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EVALUATION OF DIETARY INTAKE AND QUALITY OF LIFE ON RISK OF OSTEOPOROSIS AMONG ADULTS IN UNIVERSITI MALAYSIA TERENGGANU

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ABSTRACT

The present study aimed to evaluate the link between dietary intake and quality of life on risk of osteoporosis among adults in Universiti Malaysia Terengganu. This study involved 73 respondents (61.6% students and 38.4% staff) aged 19 to 50 years old. The median BMI among respondents was 23.6 (6.08) kg/m^2, categorized as normal weight. 58% of respondents had normal body weight, while 35.6% respondents were overweight/obese and 6.1% were underweight. Result revealed that serum calcium and phosphorus of respondents were 8.4 (0.65) mg/dL and 3.0 (0.70) mg/dL, respectively. Even though the median calcium intake of respondents was only 46.5% RNI (371.9 mg/day), the calcium concentration in serum achieved 98.8% at reference level. Moreover, 129.2% of phosphorus RDA intake (904.6 mg/day) resulted in 70% of respondents with serum phosphorus at reference level. A majority of calcium and phosphorus rich foods had low frequency consumption score among respondents. BMI and body fat percentage shows no relationship with serum calcium but have a weak reverse relationship with serum phosphorus (ρ: -0.215, p=0.07; ρ: -0.247, p=0.04). Additionally, Physical Health Composite Scale Score (PCS) and Mental Health Composite Scale Score (MCS) of respondents (53.86 (10.00); 52.42±7.44) were average and had a weak relationship with serum calcium (ρ: 0.237, p=0.04) but no relationship with serum phosphorus. Lastly, there was gender difference in terms of association between body fat percentage, BMI, quality of life, phosphorus intake and serum calcium and phosphorus.

Key words: Dietary intake, quality of life, BMI, serum calcium, serum phosphorus

INTRODUCTION

According to the National Institute of Arthritis and Musculoskeletal and Skin Disease (Nundy, 2010), osteoporosis is a disease marked by reduced bone strength causing an increased risk of fractures, or broken bones. More than one million Malaysians are at risk of developing osteoporosis, of which 20% are men. 51.8% of women suffer from osteoporosis near the age of menopause (Khan *et al.*, 2014). A common risk factor of osteoporosis is dietary intake. Moreover, Asomaning *et al.* (2006) also found that women aged 50-84 years with a low Body Mass Index (BMI) are at increased risk of osteoporosis. Health-related quality of life indicators such as physical, emotional, and psychological incapacity have been considered as an important marker of osteoporosis (Madureira *et al.*, 2012). Based on the Malaysian Adult Nutrition Survey (MANS), the median calcium intake among Malaysian adults was 357 mg/day (Zainuddin, 2015) and mean calcium intake was only 413 mg/day (Mirnalini *et al.*, 2008). Serum calcium among 44 healthy sedentary women aged 25 to 40 years in Malaysia was 9.28 ± 0.09 mg/dL (Rahim *et al.*, 2016). Serum calcium and phosphorus levels in 136 premenopausal women with a mean age of 41 in Malaysia were 9.12 mg/dL and 3.44 mg/dL, respectively (Kruger *et al.*, 2015). These data show that serum calcium and phosphorus among Malaysian lay within a healthy range. Therefore, more research should be done to verify the need of increasing calcium (in RNI) to 800 mg/day by studying the relationship between calcium intake and serum calcium level. Furthermore, factors affecting serum calcium and phosphorus can be determined from the present study. Other possible determinants such as quality of life have also been considered. Results from this

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study can serve as guidelines in preventing osteoporosis. In many cases, osteoporosis can be prevented. Healthcare financing system due to osteoporosis incidence of the country can be lowered. The present study aims to evaluate the relationship between dietary intake and quality of life in terms of risk of osteoporosis among adults in UMT.

MATERIAL AND METHODS

This study was conducted at Universiti Malaysia Terengganu (UMT). The research design included in this study was cross-sectional study which was conducted during August 2016. The participants were students and staff of UMT between the ages of 19 and 50. Convenience sampling was used, in which every subject who agreed to participate with age of 19 to 50 years is selected until the required sample size was achieved. A total of 73 respondents were involved in the study. Ethical approval for human study was obtained from UHREC, UniSZA (Reference number: UHREC/2016/4/001). There are four sections of self-administered questionnaires involved in the survey. The questionnaires are bilingual (Malay and English) and were used to obtain personal information and conduct the quality of life and dietary intake assessments. Anthropometric measurements included height, body weight and body fat percentage were measured. Participants stood without shoes, straight with arms at the sides, with feet together and heels and back in contact with wall. Measurement was taken from a line drawn by a portable stadiometer (SECA, Germany) and was recorded to the nearest 0.5 cm. Body weight was measured in light clothing without footwear using the Tanita digital body fat monitor/scale model: UM-026 (Tanita, UK), recorded to the nearest 0.1 kg. Body fat percentage was determined using a Tanita body fat monitor/scale, model UM-026 (Tanita, UK), recorded to the nearest 0.1%. From the weight and height obtained, BMI was calculated using the formula below (Kim *et al.*, 2013).

$$\text{BMI} = \frac{\text{weight (kg)}}{\text{height (m}^2\text{)}}$$

Two ml blood samples were drawn from a vein and tested using SpotChem EZ SP-4430 (SpotChem, Japan) with wavelength of 575 nm through SpotChem II Calcium Test Strips and wavelength of 610 nm through SpotChem II Inorganic Phosphorus Test Strips.

The data was analysed using Statistical Package for the Social Sciences programme version 20.0 with 95% of confidence interval (version 20.0, 2012, SPSS Inc. Chicago, IL). Probability level of $p<0.05$ was chosen to indicate significance. The scoring for quality of life was based on SF-12™ Health Survey Standard Scoring (2nd edition), which yields a score for physical (PCS-12) and mental health composite scale score (MCS-12) (Ware *et al.*, 1998).

RESULTS

Among 73 respondents, 61.6% were students while 38.4% were staff. The respondents included 29 males (39.7%) and 44 females (60.3%). Majority of the respondents were 19-25 years old (63%), 15.1% were 26-30 years old, 17.8% were 31-40 years old, followed by 4.1% were above 40 years old.

Calcium and phosphorus intakes were obtained from 24-hour dietary recall and analysed using Nutritionist Pro™ analysis software version 5.3. It was found that the median calcium intake among adults in UMT (371.9 mg/day) was less than half of the RNI Malaysia (46.5%) which is 800 mg/day, while mean phosphorus intake (904.6 mg/day) was higher than RDA (US) which is 700 mg/day.

Besides, study also conducted on calcium and phosphorus rich food consumption frequency score. Frequency categories divided into extreme low, low and medium. Examples of phosphorus rich foods were chicken/beef, egg, greens, lady fingers, legumes/beans, guava etc. while calcium rich foods were wholemeal bread, canned salmon and sardine, anchovies, milk and dairy product, shrimp etc. However, none of the food type from this study is performing high consumption frequency score.

PCS and MCS scores were 53.9 (10.00) and 52.4 ± 7.44, respectively. Median BMI among respondents was 23.6 (6.08) kg/m^2, which is a normal weight. The median of body fat percentage among women was 27.05 (11.85)% and 16 (9.9)% among men. Body fat percentages among women and men respondents were in the average and fitness categories, respectively. The present study found that the median serum calcium and phosphorus concentrations among respondents were 8.4 (0.65) mg/dL (2.1 mmol/L) and 3.0 (0.7) mg/dL (1.0 mmol/L), respectively. Based on these results, it can be interpreted that concentrations of serum calcium and phosphorus among respondents are in a healthy range.

According to Table 1, it was found that calcium and phosphorus intake had no relationship with serum calcium and phosphorus concentrations. Mental Health Composite Scale Score (MCS) has a relationship with serum calcium and no relationship with serum phosphorus. Physical Health Composite Scale Score (PCS) has a relationship with serum calcium and no relationship with serum phosphorus. Besides, BMI has no relationship to serum

Table 1. Relationship between calcium intake, phosphorus intake, MCS, PCS, BMI and body fat percentage with serum calcium and phosphorus

	Serum calcium (r)	P value	Serum phosphorus (r)	P value
Calcium intake	0.006	0.96	-0.050	0.67
Phosphorus intake	-0.035	0.77	-0.123	0.30
Mental Health Composite Scale Score (MCS)	0.237	0.04*	0.170	0.15
Physical Health Composite Scale Score (PCS)	0.237	0.04*	0.166	0.16
BMI	0.096	0.42	-0.215	0.07
Body fat percentage	-0.010	0.93	-0.247	0.04*

*p<0.05 indicates significant correlation by Spearman's rho correlation test.

Table 2. Relationship between calcium and phosphorus intake, BMI, body fat percentage, quality of life with serum calcium and phosphorus among male respondents (n = 29)

	Serum calcium		Serum phosphorus	
	r	P value	r	P value
Calcium intake	0.032	0.87	0.204	0.29
Phosphorus intake	-0.196	0.31	0.237	0.22
BMI	-0.303	0.11	-0.650	0.00*
Body fat percentage	-0.308	0.10	-0.599	0.00*
MCS	0.466	0.01*	0.216	0.26
PCS	0.466	0.01*	0.216	0.26

*p<0.05 indicates significant correlation by Spearman's rho correlation test for BMI, body fat percentage with serum phosphorus, MCS and PCS with serum calcium.

Table 3. Relationship between calcium and phosphorus intake, BMI, body fat percentage, quality of life with serum calcium and phosphorus among female respondents (n = 44)

	Serum calcium		Serum phosphorus	
	r	P value	r	P value
Calcium intake	0.050	0.75	-0.187	0.22
Phosphorus intake	0.094	0.54	-0.339	0.02*
BMI	0.326	0.03*	-0.009	0.96
Body fat percentage	0.255	0.09	-0.039	0.80
MCS	0.081	0.60	0.165	0.28
PCS	0.085	0.59	0.164	0.29

*p<0.05 indicates significant correlation by Spearman's rho correlation test for phosphorus intake and serum phosphorus, BMI and serum calcium.

calcium and phosphorus but body fat percentage significantly associated with serum phosphorus. Furthermore, Table 2 and Table 3 show the differences between males and females in terms of different variables.

DISCUSSION

Although calcium intake reported by respondents was far lower than RNI 2005, it actually close to the previous RDA 1975, which was 450 mg/day (Teoh, 1975). The serum calcium concentration before 1975 was 8.96 mg/dL among 54 pregnant women with ages ranging from 15 to 37 years (Tan & Raman, 1972). There was no improvement in current of dietary calcium intake as compared to intake before RNI for calcium was revised and the serum calcium concentration maintained at normal range. Conversely, the mean phosphorus intake among respondents was very high, as 48 respondents (65.8%) reported >700 mg/day of phosphorus intake.

In comparison, 23.3% of respondents were obese by referring to their body fat percentage, but 15.1% of respondents were obese based on their BMI. Obesity classification based on bioelectrical impedance analysis measurement was higher compared to BMI. This was due to the effects of gender and age (Ranasinghe *et al.*, 2013). When serum calcium is less than 6.0 mg/dL and serum phosphorus less than 1.5 mg/dL, there is risk of osteoporosis. In the present study, calcium intake has no relationship with serum calcium and phosphorus concentration. Study also reported that dietary calcium intake is not associated with risk of fracture and increasing calcium intake will not prevents fractures (Bolland *et al.*, 2015). Another study on postmenopausal women found that high dietary calcium (1600 mg/day) equivalent to 4-fold than the present study resulted in higher serum calcium levels by 9.5% (9.28 mg/dL) (Suriah *et al.*, 2013). However, both groups shown serum calcium at a normal level. Therefore, the true benefit provided by calcium supplementation or high calcium intake on serum calcium needs to be revised. In addition, another possible reason that explains the difference between serum calcium concentrations of two studies group could be the age group difference. Phosphorus intake has no relationship with serum calcium and phosphorus. 8 weeks of high phosphorus intervention among 66 healthy adults aged 18 to 60 years showed that high phosphorus intake has no influence on fasting plasma phosphate concentrations but plasma calcium concentration was significantly higher (Trautvetter *et al.*, 2016). Similarly, it was reported that serum phosphorus concentration was not associated with dietary intake of foods containing inorganic phosphates ($r=0.064$) and organic phosphorus ($r=0.075$) from a cross-sectional analysis done on 7895 adult aged 20-85 years based on 24-hour food recall. The mean serum phosphorus levels of participants taking dietary supplements containing 126.3 mg/day of phosphorus (3.81 mg/dL) were not statistically different from those not taking supplements (3.80 mg/dL, $P=0.50$) in that study (Moore *et al.*, 2015). In fact, age, medical conditions, meal composition, genetics, smoking status and many other factors also contribute to inequivalences between nutrient intake and biological availability. It is affecting in terms of absorption and utilization by the body (Varela-López *et al.*, 2016). This study has limitation, primarily due to the single-day dietary intake analysis and comparison to a single day's serum calcium and phosphorus concentration cannot evaluate the long-term effect of dietary intake on serum calcium and phosphorus concentration. Following RDA and RNI recommendations for calcium and phosphorus intake is in doubt since intake lower than the recommendations is already adequate in preventing risk of osteoporosis.

It was reported that the presence of hyper-corticoidism in individuals with depression leads to osteoporosis (Gold & Solimeo, 2006). Even though mental health does not significantly affect serum calcium and phosphorus, results from the present study show that serum calcium may be associated with mental health, similar to results in a report from Chowdhury (2014) stating that psychological factors such as depression increase the risk of osteoporosis. Increases in physical activity and fitness helps in the primary and secondary prevention of osteoporosis because exercise is the stimulus for bone to maintain its structural and functional strength (Warburton *et al.*, 2006). Age, social class, BMI and co-morbidities are factors that affect the relationship between quality of life and risk of osteoporosis. Quality of life may be an important predictor of osteoporosis, but is not the only factor affecting bone loss.

In the present study, BMI shows no significant relationship with serum calcium and phosphorus. According to the 5th Tromso study (2004), serum calcium has a positive relationship with BMI ($p<0.001$) among adults ($n=7954$) aged 30 to 89 years (Kamycheva *et al.*, 2004). The elevated serum parathyroid hormone in obesity disturbs the renal handling of calcium, leading to a negative calcium balance. A previous study reported that BMI was negatively associated with the serum phosphorus concentration among adults. Effect of BMI on serum phosphorus was in an inverse association (Moore *et al.*, 2015). From the two studies above, BMI has a positive relationship with serum calcium and negative relationship with serum phosphorus. This statement was different from result of present study whereby serum calcium and phosphorus show no relationship with BMI. BMI *per se* cannot be concluded as factor affecting risk of osteoporosis in this present study. Environment factors such as dietary intake, physical activity, and hormonal factors have been documented to exert an effect on BMD (Mishra *et al.*, 2016). However, body fat percentage is significantly associated with serum phosphorus in the present study. The relation between BMI and body fat percentage is not linear and differs for men and women. BMI as a measure of obesity can introduce misclassification problems (Rothman, 2008; Romero-Corral *et al.*, 2008). Body fat percentage was the contributing factor to study the effect on serum calcium and phosphorus concentration. Body fat percentage has no relationship with serum calcium and has weak inverse relationship with serum phosphorus which similar to 5th Tromso study (2004) and research done by Moore *et al.* (2015) which measure body fat status using BMI. This can be explained by the unfavourable effects of adipokine from abdominal fat on bone growth-related factors associated with visceral fat (Jeon *et al.*, 2014).

Calcium and phosphorus intake were not associated with serum calcium and phosphorus, except that phosphorus intake correlates significantly with serum phosphorus in female respondents only, which may be due to the increased PTH secretion and other factors affecting bone mass, such as vitamin D, fibroblast growth factor 23 and oestrogen (Moore *et al.*, 2015). BMI showed no association with serum calcium and phosphorus but correlation was shown when BMI was analyzed separately according to gender. Both genders demonstrate a relationship between BMI and risk of osteoporosis in this present study, even though the relationships were opposed, such that BMI was positively associated with serum calcium in females but negatively associated with serum phosphorus in males. Possible explanations include the different bioavailability of dietary calcium and phosphorus depending on dietary sources, physiologic function, estrogen deficiency and interactions with other nutrients, which might affect serum levels (Song *et al.*, 2007). Body fat percentage shows a significant inverse relationship with serum phosphorus among men only (n=29). Sex-specific differences in weight and fat distribution provide a partial explanation for a gender difference in the BMI-osteoporosis relationship (Nielson *et al.*, 2012). Several studies have shown that fat mass is an important determinant of BMD in women but not in men (Reid *et al.*, 1992). A majority of male adults in the current study had body fat percentages ranging from athletic to average while a majority of female adults had body fat percentages of average to obese. Body fat percentages among female adults have a narrower range compared male adults. This factor can contribute to the lack of relationship between body fat percentage and risk of osteoporosis among females in this study.

In the present study, quality of life has a relationship with risk of osteoporosis among male respondents only. There is lack of study explaining the difference in relationship of quality of life on risk of osteoporosis according to gender. Further study may be conducted in the future. Hence, it can be concluded that gender is one of the components affecting risk of osteoporosis in terms of body fat percentage, quality of life, BMI, and phosphorus intake with serum phosphorus.

CONCLUSION

The findings show that calcium and phosphorus intake has no relationship with serum calcium and phosphorus concentrations. In addition, dietary phosphorus intake only correlates significantly with serum phosphorus in female respondents. Therefore, it is suggested that 400 mg/d of dietary calcium is actually sufficient instead of 800 mg/day according to RNI of calcium to maintain serum calcium concentrations at a normal level.

BMI has no relationship with serum calcium and phosphorus. Body fat percentage has no relationship with serum calcium but a weak relationship with serum phosphorus (ρ: -0.247, p=0.04). Different results were shown by BMI and body fat percentage because obesity based on bioelectrical impedance analysis measurement was lower compared to BMI due to the effects of gender and age. Therefore, body fat percentage was a contributing factor to examining effects on serum calcium and phosphorus concentration. In addition, there were gender differences between body fat percentage and BMI with serum calcium and phosphorus due to differences in weight and fat distribution, as females have a narrower body fat percentage range than males.

Lastly, the quality of life component (PCS and MCS) was within a normal range and is still able to result in a majority of respondents experiencing normal serum calcium and phosphorus concentrations. Quality of life correlates to serum calcium, indicating it may be important predictors of osteoporosis, but they are not the only factors affecting bone loss because bone loss may also be affected by gender, age, social class, BMI and co-morbidities.

Given the limitations of the present study, future studies should consider a more heterogenous, randomly selected sample. Three days' food recall can be obtained instead of one day to get the average amount of nutrient intake. This is because calcium and phosphorus intake levels are the main component on this present study and average result from three days food recall might increase the validity of research. Additionally, vitamin D intake should be analyzed, since it will affect serum calcium and phosphorus. Apart from that, physical activity among respondents may be investigated to determine their activity level.

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