, 2007), the vitamin D dose was calculated in IU.

2. Material and Methods

2.1. Subjects

The measurements used had been obtained in previous studies, mostly carried out in Valencia on different groups of people. UV sensitive spore-film dosimeters (Bio-Sense

VioSpor blue line, Bornheim, Germany) were used to measure personal UVER doses. One of these studies involved children at school (Serrano et al., 2011) with the aim of quantifying their exposure to UVER radiation in the course of their activities. They wore the UV dosimeters attached either to their shoulders or wrists from 9 am to 5 pm (local time). This study took place with two age groups in two primary schools in Valencia, Spain. Since the aim was to study the exposures on days of maximum solar radiation, the readings were taken on cloudless days. The school was asked not to change their normal activities during the measurement sessions. Two other studies also involved children, one during a summer school (Serrano et al., 2012a) and another (Serrano et al., 2013) at the Panticosa (Huesca) ski resort. Table 1 gives the dates and seasons in which the measurements were taken at each school, together with the numbers of the children who participated in the study.

<Table 1>

Other studies carried out in Valencia focused on outdoor workers and athletes, such as gardeners and lifeguards (Serrano et al., 2009), cyclists (Serrano et al., 2010), construction workers (Serrano et al., 2012b), environmental workers (Serrano et al., 2014), and golfers (Gurrea et al., 2014). Table 2 gives the dates and times in which the measurements were taken and the number of individuals who participated. All the subjects, except the environmental agents, wore the UV dosimeters throughout their daily activities on cloudless days. They were also asked not to make any changes to their normal routines during the measurements. The gardeners wore the dosimeters on their shoulders, the lifeguards attached to the wrist and the cyclists on their helmets. Half the construction workers wore the dosimeters on their shoulders and half on the chest. The environmental agents wore dosimeters from 8 am to 3 pm and from 3 pm to 10 pm in different shifts, on the wrist, head or shoulder, while the golfers had two dosimeters, one on top of their caps and another on the wrist.

<Table 2>

2.2. Methods

According to Eq. (1) below, the daily personal UVER dose in J/m^2 was converted to vitamin D doses (UVD) in J/m^2 using action spectrum conversion factors (ASCFs) (Pope et al., 2008), which are function of the latitude, season of the year and ozone content of the atmosphere.

$$UVD(J/m^2) = UVER(J/m^2) \cdot ASCF \qquad (1)$$

The UVER dose was obtained from the measurements made in the above-cited studies. The ASCF values, shown in Tables 1 and 2, were obtained (Pope et al., 2008) for 40ºN (approximate latitude of Valencia) taking into account the ozone content of the atmosphere in the period of each of the cited studies in Section 2.1, and the season of the year in which the measurements were taken. The ozone data was obtained from the Ozone Monitoring Instrument (NASA) for each day of the studies, and its average value for each measurement period is shown in Tables 1 and 2.

Following the CIE guidelines (2014) which proposed a newly defined minimum vitamin D dose (MDD), the MDD (J/m^2) needed to produce the daily recommended dose of vitamin D (1000 IU) was estimated considering that pale-skinned full-body exposure (Type II) under strong sunlight (UVI = 10) produces 1000 IU in less than 1 min (Mckenzie et al., 2009). This criterion is based on studies by Holick (2002, 2007), who found that 1 minimal erythemal dose (MED) on skin type II (250 J/m^2) for full body exposure was similar to an oral dose of vitamin D in the range 10000-25000 IU. When UVI=10 (UVER=0.25 W/m^2), the MED would be accumulated in 16.7 min, so considering a mean vitamin D dose of 17500 IU, 1 minute would be enough to receive an UVER dose of around 15 J/m^2 and about 1000 IU of vitamin D. The corresponding 1 min UVD dose would be 30 J/m^2, since the ratio (R) of UVD to UVER at UVI 10 is approximately 2 (McKenzie et al., 2009). Then, 30 J/m^2 would be the MDD dose for skin type II and full body exposure. Using the following Eq. (2), the MDD for other skin types and body exposures would be estimated, where PBE is the exposed body fraction and according to Eq. (3) below, STF is the skin type factor used to adjust for skin types other than type II. In Eq. (3) a MED is the minimum UVER dose which causes erythema with sharply defined edges 24 hours after sun exposure whose values depend on skin type (Fitzpatrick, 1988) shown in Table 3.

$$MDD(\mathrm{J/m^2}) = \frac{30(\mathrm{J/m^2})}{STF \cdot PBE} \qquad (2)$$

$$STF = \frac{250(\mathrm{J/m^2})}{MED(\mathrm{J/m^2})} \qquad (3)$$

<Table 3>

As skin type III is considered the commonest type among the Spanish population, then STF=250/350, except for the golfers, who were mostly from northern Europe and lighter skinned (skin type II; STF=1). PBE was estimated following the Lund-Browder chart used to assess sunburned body surface area (Lund and Browder, 1944). For the children in winter it was face, neck and hands; in autumn the lower arms were added, and in spring the lower legs; and for the children at the ski school face and neck only. For the cyclists and environmental workers in summer it was face, neck, hands, lower arms and lower legs, and for lifeguards and construction workers, these areas plus half the upper arms and half the upper legs. As the gardeners kept their legs covered due to their type of work, their face, neck, hands and lower arms were considered in summer. In winter, for cyclists, only face and neck, and for golfers, face, neck and hands (Engelsen, 2010; Godar et al., 2011).The figures for these exposures are shown in Tables 1 and 2.

Table 4 shows the MDD calculated according Eq. (2) for each skin type and for different PBEs. In winter, with 11.5% PBE, an individual with skin type III would need an MDD of 370 J/m^2, but in summer with 43% PBE the same individual would need a dose of 98 J/m^2.

<Table 4>

Finally, Eq.(4) was used to estimate the amount of daily vitamin D produced from a personal median daily UVER exposure:

$$VitaminD(\,IU\,/\,day\,) = \frac{UVD(\,J/m^2\,/\,day\,)\cdot 1000IU}{MDD(\,J/m^2\,)}\cdot\frac{AF}{SPF} \quad (4)$$

where AF is the age factor and SPF is the sun protection factor of any sun block applied over the entire exposed body surface.

The children’s age factor was AF=1, for lifeguards AF=0.9 (around 25 years old), for golfers AF=0.6 (adults from 50-70 years old) and for other adults AF=0.7 (adults from 30-50 years old) (Godar et al., 2011).

Regarding SPF, two possibilities were considered, skin without protection (SPF=1) and the use of sun protective cream (SPF=15 in spring/autumn and SPF=30 in summer) over the entire exposed body surface. These values were chosen following the guidelines of the Spanish Ministry of Health which recommends the appropiate SPF for each skin type according to the UV index.

2.3. Statistical analysis

Data is analysed using the Statgraphics Plus Statistical Package v5.1 software and is expressed as median (25–75 percentiles).

3. Results

The daily dose of vitamin D (IU/day) estimated by Eq.(4) from daily exposure to UV solar radiation obtained from the cited studies is shown in Tables 5 and 6.

Table 5 gives the vitamin D daily dose estimated for schoolchildren in their normal school activities, summer school and ski school. Considering the non-use of sunscreen, in spring the calculated doses of vitamin D for children in outdoor school activities would exceed the recommended dose of 1000 IU/day, with median values between 1100 and 1900 IU. In autumn the doses would range from 330 to 660 IU/day, depending on the age of the child and the school at which the measurements were carried out. However, the winter dose would range from 150 to 230 IU, only one fifth of the recommended dose. In summer, the median vitamin D dose for the children at the summer school would be 2700 IU, well above the recommended dose.

<Table5>

<Table 6>

The daily vitamin D dose estimated for adults in the different activities is shown in Table 6. Considering not using sunscreen, the median vitamin D dose estimated in summer would vary between the gardeners' 1500 IU/day and the lifeguards' 11000 IU/day. It can be seen that all the subjects would exceed the recommended daily dose in summer. In winter, the median vitamin D dose estimated would be about 250 IU/day for cyclists and golfers, in a similar pattern to the children in winter, or around a quarter of the recommended daily dose.

Considering an adequate application of sunscreen over the exposed body surface, the dose of vitamin D obtained by the same groups was estimated. In spring and summer the estimated median doses of vitamin D for children would be between 73 and 130 IU/day, whereas that in autumn and winter the doses would range from 10 to 44 IU/day (Table 5). For adults, estimated median doses of vitamin D would range from 50 to 370 in summer, and around 16 IU/day in winter (Table 6).

4. Discussion

It should be remembered that there is uncertainty about the applicability of the vitamin D action spectrum and the appropriate wavelength at which it should begin (McKenzie et al., 2009). Besides, in the daily vitamin D dose calculations (IU/day) shown in Tables 5 and 6, Holick's indications (2002, 2007) were adopted on the equivalence between the exposure to 1 MED and the oral dose of vitamin D of between 10000 and 25000 IU, using the average value. It should also be noted that Holick's indications are based on studies carried out since the 1980s, so that their precise conditions are difficult to verify from the literature (Dowdy et al., 2010), so the minimum UVD dose (MDD) required to reach the recommended daily dose of vitamin D should be considered as only approximate.

However, this information may not be at all relevant, since experimental studies have shown that vitamin D levels from solar exposure can be different from one person to another even within the same skin type, as a result of genetic predisposition (Abboud et al, 2017; Lucas et al., 2013; Touvier et al. 2015; Wang et al., 2010).

Otherwise, several authors (McKenzie et al., 2012) have suggested that there is a saturation effect that protects against overdoses in vitamin-D production for exposures greater than approximately 0.5 MED.

Besides, it should also be taken into account that solar irradiance is not omni-directional as in artificial sources with vertical lamps in a phototherapy unit, but that the downwelling component prevails (Webb et al., 2011), and some authors consider

(Dowdy et al., 2010) it may be necessary to increase exposure times. The UV dose received by the different body parts has been measured in several studies (Webb et al., 2011) and the results show that vertical body areas (legs, arms, torso) receive about 30–60% of the dose received on a horizontal surface (tops of shoulders, feet, head) when the sun is high in the sky. The areas between the vertical and horizontal can receive more irradiance than a horizontal surface when facing the sun because they can be perpendicular to the sunlight. The amount of radiation received also depends on factors that cannot be tabulated, such as posture, body shape, and type of clothing worn.

Other factors to consider are that not all skin areas synthesize vitamin D with the same efficiency (Holick et al., 2007; Meinhardt-Wollweber and Krebs, 2012), and that obese subjects can lock vitamin D into their fatty tissues (Holick, 2004; 2005; 2007). However, these factors were not considered in the calculations.

Taking into account all the different imprecise conditions, the results obtained in this study regarding the calculated vitamin D doses should be taken with caution and be considered as estimated values only.

The daily UV solar exposure would seem to be sufficient for the daily vitamin D requirements of adults in summer and children in spring if sunscreen is not used. In autumn, children would receive half the recommended dose, which differed between the schools considered, which could have been related to the different activities or to the different school layouts. The EP school building, whose children received lower doses, faces south and casts a shadow over the playground when the solar height is low in autumn. The PC school has trees and shade, but in autumn the children presumably flee from the shade to be in the sun, to which must be added the fact that the readings were taken on different days.

The dose estimated in winter both for children and adults considering SPF=1, would be only around one fifth of the recommended dose, so that it could be said that in winter neither children nor adults obtain the recommended daily dose of vitamin D in their normal activities. These findings agree with recent studies indicating that a high percentage of the Spanish population suffers vitamin D deficiency. One study (Serrano et al., 2017) found that in the winter months around noon, more than two hours of exposing face, neck and hands are required to obtain the recommended daily dose of vitamin D. This time is so long that it seems unrealistic to consider that the recommended dose can be achieved in winter. However, the same study (Serrano et al., 2017) found that there is sufficient UV radiation in the northern mid-latitudes in winter to produce the recommended vitamin D dose, in agreement with the findings of other research groups (McKenzie et al., 2009).

The proper use of an SPF15 sunscreen can reduce Vitamin D doses by 93% (Eq. 4), so with protective sun cream the values of vitamin D dose estimated for children and adults would be very low (tables 5 and 6). As most people apply less than the recommended sunscreen dose, the estimated values of vitamin D would be intermediate between those calculated for SPF = 1 and that calculated for SPF = 15.

On the other hand, there is some evidence that exercise promotes storage of 25(OH)D in muscle (Abboud et al., 2013; Abboud et al., 2017; Scragg et al., 1992), so that it would be possible that adequate levels of vitamin D could be maintained throughout the winter months, which means the winter vitamin D of those who participle in sports activities could be higher than that estimated in this study. However, several studies have found a high percentage of the Spanish population with vitamin D insufficiency, among them professional football players (Galan et al. 2011), two- thirds of which had vitamin D insufficiency in mid-winter, so further studies would be necessary in this area.

5. Conclusions

Taking into account that the estimated daily vitamin D doses obtained in winter and autumn from the sun in routine daily activities are in the order of one-fifth to one-half of the recommended doses even without using sunscreen, and considering the above-mentioned possible inaccuracies, it would be advisable to increase the dietary intake of vitamin D. As many specialist recommend (Gonzalez-Rodríguez et al., 2013; Ortega et al., 2012; Rodríguez-Rodríguez et al., 2011; Rodríguez-Sangrador et al., 2008; Seckmeyer et al., 2013; Zittermann, 2010) this could be achieved by consuming foods with high vitamin D content, such as oily fish or cod liver oil, taking vitamin D-fortified daily products such as milk and cereals, or resorting to vitamin D supplements under medical supervision. Also, but always with due attention to possible harmful effects, it is suggested that larger areas of the skin exposed to the sun than is normal in autumn and winter could achieve higher end of summer 25(OH)D levels (Webb et al., 2010) without increasing the risk of skin cancer, although further studies are needed in this field.

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Table 1

Measurement dates of each school group and period of the study, number of children who participated in the study and action spectrum conversion factors (ASCF).

Group (number of children)	Measurement Dates	Measurement Period	ASCF
*P.C. (30)	26-30 May 2008	Spring 2008	0.96
E.P. (6)	29,30 April; 20,21,26,28,29 May 2008	Spring 2008	0.98
P.C. (34)	16,21,27 October 2008; 3-5 November 2008;	Autumn 2008	0.91
	27,28 January 2009; 3,4,11,18 February 2009	Winter 2008-09	0.64
E.P. (6)	13,27 October 2008; 3,10,12,13 November 2008;	Autumn 2008	0.94
	28 January 2009; 3,4,11,18,19 February 2009	Winter 2008-09	0.64
P.C. (27)	24-26 March; 1,3,6,8 April; 21,22,25-29 May 2009	Spring 2009	0.94
E.P. (6)	25-27 March; 3,6,23 April; 25-29 May 2009	Spring 2009	0.94
Summer school (15)	8,10,11,18,22,23,29,30 July 2008	Summer 2008	1.08
Ski school (10)	27-30 December 2010	Winter 2010	0.67

*School and, in brackets, number of children who participated in the study.

Table 2

Measurement dates of each group and number of individuals who participated in the study. Action spectrum conversion factors (ASCF), percentage of body exposure (PBE) and age factor (AF) of each adult group and period of the study.

Group	Measurement Dates	ASCF	PBE	AF
Gardeners (4)*	16,17,19,20 June 2008 (6 am-1 pm)**	1.05	20	0.7
Lifeguards (5)	30 June; 1-3,7,8 July 2008 (10 am-7:30 pm)	1.08	43	0.9
Cyclists Summer (5)	7,14 June; 5,19 July 2008 (7:40 am-2:40 pm)	1.05	34.5	0.7
Cyclists Winter (5)	7,14,21 February; 7 March 2009 (8:40 am-2 pm)	0.63	4.5	0.7
Construction workers (11)	7-9, 12,13 July 2010 (8 am-7 pm)	1.05	43	0.7
Environmental agents (8)	13,14,21,22,28,29 June; 30,31, August; 6,7,13,14 September 2012	1.07	34.5	0.7
Golfers (7)	7,8,15,21-23,29,31 January 2013 (10 am-3 pm)	0.71	9.5	0.6

*In brackets, number of individuals who participated in the study.

** Local Time

Table 3

General characteristics of skin types and Minimal Erythemal Dose (J/m^2) according to COST-713 (Vanicek et al., 2000).

Skin type	Tan	Burn	Minimal Erythemal Dose (J/m^2)
I	Never	Always	200
II	Sometimes	Sometimes	250
III	Always	Rarely	350
IV	Always	Never	450

Table 4

Minimum daily UVD dose (MDD) according to skin type and body exposure.

Skin type			MDD (J/m^2)			
	PBE=0.045	PBE=0.065	PBE=0.115	PBE=0.138	PBE= 0.25	PBE=0.43
I	533	369	209	174	96	56
II	667	462	261	217	120	70
III	933	646	365	304	168	98
IV	1200	831	470	391	216	126

Table 5

Percentage of body exposure (PBE) and age factor (AF) of each age group of children and period of the study.

Group	PBE	AF
Children 6-8 years winter	13.8	1.0
Children 10-11 years winter	11.5	1.0
Children 6-11 years spring	30.0	1.0
Children 6-8 years autumn	19.8	1.0
Children 10-11 years autumn	17.5	1.0
Children 9-12 years ski school	6.5	1.0
Children 7-12 years summer school	42.0	1.0

Table 6

UVER dose, vitamin D dose (VDD), both in J/m^2 and vitamin D(IU) per day of different school groups.

	UVER dose (J/m^2)	VDD (J/m^2)	Vit D (IU/day)
Spring 2008			
6-8 y School P.C.	260 (180-370)*	250 (170-350)	1800 (1200-2500)
6-8 y School E.P.	270 (210-390)	270 (210-380)	1900 (1500-2700)
10-11y School P.C.	200 (160-270)	190 (150-260)	1400 (1100-1800)
Spring 2009			
6-8 y School P.C.	170 (110-210)	160 (110-200)	1100 (760-1400)
6-8 y School E.P.	180 (100-220)	170 (97-210)	1200 (690-1500)
10-11y School P.C.	150 (90-210)	150 (91-210)	1100 (650-1500)
Autumn 2008			
6-8 y School P.C.	130 (100-170)	110 (92-160)	540 (430-750)
6-8 y School E.P.	76 (45-100)	71 (42-97)	330 (200-460)
10-11y School P.C.	170 (130-190)	160 (120-170)	660 (530-720)
Winter 2008-09			
6-8 y School P.C.	94 (60-110)	60 (39-72)	200 (130-240)
6-8 y School E.P.	110 (58-160)	70 (37-99)	230 (120-330)
10-11y School P.C.	86 (48-100)	55 (31-65)	150 (85-180)
Summer School	280 (180-400)	270 (160-420)	270 (160-420)
Snow School	210 (160-280)	140 (110-190)	220 (160-290)

*Data are expressed as median (25-75 percentiles).

Table 7

UVER dose, vitamin D dose (VDD), both in J/m^2 and vitamin D (IU) per day of different groups.

	UVER dose (J/m^2)	VDD (J/m^2)	Vit D (IU/day)
Summer			
Gardeners	410 (380-470)*	460 (380-490)	1500 (1300-1600)
Lifeguards	1100 (970-1400)	1200 (1100-1500)	1100 (970-1400)
Cyclists	1600 (1400-1800)	1700 (1500-1900)	5600 (5100-6300)
Construction workers	610 (420-1200)	640 (440-1300)	4600 (3100-9300)
Environmental agents	310 (190-450)	330 (200-480)	1900 (1200-2800)
Winter			
Cyclists	540 (390-650)	340 (240-410)	250 (180-310)
Golfers	210 (170-250)	120 (100-150)	240 (200-280)

*Data are expressed as median (25-75 percentiles).