

# Serum 25OHD concentrations of New Zealanders aged 15 years and older

C. Murray Skeaff, Jennifer E.P. Rockell, Timothy J. Green

Department of Human Nutrition, University of Otago, PO Box 56, Dunedin, New Zealand

**Abstract.** Our purpose was to measure serum 25OHD (25OHD) concentrations and their determinants in a national sample (n=2948) of New Zealanders aged 15 y and over. Mean (99% CI) serum 25OHD concentrations were 47 (45, 50) nmol/L in women and 52 (49, 55) nmol/L in men. Mean concentrations in New Zealand European and Others (NZEО, n=2442), Maori (n=370), and Pacific (n=136) were 51 (49, 53), 42 (38, 46), and 37 (33, 42) nmol/L, respectively. 3% of New Zealanders had serum 25OHD concentrations indicative of deficiency ( $\leq 17.5$  nmol/L); 48% and 84% were insufficient based on cutoffs of  $\leq 50$  and  $\leq 80$  nmol/L. Determinants of serum 25OHD concentrations in women were age, ethnicity, obesity, latitude and season; determinants in men were ethnicity and season. Serum 25OHD in women declined with age; mean concentration was 13 (8, 18) nmol/L lower in women 65 y or older and 9 (5, 13) nmol/L lower in women 45-64 y compared with women 15-18 y. Spring to summer differences in serum 25OHD were 31 (28, 34) and 28 (25, 31) nmol/L in women and men respectively. Obese women had lower vitamin status than normal weight women by 6 (3,10). Women living in the South Island had a mean serum 25OHD that was 6 (3, 9) nmol/L lower than women living in the North Island. Ethnicity and season are the major determinants of serum 25OHD in New Zealanders. The high prevalence of vitamin D insufficiency in New Zealanders, particularly in older women, may warrant strategies to improve vitamin D status.

## Introduction

It has been assumed that the New Zealand population obtains sufficient vitamin D from sunlight exposure to maintain adequate vitamin D status (1). However, no population-based surveys exist to substantiate this assumption. The most serious clinical consequence of vitamin D deficiency in adults is osteomalacia. Lesser degrees of vitamin D deficiency, often referred to as insufficiency, are associated with poor calcium absorption leading to secondary hyperparathyroidism with accelerated bone loss and risk of risk of osteoporotic fracture (2). Vitamin D supplementation with or without calcium has been shown to reduce this risk in some clinical trials (3). Recent discoveries indicate that vitamin D has functions unrelated to calcium in bone, specifically in cell differentiation and in the immune system (4). Furthermore, vitamin D insufficiency has been implicated in the development of Type 1 diabetes (5) and increased risk of some cancers (6). The widening spectrum of diseases in which vitamin D may play an etiological role gives greater relevance and priority to monitoring the vitamin D status of populations.

The purpose of our study was to describe the vitamin D

status of the New Zealand population ( $\geq 15$  y) by measuring the 25OHD concentration and its determinants in serum samples collected from participants in the 1997 National Nutrition Survey.

## Subjects and Methods

The 1997 National Nutrition Survey (NNS97) was conducted as an extension of the 1996/97 New Zealand Health Survey, a population-based, nation-wide survey of non-institutionalized adolescents and adults 15 y and over. An area-based sampling frame was used with a three stage stratified design consisting of a selection of primary sampling units (PSU), households within a selected PSU, and a single randomly selected respondent within a household (7). Our dataset represents 42% of New Zealanders who took part in the 1996/97 Health Survey.

Ethnicity was self-reported. NZEO participants with a body mass index (BMI) of 25.0-29.9 kg/m<sup>2</sup> were classified as overweight and those with BMI  $\geq 30.0$  kg/m<sup>2</sup> were classified as obese. Maori and Pacific individuals with a BMI 26.0-32.0 kg/m<sup>2</sup> were classified as overweight and those with a BMI  $\geq 32.0$  kg/m<sup>2</sup> were classified as obese.

Blood was drawn, from subjects across a range of fasting and postprandial states, from an antecubital vein into vacuum evacuated tubes. Serum 25OHD was determined on blood using a radioimmunoassay kit (DiaSorin Stillwater, MN).

Analyses were carried out using the survey commands of STATA 8.0 that adjusted for the complex sampling design and provided appropriate estimates of the standard errors from which the 99% confidence intervals were derived. We included in the analyses only those participants with a vitamin D result and no missing relevant data (n=2946). Sampling weights, which were the inverse of the probability of being selected and adjusted for differential non-response and post-stratification by age, sex and ethnicity, were used in all analyses to obtain population estimates. Log transformations of serum 25OHD were used in calculating means and adjusted means in the regression analysis. Because age, sex, ethnicity, season, geographical location and obesity have been reported to affect serum 25OHD concentrations we used multiple linear regression models to examine the independent relationships between each of these variables and serum 25-hydroxyvitamin D, and estimated adjusted means based on these models. A significant interaction was found between age and sex; the results for each sex are reported separately. We defined vitamin D deficiency as a 25OHD  $\leq 17.5$  nmol/L. We used two cutoffs to define vitamin D insufficiency,  $\leq 50$  and  $\leq 80$  nmol/L.

## Results

Mean serum 25OHD concentration of New Zealanders 15

y or older was 50 (48, 51) nmol/L (**Table 1**). The unadjusted mean concentrations in women were 47 (45, 50) and 52 (49, 55) in men. Pacific women had the lowest [34 (29, 40) nmol/L], and NZEO men the highest [53 (51, 56) nmol/L] mean 25OHD concentrations. 3% of New Zealanders overall were classified as vitamin D deficient. The proportion of adults with vitamin D deficiency ranged from 0% in men aged 19-24 y to 10% in Pacific women. Nearly one half of New Zealanders were classified as vitamin D insufficient using a cutoff of  $\leq 50$  nmol/L and more than 80% had a 25OHD concentrations  $\leq 80$  nmol/L.

**Table 1** Serum 25-hydroxyvitamin D concentrations (nmol/L) and prevalence of deficiency and insufficiency<sup>1</sup>, in New Zealanders

Sex, age and ethnicity	n	Geometric Mean (99% CI)	Deficient (99% CI)		Insufficient (99% CI)	
			% <17.5	% <50.0	% <50.0	% <80.0
NZ Population	2946	50 (48, 51)	3 (2, 4)	48 (45, 51)	84 (82, 87)	
Female	1604	47 (45, 50)	4 (3, 6)	52 (47, 56)	86 (83, 89)	
15-18	63	55 (47, 64)	2 (0, 10)	39 (21, 57)	78 (62, 97)	
19-24	117	49 (42, 56)	3 (1, 10)	52 (35, 69)	92 (85, 100)	
25-44	730	49 (46, 52)	2 (1, 4)	51 (45, 57)	82 (77, 88)	
45-64	428	45 (41, 49)	6 (3, 13)	52 (44, 60)	88 (83, 93)	
65+	266	43 (38, 49)	6 (2, 15)	58 (47, 69)	91 (86, 96)	
Male	1342	52 (49, 55)	2 (1, 4)	45 (40, 50)	82 (79, 86)	
15-18	65	49 (40, 62)	1 (0, 19)	55 (36, 73)	84 (70, 100)	
19-24	104	48 (41, 56)	0 (0, 0)	54 (39, 69)	89 (80, 99)	
25-44	548	52 (48, 56)	2 (1, 6)	42 (35, 49)	81 (75, 87)	
45-64	419	52 (49, 57)	1 (0, 7)	45 (36, 53)	83 (77, 89)	
65+	206	55 (49, 62)	3 (1, 12)	41 (30, 51)	76 (68, 86)	
NZEO <sup>1</sup>	2440	51 (49, 53)	3 (2, 4)	46 (52, 50)	83 (80, 85)	
Female	1318	48 (46, 51)	4 (2, 6)	49 (44, 54)	85 (82, 89)	
Male	1122	53 (51, 56)	2 (1, 4)	43 (38, 48)	81 (77, 85)	
Maori	370	42 (38, 46)	2 (1, 6)	61 (51, 72)	90 (84, 97)	
Female	212	41 (36, 46)	3 (1, 8)	68 (56, 80)	91 (84, 98)	
Male	158	43 (37, 50)	2 (1, 9)	56 (40, 71)	90 (80, 100)	
Pacific	136	37 (33, 42)	4 (1, 14)	69 (56, 82)	96 (92, 100)	
Female	74	34 (29, 40)	10 (3, 32)	79 (65, 94)	99 (98, 100)	
Male	62	40 (33, 49)	3 (0, 33)	62 (43, 81)	94 (88, 100)	

<sup>1</sup> NZEO. New Zealand European and Others

The independent effects of age, ethnicity, latitude (the North versus South Island), season and BMI category on serum 25OHD concentrations in both men and women are presented as adjusted means and adjusted prevalence in **Table 2**. Women had lower 25OHD concentrations than men by 5 (3, 8) nmol/L [adjusted mean difference (99% CI)]. Serum 25OHD in women declined with age; mean concentration was 13 (8, 18) nmol/L lower in women 65 y or older and 9 (5, 13) nmol/L lower in women 45-64 y compared with women 15-18 y. Serum 25OHD did not change with age in men. Ethnicity was a strong determinant of 25OHD concentration in both women and men. Maori women were 11 (7, 14) nmol/L and Pacific women 16 (11, 20) nmol/L lower than NZEO women. Maori men were 10 (4, 15) nmol/L and Pacific men 12 (3, 19) nmol/L lower than NZEO men. Region was not a determinant of serum 25OHD in men (P=0.014). However, women living in the South Island (~40 - 47 °S) had significantly lower mean serum 25OHD by 6 (3, 9) nmol/L than those in the North Island (~35 - 40 °S). Women, but not men, who were obese had a mean serum 25OHD concentration 6 (3, 10)

nmol/L lower than those with a normal weight. Mean 25OHD concentrations changed markedly with season, the difference between spring and summer concentrations was 31 (28, 34) nmol/L in women and 28 (25, 31) in men.

**Table 2** Adjusted mean (99% CI) serum 25-hydroxyvitamin D concentrations (nmol/L) in New Zealanders<sup>1</sup>

Characteristic	n	Females	n	Males
Age y				
15-18	63	54 (47, 61) <sup>*</sup>	65	49 (40, 59)
19-24	117	51 (45, 58)	104	51 (45, 59)
25-44	730	49 (47, 52)	548	52 (49, 56)
45-64	428	45 (41, 49)	419	52 (49, 55)
65+	266	41 (37, 46)	206	52 (46, 59)
Ethnicity				
NZEO <sup>2</sup>	1318	49 (47, 51) <sup>a</sup>	1122	53 (50, 56) <sup>a</sup>
Māori	212	38 (35, 42) <sup>b</sup>	158	43 (38, 49) <sup>b</sup>
Pacific	74	33 (29, 38) <sup>b</sup>	62	41 (34, 50) <sup>b</sup>
Region				
South Island	573	43 (40, 46) <sup>a</sup>	491	49 (45, 53)
North Island	1031	49 (47, 52) <sup>b</sup>	851	53 (50, 56)
Season				
Summer (Dec-Feb)	265	67 (61, 74) <sup>*</sup>	242	70 (64, 76) <sup>*</sup>
Autumn (Mar-May)	420	53 (50, 57)	308	63 (58, 68)
Winter (Jun-Aug)	468	44 (41, 47)	399	45 (42, 49)
Spring (Sep-Nov)	451	36 (33, 39)	393	42 (39, 45)
Body Mass Index				
Healthy weight	766	48 (45, 51) <sup>a</sup>	536	53 (49, 56)
Overweight	504	49 (46, 52) <sup>a</sup>	616	52 (49, 56)
Obese	334	42 (38, 45) <sup>b</sup>	190	47 (41, 53)

<sup>1</sup> Adjusted for age, ethnicity, season, region and BMI category

<sup>2</sup> NZEO, New Zealand European and Others

<sup>\*</sup> P for trend <0.001

<sup>a, b, c</sup> Means not sharing a common superscript are significantly different, P<0.01

## Conclusions

We report a high prevalence of insufficient vitamin D status in New Zealand adolescents and adults. Programmes to improve the vitamin D status of New Zealanders such as fortification and/or supplementation may be required.

## References

1. National Health and Medical Research Council (1991) Recommended Dietary Intakes for use in Australia. In. NHMRC, Canberra.
2. Holick MF (2004) Vitamin D: importance in the prevention of cancers, type 1 diabetes, heart disease, and osteoporosis. *Am J Clin Nutr* 79:362-371.
3. Dawson-Hughes B et al. (1997) Effect of calcium and vitamin D supplementation to prevent hip fractures in the elderly woman 65 years of age and older. *New Engl J Med* 337:670-676.
4. DeLuca HF (2004) Overview of general physiologic features and functions of vitamin D. *Am J Clin Nutr* 80:1689S-1696S.
5. Hypponen E et al. (2001) Intake of vitamin D and risk of type 1 diabetes: a birth-cohort study. *Lancet* 358:1500-1503.
6. Garland CF et al (1989) Serum 25OHD and colon cancer: eight-year prospective study. *Lancet* 2:1176-1178.
7. Russell DG, Parnell, WC, Wilson, NC (1999) NZ Food: NZ People. Key Results of the 1997 National Nutrition Survey. In. Ministry of Health, Wellington.