

## Ethnic variation in osteoporosis risk factors: dietary calcium, vitamin D intake and body mass index (BMI)

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### Abstract

Osteoporosis is the most common bone disease in humans, representing a major public health problem. Few studies have investigated osteoporosis risk factors such as calcium and vitamin D intake, quality of life and body mass index (BMI) among multi-ethnic adults in the Malaysian context. This study aimed to determine the ethnic variation in osteoporosis risk factors among students in Universiti Malaysia Terengganu (UMT). A cross-sectional study via a self-administrated questionnaire was carried out among 198 respondents aged 19 to 25 years from UMT. The data in the present study included a three-day food record and anthropometric measurements. Nutritionist Pro™ analysis software version 5.3 was used to calculate dietary calcium and vitamin D intake from the diet histories, based on the Nutrient Composition of Malaysian Food Database guidance for the dietary calcium intake and the United States Department of Agriculture (USDA) for vitamin D intake. The data were analyzed using Kruskal-Wallis, Mann-Whitney and Chi-Square tests. The findings indicate the median calcium intake was 348.3 mg/day while for vitamin D intake was only 1.37 µg/day. Indian participants had a significantly lower intake level of calcium (243.5 mg/day), followed by Chinese (362.3 mg/day) and Malays (440.4 mg/day). The median vitamin D intakes of Malay, Chinese, and Indian adults were 2.15 µg/day, 1.37 µg/day and 1.14 µg/day, respectively. Furthermore, the BMI among respondents at 20.88 (6.4) kg/m<sup>2</sup> categorized as normal weight. It was found that there was no significant difference ( $p > 0.05$ ) in BMI across ethnicity. Lastly, there was a significant association ( $p < 0.05$ ) between ethnicity and calcium intake ( $p = 0.001$ ).

## 1. Introduction

Osteoporosis is a major health problem worldwide, particularly in Asia. It is characterized by low bone mass, deterioration of bone tissue, disruption of bone microarchitecture or porous bone, which are associated with higher fracture risk (Kling *et al.*, 2014; Sozen *et al.*, 2017). This chronic progressive disease occurs in both men and women of all races and age groups. This disease generally does not become clinically apparent until a fracture occurs and thus it is described as a “silent thief” (Kamau, 2011).

It is important to recognize osteoporosis risk factors early in life and take appropriate action, as prevention may have an enormous positive impact on bone health in later years. Young people should focus on building the peak bone mass that will keep them in good stead for the rest of their lives (International Osteoporosis Foundation, 2017). Currently, more than one million Malaysians are at risk of developing osteoporosis. About 20% of men

and 51.8% of women suffer from osteoporosis near the age of menopause (Khan *et al.*, 2014). In contrast to childhood and postmenopausal or elderly subjects, diagnosis and treatment of osteoporosis in young adults remain poorly defined (Ferrari *et al.*, 2012). Hence, the risk factors of osteoporosis should be clearly determined in young adulthood. Family history of osteoporosis and fracture, tobacco consumption, dietary habits, sedentary lifestyle, cigarette smoking, alcohol abuse and caffeine consumption are common factors closely related to the occurrence of osteoporosis. Body mass index (BMI) also affects osteoporosis (Assomaning *et al.*, 2006).

Calcium and vitamin D are two essential nutrients long been recognized as important and required nutrients for their role in bone health and maintenance. Poor calcium and vitamin D status are detrimental to skeletal health (Hawa *et al.*, 2013). In Malaysia, several studies have reported that many individuals are not meeting the daily recommendation of calcium and vitamin D intake. Recommendations for calcium and vitamin D intake for

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adults have increased from 800 mg/day to 1000 mg/day and 5 µg/day to 15 µg/day, respectively, in the Recommended Nutrient Intake (RNI) 2017 guidelines [National Coordinating Committee on Food and Nutrition (NCCFN), 2017].

In recent years, knowledge about osteoporosis has increased exponentially. However, osteoporosis not only remains under-diagnosed and under-treated in Malaysia. Its prevalence is not well known or documented, other than from a 1997 study on hip fractures (International Osteoporosis Foundation, 2013). There is a lack of data on calcium and vitamin D status among the general population in Malaysia, as most studies have been limited to pockets of populations such as children and women (Rahman *et al.*, 2004; Chee *et al.*, 2010; Mahdy *et al.*, 2014; Zaleha *et al.*, 2015; Fong *et al.*, 2016). There is also a lack of studies on the multi-ethnic adult population on risk factors of osteoporosis in Malaysia. A previous study by Lau *et al.* (2001) reported the incidence of hip fracture was higher among Chinese women than Malays and Indian. Moreover, the Chinese also has the highest incidence of osteoporosis (Muslim *et al.*, 2011). However, a higher proportion of Indian and Malay respondents had lower vitamin D status as compared to their Chinese counterpart (Green *et al.*, 2008; Nurbazlin *et al.*, 2013; Shafinaz and Moy, 2016). Lack of study based on ethnicity on osteoporosis risk factors in Malaysia. For examples, Chee *et al.* (2010) focused on calcium intake, vitamin D and bone health among postmenopausal women in Kuala Lumpur. On the other hand, Hawa *et al.* (2013) performed a study among Malays women with low-income family in Kelantan. To date, limited study determined both calcium and vitamin D intake status among multi-ethnic. Madhy *et al.* (2014) investigated calcium intake among antenatal women; whereas Chee *et al.* (2002) on postmenopausal. For vitamin D, previous studies limited to among children (with epilepsy, aged between 3 and 18 years old), adolescents and women (postmenopausal aged 50 - 65 years old and pregnant women) (Rahman *et al.*, 2004; Zaleha *et al.*, 2015; Fong *et al.*, 2016). Therefore, the present study evaluates osteoporosis risk factors among multi-ethnic young adults overall. Ethnic variation in osteoporosis risk factors such as calcium and vitamin D intake and BMI among the study population can be determined.

## 2. Methodology

### 2.1 Research design

A cross-sectional study was carried out in Universiti Malaysia Terengganu. Samples were selected through convenience sampling between September to October 2017. Three different ethnic groups with equal

proportions were selected using quota sampling. Charan and Biswas (2013) were used for sample size calculation for confidence level of 95% and precision was assumed to be 0.5. Subject's inclusion criteria were young adults between 19 - 25 years old. A total of 198 adults with 66 Malays, 66 Chinese and 66 Indians were recruited. The present study was approved by the Research Management and Innovation Centre (RMIC) Human Ethics Committee, Universiti Malaysia Terengganu with the reference number of UMT/JKEPM/2017/6. Consent forms were signed and collected from all study participants.

### 2.2 Research instrument

A self-administered questionnaire was used as the research instrument in the present study. The two sections in the bilingual Malay and English questionnaire were used to obtain dietary intake and personal information. Part A consists of three-day food records. Amounts of focused micronutrients, namely calcium and vitamin D intake in each meal, were recorded in milligrams (mg) and microgram (µg), respectively. These values were added at the end of the three days period and compared with the RNI values. Part B was personal information including gender, race, age group, smoking status and family history of osteoporosis. Both a nominal scale and ordinal scale were used.

### 2.3 Data analysis

The data was analyzed using SPSS version 20. The Kolmogorov-Smirnov Test was used to determine the normality of the data. Descriptive tests were used to analyze the socio-demographic profiles, calcium and vitamin D intake and BMI of the respondents. Mann-Whitney U and Kruskal-Wallis Tests were used to compare the median of the osteoporosis risk factors among adults in terms of ethnicity. In addition, the Chi-square Test was used to determine the association of ethnicity with the dietary calcium and vitamin D intake, and BMI. In all analysis, the significant value was set at 0.05.

## 3. Results

### 3.1 Socio-demographics and clinical characteristics

A majority of respondents (84.8%) were female. As the present study aimed to investigate the ethnic difference in osteoporosis risk, the ethnic samples were equally distributed using quota sampling. Each ethnic group contributed 66 respondents (33.3%). All respondents were students ranging from 19 to 25 years of age. Among 198 respondents, only two respondents (1.0%) were smokers. Both reported smoking 1-5 cigarettes per day. Lastly, it was found that a majority

(93.9%) of the respondents did not have a family history of osteoporosis. The data is shown in Table 1.

### 3.2 Dietary intake among respondents

The daily median energy intake of respondents was 1292 kcal/day. The median percentage of total energy contributed by macronutrients was 48.9% for carbohydrates, 15.6% for protein, and 33.5% for fat using 3-day food record. The median calcium intake was 348.3 mg/day, representing less than half of the RNI (34.8%), while median vitamin D intake was only 1.37 µg/day (9.1% of RNI). (Table 2).

### 3.3 Body mass index

The present study found that median BMI among respondents was 20.88 kg/m<sup>2</sup>, considered as normal weight. Half of the respondents (50%) had normal body weight, while almost a quarter was either underweight or overweight and obese (Table 3).

### 3.4 Comparison of osteoporosis risk factors between ethnicities

Significant differences ( $p < 0.05$ ) in the macronutrients intakes were observed among ethnic groups. A lower intake of calories, carbohydrates, protein and fat were seen in the Indian respondents. Indian respondents also had significantly lower calcium intake than their Malay and Chinese counterparts and significantly lower vitamin D intake than Malay. It was found that there were no significant differences ( $p > 0.05$ ) in BMI across ethnicities, as shown in Table 4.

### 3.5 Associations between ethnicity and osteoporosis risk factors

There was a significant difference ( $p < 0.05$ ) between ethnicity and calcium intake ( $p = 0.000$ ), however, no significant difference ( $p > 0.05$ ) was found between ethnicity and dietary vitamin D intake as well as BMI of respondents, as shown in Table 5.

## 4. Discussion

In the present study, as compared to RNI, the calorie intake of respondents was low. This may be because more female students (84.8%) were involved. A previous study showed that male students had significantly higher energy intake than females (Abdull Hakim *et al.*, 2012; Abdul Majid *et al.*, 2016). As compared to the previous study by Zainuddin (2015), the present study shows a lower median energy and carbohydrate intake but higher fat intake among undergraduate respondents. Students may even skip meals or simply eat some biscuits. Thus, low-calorie intake may be due to students in UMT having limited food choices.

Previous studies found that the calcium intake of Malaysians averaged between 357 mg/day to 397.2 mg/day (Mirnalini *et al.*, 2008; Zainuddin, 2015; Suriawati *et al.*, 2016). Hence, 348.3 mg/day (34.8% RNI 2017) calcium intake by respondents in the present study was close to the average Malaysian adults' intake, which is consistently below the RNI. The findings of International Osteoporosis Foundation (IOF) research committee show that South, East, and Southeast Asia have the world's lowest average calcium intake, often less than 400 mg/day (Balk *et al.*, 2017). Although the calcium intake among respondents was low, it does not indicate that it will necessarily affect the serum calcium level. A previous study showed that even though the median calcium intake of respondents was only 371.9 mg/day, the calcium concentration in serum still can reach 98.8% at reference level. Nevertheless, it is suggested that 400 mg/day of dietary calcium is actually sufficient, instead of 800 mg/day according to RNI 2005 of calcium to maintain serum calcium concentrations at a normal level (Ang *et al.*, 2017). For vitamin D, 1.37 µg/day intake was not within the normal range for the recommended intake of Malaysian population and is far from RNI 2017. The results of the previous study among postmenopausal women, pregnant women as well as adolescent were in accordance with the present study with the majority of respondents fail to meet the RNI of Malaysia for dietary vitamin D (Rahman *et al.*, 2004; Zaleha *et al.*, 2015; Suriawati *et al.*, 2016). Therefore, interventions and stricter reinforcements of existing guidelines for vitamin D supplementation are needed in Malaysia, especially for groups at risk of vitamin D insufficiency or deficiency.

The lower intake of calorie, carbohydrate, protein and fat were seen in the Indian respondents. As shown in a study by Moy *et al.* (2009), Indian undergraduates were more likely to skip breakfast compared to their Chinese counterparts. The same habit can actually be observed from their three-day food record in the present study. Malays had significantly higher calorie and fat intake than Chinese and Indian. Differences in food availability, cultural preferences and socioeconomic factors also contribute to differences in dietary intake between ethnic groups within and between countries (Redmond *et al.*, 2014). From the result of three-day food record in the present study, most of the Chinese and Indian respondents cooked their own meals rather than eating out. Additionally, the frequency of fast-food consumption was also lower among Chinese and Indian respondents as compared to their Malay counterparts.

In terms of calcium and vitamin D intake, Indians had a significant lower calcium intake than Malays and Chinese, as well as significantly lower vitamin D intake

Table 1. Demographic characteristics of the respondents

Category	Number of respondents (n = 198)	Percentage (%)
<b>Gender</b>		
Male	30	15.2
Female	168	84.8
<b>Race</b>		
Malay	66	33.3
Chinese	66	33.3
Indian	66	33.3
<b>Age (Year)</b>		
19	9	4.5
20	68	34.3
21	28	14.1
22	48	24.2
23	38	19.2
24	2	1
25	5	2.5
<b>Highest education level</b>		
<PMR	0	0
SPM	6	3
STPM/ Matriculation	188	95
Diploma	0	0
Bachelor degree	0	0
Master or higher	1	0.5
Others	3	1.5
<b>Smoking status</b>		
Yes	2	1
No	196	99
<b>Family history of osteoporosis</b>		
Yes	12	6.1
No	186	93.9

Table 2. Dietary intake among respondents

Dietary intake	Median (IQR)	Total energy contribution (%)
Calorie intake (kcal/day)	1292 (546)	-
Carbohydrate intake (g/day)	158 (64)	48.9%
Protein intake (g/day)	51 (27)	15.6%
Fat intake (g/day)	48 (28)	33.5%
<b>Reference value</b>		
Calcium intake	348.3 (235.1) mg/day (25 <sup>th</sup> – 75 <sup>th</sup> percentile RNI)	RNI (Malaysia): 1000 mg/day RDA (US): 1000 mg/day
Vitamin D intake	1.37 (1.79) µg /day (<25 <sup>th</sup> percentile RNI)	RNI (Malaysia): 15 µg/day RDA (US): 15 µg/day

Table 3. BMI classification among respondents

Classification	Number of respondents (n=198)	Percentage (%)
Underweight	49	24.7
Normal BMI	99	50
Overweight and obese	50	25.3
Total	198	100

Table 4. Comparison of osteoporosis risk factors between ethnicity

Comparison	Median (Interquartile range)			Sig.
	Malay	Chinese	Indian	
<b>Dietary intake</b>				
Calorie intake	1537.07 (571.57) <sup>a</sup>	1308.10 (420.28) <sup>b</sup>	1009.78 (332.63) <sup>c</sup>	0.000*
Carbohydrate intake	194.04 (81.92) <sup>a</sup>	160.55 (56.18) <sup>a</sup>	134.20 (42.85) <sup>b</sup>	0.000*
Protein intake	64.31 (21.80) <sup>a</sup>	51.69 (24.35) <sup>a</sup>	38.98 (14.39) <sup>b</sup>	0.000*
Fat intake	62.14 (26.47) <sup>a</sup>	48.08 (25.74) <sup>b</sup>	35.38 (17.24) <sup>c</sup>	0.000*
Calcium intake (mg/day)	440.4 (250.37) <sup>a</sup>	362.3 (188.09) <sup>a</sup>	243.5 (125.72) <sup>b</sup>	0.000*
Vitamin D intake (µg/day)	2.15 (2.74) <sup>a</sup>	1.37 (1.15) <sup>ab</sup>	1.14 (1.00) <sup>b</sup>	0.004*
<b>BMI</b>	21.64 (7.37)	20.70 (5.20)	20.95 (5.46)	0.551

\*p<0.05 indicates significant difference by Kruskal-Wallis Test. Letters with superscript a, b and c indicate significant differences between ethnic groups by Mann-Whitney U test.

Table 5. Association between ethnicity with osteoporosis risk factors

Characteristics	Ethnicity						Pearson Chi-square	
	Malay		Chinese		Indian		$\chi^2$	p value
	n	%	n	%	n	%		
<b>Dietary intake</b>								
% calcium intake with reference to RNI							40.178	0.000*
<25%	5	7.6	12	18.2	34	51.5		
25-75%	54	81.8	46	69.7	32	48.5		
>75%	7	10.6	32	12.1	0	0		
% vitamin D intake with reference to RNI							5.184	0.075
<25%	49	74.2	57	86.4	58	87.9		
>25%	17	25.8	9	13.6	8	12.1		
<b>BMI</b>								
Underweight	17	25.8	17	25.8	15	22.7	6.374	0.383
Normal	30	45.5	34	51.5	35	53		
Overweight	9	13.6	11	16.7	13	19.7		
Obese	10	15.2	4	6.1	3	4.5		

\*p < 0.05 indicates significant association by Chi-Square Test. 0 cells (0.0%) have expected count less than 5.

than Malays. The low calcium intake of Indian respondents was mainly due to less calcium-rich food consumption such as milk, dairy products and also fish, as reported in their three days food record. Moreover, the survey found that consumption of fish among Malays was significantly higher compared with the Chinese and Indian ethnic groups (Ahmad *et al.*, 2016). Hence, based on supporting findings from the previous study, it can still be concluded that Indians might not consume an adequate amount of calcium and vitamin D compared with other major ethnicities in Malaysia. When the data of three-day food record was analyzed to determine food sources of vitamin D intake among respondents, the sources were found to be primarily sardine, bread, milk, egg, fried catfish or fried mackerel. So, the Indian respondents should increase consumption of foods high in calcium and vitamin D like sardine and milk, as well as vitamin D fortified foods such as yogurt and milk products. Nutrition information and nutrient claims should be observed before buying food products in the marketplace. They should try to choose products high in vitamin D or source of vitamin D claim.

The present study found a significant association (p< 0.05) between ethnicity and calcium intake of respondents. These results are supported by studies by Newby *et al.* (2012) and Raouf (2013). A possible explanation is that dietary intake patterns depend on religion, cultural context and social milieu (Mullin *et al.*, 2014). However, no significant association was found between ethnicity and vitamin D intake. Thus, even though Table 4 shows that significant ethnic differences in vitamin D intake (p< 0.05), these differences actually without association with their ethnicity. A previous study found that fish consumption patterns were significantly associated with ethnicity (Ahmad *et al.*, 2016). Therefore, the differences in vitamin D intake among respondents might be due to the difference in fish consumption pattern. There are also some other factors that will affect the vitamin D intake among the ethnic groups. For example, vitamin D intake was associated with dietary patterns. High consumption levels of milk, dairy products, whole grains, and fish are associated with higher consumption of vitamin D (Denova-Gutiérrez *et al.*, 2016).

The findings of the Malaysian Adult Nutrition Survey (MANS) reported that BMI among Malaysian adult was 24.37 kg/m<sup>2</sup> with 38.9% were obese or overweight (Azmi *et al.*, 2009). Similar to the results in the present study, a majority of the respondents had normal BMI, but the percentage of overweight or obese was lower than previous studies.

Medians of BMI were not significantly different among ethnics. The similar result was obtained from a research in Singapore reported that differences in BMI among three ethnic groups were not statistically significant (Hong *et al.*, 2004). However, a study by Seo and Torabi (2006) found a significant difference in the mean BMI of different ethnic groups. The ethnic groups involved were Hispanics, non-Hispanic whites and non-Hispanic blacks. Another study also stated that significant racial or ethnic differences were found in both measured and self-reported BMIs. In the study, the ethnic group involved were White, Black, Hispanic, Asian and Native American (Richmond *et al.*, 2015). The discrepancies found in the previous study compared with the present respondents are probably due to the characteristics of respondents. When compared with the obesity rates in the WHO report, the overall obesity rate for Malaysian adults aged 18-59 years was below those for the developed and industrialized countries, particularly the United States (Azmi *et al.*, 2009).

Associations between ethnicity and BMI have not been as widely studied, but several studies have compared health and religiosity. Previous studies have shown that religion has been associated with health behaviors included eating habits and physical activity as well as obesity in the African American population (Dodor, 2012). From this, we can predict that there should be an association between ethnicity and BMI, suggesting the importance of studying associations between religious life and BMI.

New imaging technologies have determined ethnic differences in terms of bone geometry, volumetric density, microarchitecture, and bone strength which may contribute to a better understanding of ethnic differences in fracture risk. Factors associated with ethnicity also affect BMD and fracture risk through direct and indirect mechanisms (Leslie, 2012). Thus, dietary calcium intake associated with ethnicity and will most probably affect BMD and risk of osteoporosis or fracture among young adults.

## 5. Conclusion

This study shows that calcium and vitamin D intake of young adults was only 34.8% and 9.1% of RNI, respectively. The addition of vitamin D in the Malaysian

Food Composition Database should be emphasized to encourage more local research on dietary intake of vitamin, D due to the low intake level and low fulfillment of latest RNI among Malaysians. There were significant differences between ethnicity and dietary intake. Indians had significantly lower macronutrients and calcium intake than Malays and Chinese. Thus, Indian students have a relatively high risk of osteoporosis, as they tend to eat fewer calcium-rich foods than their Malay and Chinese counterparts. In theory, this factor should increase the risk of developing osteoporosis.

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