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Vitamin D status and dietary intake in young university students in the UK

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1 Abstract

2 Purpose

3 Vitamin D deficiency is prevalent worldwide. This cross-sectional study aimed to
4 investigate the vitamin D status and dietary intake in young university students.

5 Design/methodology/approach

6 Forty-one healthy students aged 18-29 years from Coventry University UK were
7 recruited during January-February 2019, including white Caucasians (n=18),
8 African-Caribbeans (n=14) and Asians (n=9). Plasma 25(OH)D concentrations
9 were measured, and dietary vitamin D intake was determined. Chi-square and
10 simple linear regression were used to analyse the data.

11 Findings

12 The plasma 25(OH)D concentrations were (36.0 ± 22.2) nmol/L in all subjects,
13 (46.5 ± 25.3) nmol/L in white Caucasians, (22.6 ± 7.4) nmol/L in African-
14 Caribbeans and (37.4 ± 21.7 nmol/L) in Asians. The majority (85.7 %) of
15 African-Caribbeans were vitamin D deficient compared with 22.2 % of white
16 Caucasians and 33.3 % of Asians (P=0.001). Overweight/obese subjects
17 showed a significant higher proportion of vitamin D deficiency (65 %) than
18 normal weight subjects (28.6 %) (P=0.04). The average dietary vitamin D intake
19 in all subjects was (4.6 ± 3.9) µg/day. Only 12.1 % of the subjects met the
20 recommended dietary vitamin D intake of 10µg/day. Dietary vitamin D intake
21 (P=0.04) and ethnicity (P=0.01) were significant predictors of 25(OH)D levels
22 and accounted for 13 % and 18.5 % of 25(OH)D variance respectively.

23 **Research limitations/implications**

24 This small-scale study showed an alarmingly high prevalence of vitamin D
25 deficiency amongst subjects from African-Caribbean origin during wintertime.
26 Education programs and campaigns are urgently needed to fight the vitamin D
27 deficiency in this population.

28 **Originality**

29 The targetted population were in a critical period of transition from adolescence
30 toward adulthood involving changes in behaviours and nutrition.

31 **Keywords**

32 ethnicity, vitamin D status, vitamin D deficiency, dietary vitamin D intake, young
33 adults

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42 Introduction

43 Vitamin D, a fat-soluble pre-hormone, is a unique essential nutrient with limited
44 natural food sources mostly of animal origin such as oily fish, red meat and egg
45 yolk. Most vitamin D (80-90%) is produced in the skin in response to ultraviolet
46 B (UVB) radiation from the sun (Wacker and Holick, 2013). Apart from its
47 classical role of promoting calcium absorption in the gut, vitamin D also plays
48 important roles in the modulation of cell growth, neuromuscular and immune
49 function, and anti-inflammation (Nair and Maseeh, 2012). Vitamin D deficiency
50 is prevalent worldwide reported as 9.9 % in the US (Ganji *et al.*, 2012), 7.4 % in
51 Canada (Sarafin *et al.*, 2015), 4.6 % to 30.7% in Western Europe (Lips *et al.*,
52 2019) (vitamin D deficiency was defined as serum 25(OH)D < 30 nmol/L), and
53 18.8 % in the UK (vitamin D deficiency was defined as serum 25(OH)D
54 concentration < 25 nmol/L) (Sutherland *et al.*, 2021). Reasons for vitamin D
55 deficiency include personal, social and cultural factors influencing sun exposure
56 and dietary intake, skin pigmentation, and the genetics of vitamin D metabolism
57 (Patel *et al.*, 2013; Gallagher *et al.*, 2014). Evidence shows vitamin D deficiency
58 is significantly associated with increased risks to musculoskeletal disease such
59 as osteomalacia (Minisola *et al.*, 2021), and non-musculoskeletal health
60 outcomes such as cardiovascular disease (CVD) and diabetes (Ganji *et al.*,
61 2020a), breast cancer (Estébanez *et al.*, 2018), mortality from respiratory
62 diseases (Brenner *et al.*, 2020) and reduced lung functions (Ganji *et al.*, 2020b).
63 Serum 25(OH)D levels increase in summer and decrease in winter due to
64 dependency of vitamin D on sunlight (Klingberg *et al.*, 2015). People with dark
65 skin colour have reduced cutaneous vitamin D biosynthesis, primarily due to

66 increased skin pigmentation that absorbs sun's UVB (Webb *et al.*, 2018). It has
67 also been demonstrated that serum 25(OH)D levels depend on latitude where
68 less cutaneous vitamin D is synthesised at higher latitudes (Nikooyeh *et al.*,
69 2017). In the UK serum 25(OH)D concentration falls by around 50 % through
70 winter due to the seasonal variation and high latitude (55.3781° N, 3.4360° W)
71 (Hypponen and Power, 2007). Although the worldwide prevalence of vitamin D
72 deficiency is well known, few studies have focused on young university
73 students. An American study (Tangpricha *et al.*, 2002) found that vitamin D
74 deficiency was significantly more prevalent in young adults (aged 18-25 years
75 old, most were university students) than other older adult groups in winter. A
76 recent Australian study showed similar results that more young adults (aged
77 18–24 years) were vitamin D deficient than adults aged ≥ 25 years due to low
78 dietary vitamin D intake, being overweight and low physical activity (Horton-
79 French *et al.*, 2021). The transition from adolescence toward adulthood is a
80 critical period regarding changes in health behaviours (Desbouys *et al.*, 2019).
81 Early adulthood is associated with poor diet due to an age of transition,
82 including environmental, social and lifestyle changes (Winpenny *et al.*, 2018).
83 Moreover, the peak bone mass is achieved in the early 20s and vitamin D is an
84 important nutrient for bone health (Gordon *et al.*, 2016).

85 The aim of the study was to examine the vitamin D status and dietary vitamin D
86 intake during the winter in a sample of university students of white Caucasian,
87 African-Caribbean and Asian origin.

88 **Methods**

89 This was a cross-sectional study carried out during January and February 2019
90 in Coventry, UK (latitude 52.4068° N, 1.5197° W). The study was approved by
91 the Coventry University Ethics Committee (Ref P79982). All subjects gave their
92 written consent before participating the study.

93 *Subjects*

94 The study recruited Coventry University students, 18-29 years old, white
95 Caucasians (CA), Black/African/African-Caribbean origin (collectively presented
96 as AC), and Asians in self-reported good health. Exclusion criteria were taking
97 vitamin D supplementation at a dose of more than 10 µg/day, liver or kidney
98 disease, digestive system disease, diabetes, cancer, autoimmune disease,
99 regular smokers (one or more cigarettes per day), alcohol consumption more
100 than 14 units per day, travelling to a sunny region for holidays in the past 3
101 months. The exclusion criteria were set up to avoid potential influences of
102 certain diseases and unhealthy lifestyles on vitamin D status (Tsiaras and
103 Weinstock, 2011). A health and lifestyle questionnaire was used to screen the
104 eligibility of the subjects. Eligible subjects were scheduled a visit to the Health
105 and Life Sciences building of Coventry University. The body weight was
106 measured without coats, shoes, and personal possessions (keys, mobile,
107 watch, belt etc.) using weighing scales. The height was measured using a
108 stadiometer. Body mass index (BMI) was calculated by body weight (kilogram)
109 divided by square of height (meter). A blood sample and a food diary were
110 collected for measures of the plasma 25(OH)D concentration and dietary
111 vitamin D intake.

112 *Plasma 25(OH)D measurement*

113 A 2 ml blood sample was collected via phlebotomy into EDTA-treated tubes
114 (Bunzl PLC, London). Plasma was separated by centrifuging for 15 minutes at
115 1500 x g, at 2-8°C and then stored in -20°C until analysis. Vitamin D status was
116 evaluated by the measurement of plasma 25(OH)D concentrations using Tosoh
117 AIA-900 immunoassay analyser (Tosoh Bioscience, USA) following the
118 manufacturers instruction. The Tosoh ST AIA-PACK 25(OH)D assay correlates
119 well with gold standard methods (Liquid chromatography–mass spectrometry,
120 LC-MS), measures 25(OH)D₂ and 25(OH)D₃ in equimolar proportions and
121 aligns to the reference measurement procedure used in the Vitamin D
122 standardization program (VDSP) (TOSOH Bioscience, 2020). The quality
123 control was in place to verify that the result obtained was within the range of
124 expected values. Assay range of 25(OH)D was between 10 to 300 nmol/L.

125 *Dietary vitamin D intake analysis*

126 Subjects were asked to record a 3-day (consecutive days, including a weekend
127 day) estimated food diary. Food recording with a minimum of three days is
128 regarded as a gold standard method to assess nutrient intake (Ortega *et al.*,
129 2015). A template food diary with an example and guidance was provided to
130 subjects. Completed food diaries were collected via email or hard copy and
131 dietary vitamin D intake was analysed using the nutrition analytical software
132 Nutritics (Nutritics LTD, Dublin). Food diaries that were incomplete or with an
133 energy intake ≤ 1000 kcal/day or ≥ 4000 kcal/day were excluded. This was to
134 address the issue of implausible energy intake that might indicate inaccuracy in

135 the food record (Banna *et al.*, 2017). In this study none of the food diaries
136 collected were excluded.

137 *Statistical analysis*

138 Continuous variables were presented as mean \pm SD including plasma 25(OH)D
139 concentration, dietary vitamin D intake, age and BMI. Categorical variables
140 were presented as percentage (%) e.g. % of vitamin D deficiency. Vitamin D
141 status was categorised based on the plasma 25(OH)D concentration as
142 deficient (< 30 nmol/L), insufficient (30 - 50 nmol/L), sufficient (> 50 nmol/L),
143 according to guidelines by the Institute of Medicine (IOM) (IOM, 2011) and
144 optimal or desirable (\geq 75 nmol/L) (Zittermann *et al.*, 2012). Body weight was
145 classified based on BMI as underweight (BMI < 18.5 kg/m²), normal weight (BMI
146 18.5 - 24.9 kg/m²) and overweight/obese (BMI \geq 25 kg/m²) (NICE, 2014).
147 Statistical analysis was performed using SPSS software (version 26). Difference
148 in frequency (percentage) between groups were tested by Pearson Chi-Square.
149 A simple linear regression was conducted to investigate the contribution of each
150 of the independent variables including dietary vitamin D intake, BMI, age,
151 gender, and ethnicity to the variance of plasma 25(OH)D concentration
152 (dependent variable). Categorical variables (gender and ethnicity) were recoded
153 to create dummy variables with male and CA as the reference category
154 respectively against which all other groups were compared. The statistically
155 significant level was set up at $P \leq 0.05$ with two-tail. All continuous variables were
156 normally distributed tested by Kolmogorov-Smirnov method.

157 **Results**

158 *Subject characteristics*

159 Forty-four subjects were screened for the study, among which three were
160 excluded due to travel to sunny places during the Christmas holiday (n=2) or
161 taking vitamin D supplement at a dose of more than 10 µg/day (n=1). Therefore,
162 a total of 41 subjects participated in the study. Apart from one participant in the
163 CA group who took Omega-3 capsules, none of the other eligible participants
164 took any dietary supplements.

165 Table I shows the descriptive characteristics of the subjects. The mean age was
166 22 y, and mean BMI was 25 kg/m² for all subjects. There was a similar number
167 in gender with 21 females and 20 males. Regarding ethnic groups, 44 %
168 (n=18) were CAs, 34 % (n=14) were ACs and 22 % (n=9) were Asians (2
169 Indians, 3 Pakistani, 3 Arabians and one Chinese). The range of BMI was 19.1-
170 41.4 kg/m². Fifty-one percent (n=21) of the subjects were normal weight, while
171 49% (n=20) were either overweight (n=16) or obese (n=4) (Table I).

172 [insert Table I here]

173 *Plasma 25(OH)D levels and vitamin D status*

174 Table II shows the plasma 25(OH)D levels and vitamin D status in different
175 groups. The average plasma 25(OH)D in all subjects (n=41) was (36.0 ± 22.2)
176 nmol/L, ranging between 11.0 -128.6 nmol/L. The average plasma 25(OH)D
177 concentrations were (22.6 ± 7.4) nmol/L in ACs (n=14), (46.5 ± 25.3) nmol/L in
178 CAs (n=18) and (37.4 ± 21.7) nmol/L in Asians (n=9). Forty-six percent of all
179 subjects were vitamin D deficient, while 31.7 % were insufficient, and only 22 %

180 were sufficient. Only two subjects (4.9 %, one from the CA and one from the
181 Asian group) achieved the optimal level of plasma 25(OH)D at 75 nmol/L (128.6
182 nmol/L and 88.7 nmol/L respectively). There was a significant difference in
183 **vitamin D** status in ethnic groups ($P=0.001$). Eighty-six percent of AC subjects
184 were **vitamin D** deficient compared with 22.2 % in CAs, and 33.3 % in Asians.
185 None of ACs was **vitamin D** sufficient compared with 44.4 % in CAs and 11.1 %
186 in Asians. There was no significant difference in **vitamin D** status between
187 genders ($P=0.47$), but there was a significant difference in **vitamin D** status
188 between body weight categories ($P=0.04$). Sixty-five percent of the
189 overweight/obese subjects were **vitamin D** deficient compared with 28.6 % in
190 normal weight, while 15 % of the overweight/obese subjects were insufficient
191 compared with 47.6 % in normal weight. The sufficiency proportion was similar
192 between normal weight and overweight/obese subjects (23.8 % vs 20 %).

193 *[insert Table II here]*

194 *Dietary **vitamin D** intake adequacy compared with the government*
195 *recommendation*

196 The results of the dietary **vitamin D** intake were based on 33 subjects who
197 returned their food diaries, 16 CAs, 9 ACs and 8 Asians. **The average dietary**
198 **vitamin D intake was 4.6 µg/day in all subjects, 6.3 µg/day in CAs and 3.1**
199 **µg/day in both ACs and Asians (Table III).**

200 The current UK government recommendation of dietary **vitamin D** intake is 10
201 µg/day for adults and children over the age of one (SACN, 2016). Data in Table
202 III shows that only 12.1 % of all subjects met the recommendation, and all of

203 them were CA (3 males and one female), while none in the AC or Asian groups
204 met the recommendation. However, there was no significant difference in
205 dietary vitamin D intake adequacy between ethnicities, genders and body
206 weight categories (Table III).

207 *[insert Table III here]*

208 *Linear regression analysis*

209 Table IV shows the simple linear regression models of the different independent
210 variables and the dependent viable, plasma 25(OH)D. It was found that dietary
211 vitamin D intake ($P=0.04$) and ethnicity ($P=0.01$) were significant predictors of
212 25(OH)D, which accounted for 13 % and 18.5 % of 25(OH)D variance
213 respectively. An increase of 1 μg dietary vitamin D intake was associated with
214 an increase in plasma 25(OH)D of approximately 2.2 nmol/L. ACs had a
215 significant reduction of 23.9 nmol/L in the mean of 25(OH)D concentration
216 compared with CAs ($P=0.002$). No significant reduction of 25(OH)D was seen
217 for Asians compared with CAs in this model ($P=0.28$). Age, gender and BMI
218 were not significant predictors of 25(OH)D variance in the analysis.

219 *[insert Table IV here]*

220 **Discussion**

221 This study had a target population of university students in the UK from three
222 ethnic origins: CA, AC and Asian. Their vitamin D status was measured, and
223 their dietary vitamin D intake was evaluated during the wintertime. Vitamin D
224 deficiency was prevalent in this population (46.3 %), with only 4.9 % of the

225 subjects having the optimal level of plasma 25(OH)D (≥ 75 nmol/L). An
226 alarmingly high proportion (85.7 %) of vitamin D deficiency and extremely low
227 average plasma 25(OH)D at 22.6 nmol/L was observed in AC subjects. In
228 addition, overweight/obese subjects had a significant higher prevalence of
229 vitamin D deficiency (65 %) than normal weight subjects (28.6 %). Of the
230 independent variables considered: age, gender, BMI, dietary vitamin D intake
231 and ethnicity, the simple linear regression analysis indicated that only dietary
232 vitamin D intake and ethnicity were significant predictors of plasma 25(OH)D
233 levels.

234 An American study found that African Americans had a significantly lower
235 serum 25(OH)D concentration at 29 nmol/L than CAs at 36.4 nmol/L (Gallagher
236 *et al.*, 2014), while similar results were found in the UK showing that the
237 geometric mean of serum 25(OH)D concentration was much lower in black
238 (30.3 nmol/L) and Asian (mainly South Asian) (24.3 nmol/L) than in white adults
239 (44.9 nmol/L) (Sutherland *et al.*, 2021). Vitamin D deficiency (defined as serum
240 25(OH)D concentration < 30 nmol/L) was 76.2 % in South Asian vs. 54.7 % in
241 black African-Caribbeans in the UK (Patel *et al.*, 2012). Another recent study
242 showed 50 % of South Asians and 33 % of black African-Caribbeans
243 demonstrated vitamin D deficiency (defined as serum 25(OH)D concentration $<$
244 25 nmol/L) compared with around 17.5% in white Caucasians (Sutherland *et al.*,
245 2021). The current study found that the scale of vitamin D deficiency in
246 university students is much worse than reported in the previous studies,
247 demonstrated by 86 % of AC being vitamin D deficient (defined as 25(OH)D $<$
248 30 nmol/L, or 64.3 % if vitamin D deficiency is defined as 25(OH)D < 25 nmol/L)

249 compared with 22 % in CAs and 33 % in Asians. This may be due to the fact
250 that the current study was conducted in winter when vitamin D deficiency is
251 greatest, and in university students who have previously been shown to have a
252 greater prevalence of vitamin D deficiency than other adult groups (Tangpricha
253 *et al.*, 2002). Previous studies consistently showed that South Asians had
254 higher incidence of vitamin D deficiency than black people in the UK, although
255 they have a paler skin tone (Lin *et al.*, 2021, Patel *et al.*, 2012, Sutherland *et al.*,
256 2021). This might be due to poor dietary intake of vitamin D (many South
257 Asians in the UK follow a vegetarian diet), cultural needs to cover the body
258 amongst many South Asian women, and sun avoidance common to both male
259 and female South Asian adults (Lowe & Bhojani, 2017), indicating the
260 importance of sociocultural factors in determining vitamin D status. The Asian
261 group in the current study included five subjects (55.6%) of South Asian origin
262 and showed a lower vitamin D deficiency rate (33.3%) than AC subjects (85.7
263 %). It is thus inappropriate to compare our results with other studies on South
264 Asians alone. In addition, among all subjects that were approached, only one
265 from AC origin took vitamin D supplement (this subject was excluded from the
266 study) and only 12.1 % (n=4 out of 33) of the subjects met the dietary intake of
267 10 µg/day vitamin D recommended by the government, all of whom were from
268 CA group. During recruitment, subjects were asked about their vitamin D
269 awareness (not documented), the majority of the subjects had never heard of
270 vitamin D and did not know the UK government recommendation of dietary
271 vitamin D intake (10 µg/day). The poor awareness or practice of the government
272 recommendation of vitamin D intake in the young university students is of

273 particular concern especially considering the limited sunlight availability in the
274 UK winter. Education programs or public awareness campaigns aiming to
275 improve the **vitamin D** awareness and intake particularly in populations of AC
276 and Asian origin, are urgently needed in the UK.

277 There is evidence to support daily sunlight exposure between April and
278 September of 10-15 minutes for people with lighter skin types, but 25-40
279 minutes for dark skin (brown) is required to provide sufficient year-round **vitamin**
280 **D** (Webb *et al.*, 2018). The recommended dietary intake recommendation is 10
281 $\mu\text{g}/\text{day}$ of **vitamin D** from the diet or supplement in the UK for people above one
282 year old regardless of age and ethnicity (SACN, 2016). **The current study**
283 **showed dietary vitamin D intake was a significant predictor to the 25(OH)D**
284 **variance, and an increase of 1 μg dietary vitamin D intake led to a rise of 2.2**
285 **nmol/L of plasma 25(OH)D**, indicating the importance of dietary **vitamin D** intake
286 in the wintertime. **Due to the reduced sunlight exposure and limited dietary**
287 **sources of vitamin D, vitamin D supplementation would be key to prevent**
288 **vitamin D deficiency during the wintertime in the UK.** However, it is questionable
289 whether AC or Asian people could achieve comparable levels of plasma
290 25(OH)D to CAs from the same recommended dietary **vitamin D** intake or same
291 dose of **vitamin D** supplementation. For example, 10 $\mu\text{g}/\text{day}$ of vitamin D from
292 the diet or supplementation would raise 25(OH)D concentration by only 22
293 nmol/L **based on our model, or by only 10 nmol/L based on the Holick formula**
294 **of 2.5 μg dietary vitamin D raising 25(OH)D concentration by 2.5 nmol/L (Holick,**
295 **2008)**, which is insufficient for ACs or Asians to achieve the comparable level as
296 CAs, let alone to achieve 75 nmol/L **which is regarded as optimal for non-**

297 skeletal health outcomes (Ganji *et al.* 2020a; Zittermann *et al.*, 2012).
298 Therefore, further research is needed to investigate whether higher dietary
299 vitamin D recommendation is required for the AC and South Asian ethnic
300 groups in the UK.

301 The recent UK National Diet and Nutrition Survey (NDNS) report showed an
302 average dietary vitamin D intake of 2.7 µg/day in the UK adults (19-64 y) (PHE,
303 2018), similar to that in AC and Asians at 3.1 µg/day in the current study.
304 However, CA subjects showed a much higher dietary intake at 6.3 µg/day,
305 among which 4 out of 16 had a dietary vitamin D intake more than 10 µg/day.
306 The food diaries showed that the high dietary vitamin D intake was mainly from
307 salmon, fortified breakfast cereal, canned tuna, and eggs.

308 Though the simple linear regression did not indicate a significant contribution of
309 BMI to 25(OH)D variance, our results show that overweight/obese subjects had
310 a significantly higher prevalence of vitamin D deficiency (65 %) than normal
311 weight subjects (29 %), which supports the observation that obesity has been
312 associated with lower 25(OH)D concentrations (Rafiq and Jeppesen, 2018).
313 Volumetric dilution is the most accepted explanation (Duan *et al.*, 2020), while
314 vitamin D, being fat soluble, can also be stored in cutaneous and visceral
315 adipose tissues, resulting in lower plasma vitamin D levels in overweight and
316 obese individuals (Duan *et al.*, 2020). It is still unclear whether vitamin D
317 deficiency is a cause or an outcome of obesity, and it may be a complex of
318 mutual influence because vitamin D receptors are expressed on adipose cells
319 and have a role in the function of those cells (Vranić *et al.*, 2019).

320 Although observational studies have shown no association of poor vitamin D
321 status with elevated incidence of osteoporosis in South Asian adults in the UK
322 (Lowe *et al.*, 2010) and in Black Americans (Aloia *et al.*, 2000), levels of
323 25(OH)D less than 30 nmol/L render a greater risk for osteomalacia or rickets
324 (Brown *et al.*, 2018). Apart from bone health, lower serum 25(OH)D levels are
325 associated with a 1.77-fold higher risk of Type 2 Diabetes Mellitus
326 (Tabatabaeizadeh & Tafazoli, 2021) and increased the risk of CVD by 44 % and
327 CVD mortality by 54 % (Gholami, *et al.* 2019). Recent data indicated that people
328 of AC and South Asian origin had a 2-fold and 2.4-fold higher mortality rate
329 respectively from COVID-19 compared with white CAs (CDC, 2021), and
330 vitamin D deficiency was significantly associated with COVID-19 severity and
331 mortality (Campi *et al.*, 2021) and longer recovery time from COVID-19 (Al-
332 Salman *et al.*, 2021). Currently, the role of vitamin D supplementation, and the
333 optimal vitamin D dose and status, are subjects of debate, because large
334 interventional studies have been unable to consistently show a clear benefit of
335 vitamin D supplementation (Amrein *et al.*, 2020), however very few such studies
336 have been conducted in minority populations in the UK.

337 The key limitation of the current study is the small sample size; however, the
338 results provided a glimpse of the vitamin D status in a specific population of
339 university students in the UK (Coventry University). Education programs or
340 campaigns are urgently needed to promote the awareness of vitamin D
341 deficiency and encourage the use of vitamin D supplements in young university
342 adults during the wintertime. It is worth investigating a revision of dietary
343 recommendation of vitamin D intake to ACs in the UK to reduce the vitamin D

344 deficiency prevalence observed. [Future large-scale studies to investigate the](#)
345 [vitamin D status and its health implications in the university students are](#)
346 [warranted.](#)

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351 **Authors' contributions**

352 HD, VA, NM and MM designed the study. VA, NM and MM conducted the study.
353 HD took blood samples from subjects. HD and VA prepared the manuscript.

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357 **Data Availability**

358 The data of the study are available upon request to the corresponding author.

359 **Consent for publication**

360 All authors approved the submission of the manuscript and consented to the
361 publication of this manuscript.

362 **Declaration of conflicting interests**

363 The authors declared no potential conflicts of interest with respect to the
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Tables

Table I. Descriptive characteristics of study subjects

		Number (%)	Age (year)	BMI (kg/m ²)
Total subjects		41 (100 %)	22.0 ± 2.6	25.1 ± 4.4
Gender	Female	21 (51.2 %)	21.2 ± 2.3	24.9 ± 3.3
	Male	20 (48.8 %)	22.8 ± 2.7	25.4 ± 5.3
Ethnicity	CA	18 (43.9 %)	22.0 ± 2.6	24.2 ± 3.4
	AC	14 (34.1 %)	22.2 ± 2.5	25.7 ± 3.7
	Asian	9 (22.0 %)	21.6 ± 3.0	26.1 ± 6.8
Body weight	Normal weight	21 (51.2 %)	21.2 ± 2.0	21.8 ± 1.6
	Overweight/obese	20 (48.8 %)	22.8 ± 3.0	28.6 ± 3.5

Data are presented as mean ± SD; AC, African-Caribbean; BMI, body mass index; CA, Caucasian. Normal weight: body mass index (BMI) 18.5-24.9 kg/m²; Overweight/Obese: BMI ≥ 25 kg/m².

Table II. Plasma 25(OH)D concentrations and vitamin D status

Groups		Plasma 25(OH)D (nmol/L)	Vitamin D status (%)			P value*
			Deficient	Insufficient	Sufficient	
Total subjects		36.0 ± 22.2	46.3	31.7	22.0	
Ethnicity	CA	46.5 ± 25.3	22.2	33.3	44.4	0.001
	AC	22.6 ± 7.4	85.7	14.3	0.0	
	Asian	37.4 ± 21.7	33.3	55.6	11.1	
Gender	Female	31.6 ± 17.3	40.0	30.0	30.0	0.47
	Male	41.4 ± 26.2	52.4	33.3	14.3	
Body weight	Normal weight	38.4 ± 18.4	28.6	47.6	23.8	0.04
	Overweight/obese	34.1 ± 26.1	65.0	15.0	20.0	

Plasma 25(OH)D concentration was presented as mean ± SD. AC, African-Caribbean; CA, Caucasian. *Pearson Chi-Square for vitamin D status. Vitamin D deficiency: < 30 nmol/L; insufficiency: 30-50 nmol/L; sufficiency: > 50 nmol/L based on the plasma 25(OH)D concentration. Normal weight: body mass index (BMI) 18.5-24.9 kg/m²; Overweight/Obese: BMI ≥ 25 kg/m².

Table III. Dietary vitamin D intake and the percentage of subjects who met dietary vitamin D intake recommendation

	Groups	Dietary vitamin D intake ($\mu\text{g}/\text{day}$)	Adequate % (n)	Inadequate % (n)	<i>P</i> values*
	All subjects	4.6 \pm 3.9	12.1 % (4)	87.9 % (29)	
Ethnicity	CA	6.3 \pm 4.6	25.0 % (4)	75.0 % (12)	0.09
	AC	3.1 \pm 2.9	0	100 % (9)	
	Asian	3.1 \pm 2.0	0	100 % (8)	
Gender	Female	3.2 \pm 3.1	5.9 % (1)	94.1 % (16)	0.26
	Male	6.2 \pm 4.2	18.8 % (3)	81.2 % (13)	
Body weight	Normal weight	5.2 \pm 3.9	11.1 % (2)	88.9 % (16)	0.85
	Overweight/Obese	4.0 \pm 4.0	13.3 % (2)	86.7 % (13)	

Dietary vitamin D intake was presented as mean \pm SD. AC, African-Caribbean; CA, Caucasian; *Pearson Chi-Square for dietary vitamin D intake adequacy. Adequacy: dietary vitamin D intake $\geq 10 \mu\text{g}/\text{day}$; Inadequacy: dietary vitamin D intake $< 10 \mu\text{g}/\text{day}$. Normal weight: body mass index (BMI) 18.5-24.9 kg/m^2 ; Overweight/Obese: BMI $\geq 25 \text{kg}/\text{m}^2$.

Table IV. Simple linear regression analysis summary for plasma 25(OH)D concentration (dependent variable)

Independent variables (predictors)	Adjusted R ²	P value (ANOVA)	Constant	Unstandardized beta (B)	Standardized beta (β)	95 % CI for B
Dietary vitamin D intake	0.13	0.04	28.234	2.164	0.36	(0.109, 4.218)
BMI	0.003	0.72	43.852	-0.298	-0.059	(-1.944, 1.348)
Age	0	0.93	33.487	0.131	0.015	(-2.649, 2.911)
Gender	0.025	0.16	41.374	-9.794	-0.222	(-23.738, 4.150)
Ethnicity	0.185	0.01	46.497	AC -23.869, Asian -9.063	AC -0.513, Asian -0.170	AC (-38.423, -9.314) ¹ , Asian (-25.737, 7.612) ²

¹ Coefficient $P= 0.002$; ² Coefficient $P= 0.28$; AC, African-Caribbean; BMI, body mass index; CI, Confidence interval.