

Ethnicity and season are major determinants of serum 25-hydroxyvitamin D in New Zealand children

T.J. Green, J.E. Rockell, C.M. Skeaff, S.J. Whiting, R. W. Taylor, S. M. Williams, W.R. Parnell, R. Scragg, N. Wilson, D. Schaaf, E.D. Fitzgerald

Department of Human Nutrition, LINZ Activity and Health Research Unit and Preventive and Social Medicine, University of Otago, Dunedin, New Zealand; College of Pharmacy and Nutrition, University of Saskatchewan, Saskatoon, Saskatchewan, Canada; School of Population Health, Faculty of Medicine and Health Science, University of Auckland, Auckland, New Zealand; School of Māori Studies, Massey University, Palmerston North, New Zealand.

Abstract. The aim of this study was to determine 25-hydroxyvitamin D concentrations and their determinants in a national sample of New Zealand children aged 5-14 y. The 2002 National Children's Nutrition Survey was designed to survey New Zealand school aged children, including over-sampling of Māori and Pacific children to allow ethnic-specific analyses. Serum 25-hydroxyvitamin D concentration [mean (99% CI) nmol/L] in Māori children (n=456) was 43 (38, 49), in Pacific (n=646) 36 (31, 42), and in New Zealand European and Others (NZEО) (n=483) 53 (47, 59). Among Māori, Pacific and NZEO respectively, prevalence (%; 99% CI) of serum 25-hydroxyvitamin D deficiency (<17.5 nmol/L) was 5% (2, 12), 8% (5, 14), and 3% (1, 7). Prevalence of insufficiency (<37.5 nmol/L) was 41% (30, 54), 60% (43, 74) and 26% (16, 37), respectively. Multiple regression analysis found 25-hydroxyvitamin D concentrations were lower in winter than summer [adjusted mean difference (99% CI) nmol/L; 15 (8, 22)], lower in females than males [5 (1, 10)], and lower in obese than those of 'normal' weight [8 (3,13)]. Relative to NZEO, 25-hydroxyvitamin D concentrations were lower in Māori [9 (3, 15)] and Pacific children [16 (10, 22)]. Ethnicity and season are major determinants of serum 25-hydroxyvitamin D. There is a high prevalence of vitamin D insufficiency in New Zealand children.

Introduction

Vitamin D plays an essential role in calcium and phosphorus homeostasis. The most serious clinical consequence of vitamin D deficiency in children is rickets, (1). Though still uncommon in western countries, it would appear from the increasing number of case reports being published that rickets is re-emerging as a public health problem (2). Lesser degrees of vitamin D deficiency, referred to as insufficiency, have been associated with lower bone mineral density (3) and bone accretion rates in children (4), as well as elevated serum parathyroid hormone concentrations (3); these effects are consistent with secondary hyperparathyroidism. Recent discoveries indicate that vitamin D has functions unrelated to calcium, specifically in cell differentiation and in the immune system. These biological effects add plausibility to reports that low vitamin D status is associated with increased risk of childhood-onset Type 1 diabetes and increased risk of some types of cancer in adult. We present the serum 25-hydroxyvitamin D results from the Children's Nutrition Survey (CNS02), a large national survey of New Zealand

school-aged children in 2002. New Zealand lies geographically from ~35 °S to ~47 °S and has a food supply with minimal vitamin D fortification. Furthermore, there are three main ethnic groups with varying skin colour: Māori, Pacific, and New Zealand European. Moreover, the survey provides a unique opportunity to explore the independent effects of season, age, ethnicity, and obesity on serum 25-hydroxyvitamin D concentrations in children 5-14 y.

Subjects and Methods

The 2002 National Children's Nutrition Survey (CNS02) was a cross-sectional survey of a national sample of New Zealand school children and adolescents aged 5 to 14 y, conducted during the 2002 school year. A school based sampling frame of children was used with over-sampling of Māori and Pacific children to allow for ethnic specific analysis. The CNS02 aimed to recruit 3000 children with 1000 from each of three ethnic groups: Māori, Pacific, and New Zealand Europeans and Others (NZEО). Children from selected schools were assigned to one of three ethnic groups with a different probability of selection for each ethnic group. Details of the survey methodology are described more fully elsewhere (5). The total number of children invited to participate was 4728, 3275 participated and 1927 provided blood samples. Blood was available for vitamin D analysis for 1659 participants. Of these 1585 children had all data available that was relevant to this study; an overall response rate of 33.5%. Blood sample collection was by trained phlebotomists. The children were given no instructions to fast. Serum 25-hydroxyvitamin D was determined on surplus blood using a radioimmunoassay (RIA) kit (DiaSorin Stillwater, MN). Statistical analyses were carried out using STATA 8.0, adjusting for the complex survey design. Because age, sex, ethnicity, season, geographical location and obesity have been reported to affect serum 25-hydroxyvitamin D concentrations we used multiple linear regression models to examine the independent relationships between each of these variables and serum 25-hydroxyvitamin D. We estimated adjusted means based on these models. Results were considered significant when p<0.01. April through September were defined as 'winter' months, and October to December, and March, defined as 'summer' months.

Results

Mean serum 25-hydroxyvitamin D concentrations as well as prevalence rates of vitamin D deficiency (<17.5 nmol/L) and insufficiency (<37.5 nmol/L) by age, sex and ethnicity are presented in **Table 1**. New Zealand children had a mean concentration of 50 nmol/L, with mean

Table 1
Serum 25-hydroxyvitamin D concentrations and prevalence of deficiency and insufficiency¹,
in New Zealand children by age, sex and ethnicity²

Sex, age and ethnicity	n	Serum 25-hydroxyvitamin D (nmol/L)		
		Mean (99% CI)	% <17.5 nmol/L (99% CI)	% <37.5 nmol/L (99% CI)
New Zealand children				
All	1585	50 (45, 54)	4 (2, 6)	32 (23, 42)
Male	801	52 (47, 58)	3 (2, 6)	27 (18, 38)
5-6	157	57 (49, 65)	1 (0, 4)	19 (10, 34)
7-10	360	53 (48, 58)	2 (1, 6)	24 (16, 34)
11-14	284	50 (41, 59)	5 (2, 10)	33 (18, 52)
Female	784	47 (41, 53)	4 (2, 9)	36 (25, 48)
5-6	137	48 (43, 54)	1 (1, 4)	29 (17, 44)
7-10	362	51 (44, 58)	3 (1, 6)	31 (21, 45)
11-14	285	42 (33, 51)	6 (3, 16)	43 (25, 63)
Māori				
All	456	43 (38, 49)	5 (2, 12)	41 (30, 54)
Male	232	47 (40, 53)	5 (2, 12)	37 (24, 52)
5-6	52	48 (41, 55)	2 (0, 7)	26 (11, 50)
7-10	116	47 (40, 54)	3 (1, 11)	38 (22, 56)
11-14	64	45 (34, 57)	7 (3, 20)	40 (21, 63)
Female	224	40 (35, 45)	6 (2, 16)	46 (33, 59)
5-6	50	42 (36, 48)	2 (1, 8)	45 (26, 65)
7-10	116	46 (40, 52)	4 (1, 12)	33 (19, 50)
11-14	58	35 (28, 42)	10 (3, 28)	58 (36, 77)
Pacific				
All	646	36 (31, 42)	8 (5, 14)	60 (43, 74)
Male	297	38 (33, 44)	7 (3, 15)	54 (36, 72)
5-6	64	42 (34, 49)	3 (1, 10)	49 (29, 69)
7-10	129	40 (34, 46)	5 (2, 15)	50 (30, 70)
11-14	104	36 (30, 42)	12 (6, 23)	61 (40, 78)
Female	349	34 (29, 40)	9 (5, 18)	46 (28, 64)
5-6	47	39 (31, 47)	3 (1, 10)	47 (28, 67)
7-10	145	34 (28, 40)	7 (3, 16)	66 (48, 81)
11-14	157	32 (25, 39)	15 (7, 33)	71 (52, 85)
NZEO				
All	483	53 (47, 59)	3 (1, 7)	26 (16, 37)
Male	272	56 (49, 63)	2 (1, 6)	21 (11, 36)
5-6	41	62 (52, 72)	1 (0, 3)	13 (5, 33)
7-10	115	56 (50, 63)	1 (0, 5)	17 (10, 28)
11-14	116	53 (41, 65)	3 (1, 10)	28 (11, 54)
Female	211	50 (43, 57)	3 (1, 9)	30 (18, 45)
5-6	40	52 (45, 59)	1 (0, 3)	20 (8, 43)
7-10	101	54 (45, 64)	2 (1, 6)	27 (14, 44)
11-14	70	45 (34, 56)	4 (1, 15)	36 (17, 60)

¹ Insufficiency <17.5 nmol/L; deficiency <37.5 nmol/L.

² All data adjusted for sample weighting.
Data rounded to whole numbers.

concentrations in subgroups ranging from 32 nmol/L in Pacific girls aged 11 to 14 y, to 62 nmol/L in NZEO boys aged 5 to 6 y. Four percent of New Zealand children were vitamin D deficient; nearly one third were insufficient. Prevalence of vitamin D deficiency ranged from 1% in NZEO boys and girls 5 to 6 y, to 15% in Pacific girls 11 to 14 y. Similarly, the prevalence of vitamin D insufficiency ranged from 13% in NZEO boys 5 to 6 y to more than 70% in Pacific girls 11 to 14 y. The independent effects of age, sex, ethnicity, latitude (North *cf* South Island), season ('summer' *cf* 'winter' months) and overweight/obesity on serum 25-hydroxyvitamin D concentrations are presented as adjusted means and prevalence in **Table 2**. Boys had higher 25-hydroxyvitamin D concentrations than females by [adjusted mean difference and 99% CI] 5 (1, 10) nmol/L. The effect of age category on serum 25-hydroxyvitamin D was not significant. Ethnicity was a strong determinant of 25-hydroxyvitamin D concentration; Māori children were 9 (3, 15) nmol/L and Pacific children 16 (10, 22) nmol/L lower than NZEO children. Obese children had an 8(3,13) nmol/L lower serum 25-hydroxyvitamin D concentration than normal weight

children. There was a marked independent effect of season on mean 25-hydroxyvitamin D concentrations, with a difference of 15 (8, 22) nmol/L between 'winter' and 'summer' (Table 4). Mean 25-hydroxyvitamin D concentrations adjusted for age, sex, ethnicity, latitude, and

TABLE 2
Adjusted mean serum 25-hydroxyvitamin D concentrations and prevalence of deficiency and insufficiency¹ in New Zealand children^{2,3}

	n	Serum 25-hydroxy vitamin D (nmol/L)	Adjusted Prevalence	
		Adjusted Mean (99% CI)	<17.5 nmol/L % (99% CI)	<37.5 nmol/L % (99% CI)
Sex				
Male	801	52 (48, 56) ^a	2 (1, 4)	24 (17, 33)
Female	784	47 (43, 51) ^b	3 (1, 6)	33 (24, 43)
Age (yr)				
5-6	294	53 (47, 58)	1 (0, 3) ^a	21 (13, 32)
7-10	722	51 (47, 55)	2 (1, 5)	25 (18, 34)
11-14	569	47 (41, 52)	4 (2, 10) ^b	35 (23, 49)
Ethnicity				
Māori	456	44 (39, 48) ^a	4 (1, 11)	38 (26, 52) ^a
Pacific People	646	37 (34, 40) ^b	7 (3, 13)	59 (49, 68) ^b
NZEO	483	53 (48, 57) ^c	2 (1, 4)	23 (16, 32) ^c
Region				
South Island	174	48 (44, 53)	2 (0, 8)	27 (15, 45)
North Island	1411	50 (45, 54)	3 (1, 5)	29 (21, 38)
Season				
Winter (April-Sept)	924	43 (39, 47) ^a	4 (2, 7)	42 (32, 53) ^a
Summer (Oct-Dec, Mar)	661	58 (53, 64) ^b	1 (0, 4)	14 (8, 23) ^b
Obesity⁴				
Obesity	188	42 (37, 47) ^a	1 (1, 4)	46 (29, 64) ^a
Overweight	332	50 (45, 55) ^b	2 (1, 4)	28 (18, 41)
Normal Weight	1065	50 (46, 54) ^b	3 (1, 6)	27 (20, 35) ^b

¹ Insufficiency <17.5 nmol/L; deficiency <37.5 nmol/L.

² All data adjusted for sample weighting.

³ Adjusted for age, sex, ethnicity, season, region and obesity.

⁴ Normal, overweight or obese classification according to Cole 2000³⁴

Numbers not sharing a common superscript are significantly different, p<0.01
Data rounded to whole numbers.

overweight/obesity, fell from a peak in March of 68 (57, 79) nmol/L to a nadir in August of 36 (32, 40) nmol/L

Conclusions

We report a high prevalence of insufficient vitamin D status in New Zealand school-age children; from 32% for all children to a high of 60% in Pacific children.

References

- Wharton B and Bishop N. (2003) Rickets. *Lancet* 362: 1389-1400.
- Blok BL et al. (1998) Characteristics of children with florid vitamin D deficient rickets in the Auckland region in 1998. *N. Z. Med. J.* 113: 374-376.
- Cheng SF et al. (2003) Association of low 25-hydroxyvitamin D concentrations with elevated parathyroid hormone concentrations and low cortical bone density in early pubertal and prepubertal Finnish girls. *Am. J. Clin. Nutr.* 78: 485-492.
- Lehtonen-Veromaa MK et al (2002) Vitamin D and attainment of peak bone mass among peripubertal Finnish girls: a 3-y prospective study. *Am. J. Clin. Nutr.* 76: 1446-1453.
- Parnell, W et al. NZ Food, NZ Children: Key results of the 2002 National Children's Nutrition Survey. Ministry of Health, Wellington.