

Short Communication

Serum 25-hydroxyvitamin D₃ is related to fish intake and exercise in Korean adult men

Youl Lee Lym MD and Hee-Kyung Joh MD

Department of Family Medicine, Konkuk University School of Medicine, Seoul, Korea

Vitamin D is an important factor for bone health. It is uncertain which lifestyle is associated with vitamin D status, especially in healthy middle aged Asian men. A cross-sectional analysis was performed in 149 men aged 40–69 years who visited a health check-up center in Korea. Serum vitamin D (25-OHD₃) was measured and smoking, alcohol, exercise, occupation, frequency of fish and dairy intake were estimated by self-administered questionnaire. The mean (\pm SD) 25-OHD₃ concentration was 96.5 \pm 30.7 nmol/L. Higher and lower 25-OHD₃ groups were generated with the median concentration as the cut-off point. By univariate analysis, exercise status and fish intake frequency were significantly different between two 25-OHD₃ groups ($p=0.012$, 0.019 respectively). After multivariable logistic regression, higher fish intake frequency and regular exercise were associated with higher levels of 25-OHD₃ (p for trend=0.017 and 0.02 respectively). In conclusion, frequent fish intake and regular exercise are positively associated with serum 25-OHD₃ concentrations in healthy Korean men.

Key Words: exercise, fishes, Koreans, life style, vitamin D**INTRODUCTION**

Vitamin D deficiency is known to accelerate age-related bone loss. It can also lead to loss of muscle strength and myopathy in some age groups, an increased likelihood of falling and hip fractures.^{1,2} Vitamin D insufficiency is common, especially among older adults, with reported prevalence between 25% and 50% of the population.³ Skin exposure to sunlight is a major source of vitamin D, but in modern society, many adults spend less time outdoors and the increased use of sunscreen significantly reduces cutaneous production of vitamin D.⁴ Furthermore, limited natural dietary source of vitamin D, smoking, alcohol, exercise,^{5,6} and obesity⁴ could influence vitamin D levels. Most studies of vitamin D status have been carried out in postmenopausal women or elderly men, and have studied the relationship with just one or a few lifestyle factors. To our knowledge, few studies have considered the effect of various lifestyle factors, such as alcohol, smoking, exercise, dietary habits and their relative importance on serum vitamin D, especially in Korean men. The aim of this study was to examine the independent determinants of serum vitamin D status in healthy middle aged Korean men.

MATERIAL AND METHODS

Cross-sectional analysis was performed consecutively in 175 men aged 40–69 years who were relatively healthy and ambulatory, and visited a university hospital for an annual health check up in South Korea from 9 January to 4 March 2007. Informed consent was obtained from all participants. The study protocol was designed according to the guidelines established by the Ethical Committee of Konkuk University School of Medicine. The exclusion criteria consisted of any condition that might affect vita-

min D metabolism; diabetes mellitus, thyroid function abnormality, hyperparathyroidism, Cushing syndrome, chronic kidney disease, rheumatic disease, stroke, as well as those taking medication that would affect bone density (e.g., medication for osteoporosis, vitamin D, calcium, corticosteroids, diuretics, testosterone). Accordingly we excluded 26 men and the remaining 149 were included in final analysis.

Serum 25-OHD₃ was measured by competitive radioimmunoassay (RIA) test (25OH-VIT.D3-RIA-CT, BIOSOURCE, Europe; R-counter, COBRA 5010 Quantum, PACKARD, USA). The intra- and inter-assay coefficients of variation (CV) were <4.7% and <5.3% at levels 22.8 and 40 ng/ml (N = 12) for intra-assay, 23.0 and 57.9 ng/ml (N = 25) for inter-assay, respectively. A standardized self-administered questionnaire was used to obtain information about past medical history, current medication use, occupation, smoking, alcohol, exercise and frequency of fish and dairy intake. Subjects were classified as never, former or current smoker; <7 drinks/week, 7-13 drinks/week, \geq 14 drinks/week; no exercise, irregular exercise (those who exercise less than 3 episodes/week or less than 20 minutes/episode) and regular exercise (those with exercise \geq 3 episodes/week and \geq 20 minutes/episode). Fish as a source of vitamin D on the questionnaire

Corresponding Author: Dr Hee-Kyung Joh, Department of Family Medicine, Konkuk University School of Medicine, 4-12 Hwayang-dong, Gwangjin-gu, Seoul, Korea
Tel: 82-2-2030-7682; Fax: 82-2-2030-7749
Email: joe@kuh.ac.kr

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included mackerel, Spanish mackerel, saury, tuna, and salmon, which are the most frequently consumed dark fish in Korea and contain high level of vitamin D (mackerel: 11 µg of vitamin D/100 g, Spanish mackerel: 12 µg/100 g, saury: 16 µg /100 g, tuna 12 µg/100 g, salmon 32 µg/100 g).⁷ Dairy foods on the questionnaire included milk, yogurt, cheese and ice cream. The frequency of fish and dairy intake responses included: <1/week, 1-2/week, and >3 times/week.

Higher and lower 25-OHD₃ groups were generated with the median concentration as the cut-off point. Univariate associations with the higher level of 25-OHD₃ were analyzed by t test for continuous variables or chi-square test for categorical variables. All variables found to have a significantly association ($p < 0.25$) were included in the multivariable logistic regression models. Odds ratios (ORs)±95% confidence interval (CI) were calculated for the higher level of 25-OHD₃ using the lower level as reference group. All statistics were performed using STATA version 11.0.

RESULTS

The mean (±SD) and median of 25-OHD₃ concentrations were 96.5±30.7 nmol/L and 90.3 nmol/L. Table 1 provides

Table 1. Characteristics of the study participants

Characteristic	All (n=149)
25-OHD ₃ , nmol/L, mean ± SD	96.5±30.7
Age, years, mean ± SD	50.2±6.9
40-44	33 (22.2)
45-49	53 (35.6)
50-54	30 (20.1)
55-69	33 (22.2)
BMI, kg/m ² , mean ± SD	24.0± 2.8
<22.9	59 (39.6)
23-24.9	35 (23.5)
≥25	55 (36.9)
Occupation	
Indoor	129 (86.6)
Outdoor	12 (8.1)
Smoking status	
Never	35 (23.5)
Former	56 (37.6)
Current	58 (38.9)
Alcohol intake amount, drinks/week	
<7	73 (49.3)
7-13	34 (23.0)
≥14	41 (27.7)
Exercise status	
No	37 (24.8)
Irregular	22 (14.8)
Regular [†]	90 (60.4)
Fish intake, times/week	
<1	35 (24.8)
1-2	82 (58.2)
≥3	24 (17.0)
Dairy intake, times/week	
<1	56 (40.0)
1-2	39 (27.9)
≥3	45 (32.1)

Data are presented as number of subjects (percentage) unless otherwise noted.

BMI= body mass index

[†]Regular exercise: exercise frequency ≥3 times per week and exercise duration ≥ 20 minutes

Table 2. Univariate analysis for the associated factors to the higher level of 25-OHD₃ (nmol/L)

	25-OHD ₃		<i>P</i> [*]
	Lower (n=74) (45.8-90.2 nmol/L)	Higher (n=75) (90.3-205 nmol/L)	
Age, years	49.3 ±6.4	51.1 ±7.2	0.098
40-44	17 (23.0)	16 (21.3)	0.073
45-49	32 (43.2)	19 (25.3)	
50-54	12 (16.2)	17 (22.7)	
55-69	13 (17.6)	23 (30.7)	
BMI, kg/m ²	23.9 ± 3.0	24.1 ± 2.7	0.808
<22.9	32 (43.2)	27 (36.0)	0.596
23-24.9	16 (21.6)	19 (25.3)	
≥25	26 (35.1)	29 (38.7)	
Occupation			0.366
Indoor	63 (88.7)	66 (94.3)	
Outdoor	8 (11.3)	4 (5.7)	
Smoking status			0.25
Never	20 (27.0)	15 (20.0)	
Former	23 (31.1)	33 (44.0)	
Current	31 (41.9)	27 (36.0)	
Alcohol intake amount, drinks/week			0.113
<7	39 (52.7)	34 (45.9)	
7-13	20 (27.0)	14 (18.9)	
≥14	15 (20.3)	26 (35.1)	
Exercise status			0.012
No	25 (33.8)	12 (16.0)	
Irregular	13 (17.6)	9 (12.0)	
Regular [†]	36 (48.6)	54 (72.0)	
Fish intake, times/week			0.019
<1	24 (34.3)	11 (15.5)	
1-2	38 (54.3)	44 (62.0)	
≥3	8 (11.4)	16 (22.5)	
Dairy intake, times/week			0.52
<1	31 (44.3)	25 (35.7)	
1-2	17 (24.3)	22 (31.4)	
≥3	22 (31.4)	23 (32.9)	

BMI=body mass index

^{*}*p* is from t-test (continuous variables) or chi-square test (categorized variables).

[†]Regular exercise: exercise frequency ≥3 times per week and exercise duration ≥ 20 minutes

the descriptive characteristics of the subjects. Occupation was categorized into indoor and outdoor activity. By univariate analysis (Table 2), exercise status and fish intake frequency were significantly different between the lower and the higher 25-OHD₃ groups ($p=0.012$, 0.019 respectively).

In multivariable logistic regression model with adjustment of age, smoking status, alcohol intake and regular exercise were significantly associated with the higher level of 25-OHD₃ (OR=2.77, 95% CI: 1.10-6.95). Higher level of exercise was also associated with the higher level of 25-OHD₃ (p for trend = 0.026). In addition, frequency of fish intake was significantly associated with the higher level of 25-OHD₃; OR for 1-2 times/week was 2.56 (95% CI: 1.03-6.34) and OR for ≥3 times/week was 2.93 (95% CI 0.90-9.56), with intake frequency <1 time/week as reference group. Higher frequency of fish intake was related to the higher level of 25-OHD₃ (p for trend = 0.048). Age (4 categories), smoking status and amount of alcohol consumed, as well as occupation had no association with the levels of 25-OHD₃ (Table 3).

Table 3. Multivariate odds ratios (ORs, 95% CI) for the higher level of 25-OHD₃; logistic regression models

	OR	(95% CI)	<i>p</i> for trend
Age, years			
40-44	1.00		0.166
45-49	0.60	(0.23-1.60)	
50-54	1.08	(0.35-3.32)	
55-69	1.80	(0.58-5.55)	
Smoking status			
Never	1.00		
Former	1.96	(0.76-5.07)	
Current	1.79	(0.66-4.84)	
Alcohol intake amount, drinks/week			
<7	1.00		
7-13	0.69	(0.27-1.76)	
≥14	1.37	(0.57-3.29)	
Exercise status			0.026
No	1.00		
Irregular	1.53	(0.46-5.09)	
Regular [†]	2.77	(1.10-6.95)	
Fish intake, times/week			0.048
<1	1.00		
1-2	2.56	(1.03-6.34)	
≥3	2.93	(0.90-9.56)	

[†]Regular exercise: exercise frequency ≥3 times per week and exercise duration ≥ 20 minutes.

DISCUSSION

In our study, regular exercise and frequent fish intake were significantly associated with higher level of 25-OHD₃ in middle aged Korean men. Exercise frequency and duration were related with 25-OHD₃ levels in a dose-response relationship (data not shown). An association between low activity and low 25-OHD₃ or low 1,25(OH)₂D have been reported in earlier studies.^{4,6,8-12} Whether this reflects a direct relationship between activity and vitamin D metabolism, or is a result of confounding relationship between exercise and body fat or sun exposure, is unknown.¹³ Further study to investigate the mechanism of how serum 25-OHD₃ increases by exercise is needed. Fish is one of the major sources of vitamin D in the Korean diet. The Korean population eats a varieties of fish that contains 11-32 μg (4400-12800 IU) of 25-OHD₃ per 100 g fish.^{14,15} Based on the national nutrition survey in Korea, population mean fish consumption in Korea (67.7 g/day per capita) is much higher than in the United States (21.3 g/day per capita).¹⁶ Vitamin D is present in highly concentrations, especially in dark fish (e.g., mackerel, swordfish, salmon, bluefish, sardines), and dark fish accounts for about one third of all fish consumed in Korea.¹⁶ Consequently, dietary fish intake frequency may provide a clue in explaining the adequate concentrations of 25-OHD₃ in Koreans. Although, fish consumption is much lower in people over 65 years of age in Korea,¹⁶ a group that often needs more vitamin D intake to maintain adequate serum levels. Furthermore, fish consumption

has been declining since 1995 while meat consumption is increasing in Korea.¹⁶ This study adds to the evidence that increased consumption of fish should be recommended.

Limitations of this study include a relatively small number of subjects. In addition, current vitamin D measurement is a reflection of the influence of a number of factors present throughout the lifespan. Prospective, repeated measurement of both vitamin D and life style factors would likely provide better insight. Third, we could not control sunlight exposure by using a lifestyle questionnaire or by discriminating between the indoor and outdoor exercise. The possibility remains that sunlight exposure confounds the association between exercise and serum levels of vitamin D. But this study was conducted between January and early March which, given the latitude of South Korea (37 degrees N for Seoul), would likely cover a time period in which solar UV radiation is very low, so the effects of sunlight would have been smaller than in other periods. In addition, occupation data can be used as a proxy for vitamin D status. In this study, there was no difference between subjects who perform their daily activity under the sun and indoors, although a small number of subjects were involved in outdoor activities. Despite these limitations, this study analyzed serum 25-OHD₃ levels in healthy men in Korea. There are several studies about vitamin D levels in women especially in postmenopausal women.^{17,18} But data from Asian men are sparse. The mean serum 25(OH)D in Korean postmenopausal women during the winter months was 83.3±32.8 nmol/L,¹⁷ and in Japanese postmenopausal women, 55.6± 14.6 nmol/L which are lower than our result.¹⁸

In conclusion, frequent fish intake and regular exercise are positively associated with serum 25-OHD₃ levels in middle-aged healthy Korean men. It would be desirable to determine whether the same life style factors affect vitamin D levels in other age or sex groups, especially in vulnerable elderly people. Also, frequent fish intake and regular exercise as well as the exposure to sunlight are thought to be an advisable health practices in terms of preventing vitamin D insufficiency in active elderly people.

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AUTHOR DISCLOSURES

Youl Lee Lym and Hee-Kyung Joh, no conflicts of interest.

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Short Communication

Serum 25-hydroxyvitamin D₃ is related to fish intake and exercise in Korean adult men

Youl Lee Lym MD and Hee-Kyung Joh MD

*Department of Family Medicine, Konkuk University School of Medicine, Seoul, Korea***韓國成年男性血清 25-hydroxyvitamin D₃ 與魚類攝取及運動之相關性**

維生素 D 對於骨質健康是重要的因子。生活型態與維生素 D 狀況的相關性尚不明確，尤其是在健康的中年亞洲男性。本研究為橫斷性分析，對象為參加韓國一健檢中心的 149 名男性，年齡為 40-69 歲。測量血清維生素 D (25-OHD₃)，並使用自填式問卷評估他們的抽菸、飲酒、運動、職業及魚類和奶類的攝取頻率。25-OHD₃ 濃度的平均值(±標準差)為 96.5±30.7 nmol/L。以中位數的濃度當作切點，區分成高及低 25-OHD₃ 兩組。單變項分析結果，高及低 25-OHD₃ 兩組在運動狀況及魚類攝取有顯著性差異(p 值分別為 0.012 及 0.019)。在多變項羅吉斯迴歸分析，較高的魚類攝取頻率及規律的運動與較高量的 25-OHD₃ 具有相關性(p for trend 分別為 0.017 及 0.02)。結論是，在健康的韓國男性，常吃魚及規律的運動與血清 25-OHD₃ 濃度具有正相關。

關鍵字：運動、魚類、韓國人、生活型態、維生素 D