**Detailed methods**

1. ***Serum 25(OH)D concentration-related variables as outcomes***

Serum vitamin D metabolites, 25(OH)D2, 25(OH)D3 and 24,25-dihydroxycholecalciferol (24,25(OH)2D3), were measured using modified method of liquid chromatography- tandem mass spectrometry (LC-APCI-MS/MS) (1). The modification point was derivation of extracted vitamin D metabolites with 4-[2-(6,7-dimethoxy-4-methyl-3-oxo-3,4-dihydroquinoxalyl) ethyl]-1,2,4-triazoline-3,5-dione (DMEQ-TAD) to obtain high sensitivity by increasing ionization efficiency (2).Their summation was used to calculate the total serum 25(OH)D levels.

All the serum samples were collected from a single laboratory. SRM 972a (The National Institute of Standards and Technology, NIST) which consists of four vials of level 1-4 frozen serum from healthy donors with different 25(OH)D concentrations, was used to estimate the accuracy. The concentrations of 25(OH)D2 and 25(OH)D3 in SRM 972a measured by our LC-APCI-MS/MS were 0.8±1.0% and 0.9±1.9% to the assigned values, respectively. The results satisfied the criteria for the LC-MS/MS performance threshold of the AOAC procedure for 25OH vitamin D standardization/validation (VDSP) (3). The coefficients of variation (CV) of intra- and inter-assay for Total 25(OH)D level in this study were 1.5- 8.3% and 4.6%.

References

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4. ***Estimation of the cumulative ambient UV-B irradiation***

The ultraviolet-B (UV-B) radiation flux density was calculated using a radiative-transfer code called ‘Simple Model of the Atmospheric Radiative Transfer of Sunshine, version 2 (SMARTS2)’ developed by Gueymard to calculate the flux density of solar radiation on the ground surface E(λ) for wavelengths between 280 and 4,000 nm (1). Based on this, we estimated the cumulative ambient UV-B irradiation from 1 month to 1 d before the blood was drawn.

In particular, for wavelengths from 280 to 1,700 nm, calculations can be made at 1 nm intervals. UV spectrum of wavelength *λ* at the horizontal plane surface is expressed as follows;

$$E\left(λ\right)=E\_{bn}\left(λ\right)\cos(θ\_{z})+I\_{d}(λ)$$

where

*E* (*λ*): UV flux density of the wavelength, *λ*,

*Ebn* (*λ*): UV spectrum of the direct component of solar radiation,

*θz*: solar zenith angle,

*Id* (*λ*): UV spectrum of the diffusive component of solar radiation.

 This equation allows us to calculate the UV spectrum Ebn (λ) and Id (λ) at the ground surface for a given season, time, and location under a cloudless sky. We applied this calculation to the sites where the subjects were recruited at each participating university or college. The UV flux reaching the top of the atmosphere from the sun was corrected for the distance between the earth and sun for each day of the year. The total ozone at each site is given by measurements from NASA’s OM (2) and OMPS (3) satellites that regularly report ozone total column data. The optical thickness of aerosols was observed under a cloudless sky at the Tsukuba station, Japan Meteorological Agency, using a sun-photometer that split the direct solar radiation into 368, 500, 675, 778, and 862 nm, yielding the Ångström parameters α and β. The aerosol data for Tsukuba were used when there were no data available for aerosols at the study sites. Rayleigh scattering is related to the number of air molecules that can generate atmospheric pressure. UV spectra have been observed by the Japan Meteorological Agency, every hour daily with Brewer spectra available for every 0.5 nm interval (4).

References

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