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ETHNIC DIFFERENCES IN BONE HEALTH STATUS AND ITS ASSOCIATION WITH CALCIUM INTAKE, PHYSICAL ACTIVITY AND BODY MASS INDEX AMONG MALAYSIAN OLDER ADULTS FROM BANGI AND KAJANG, SELANGOR, MALAYSIA

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ABSTRACT

The increase in sedentary activity among older adults could result in lowering bone mineral density (BMD), thus increasing the risk of osteoporosis. Physical activity and adequate dietary calcium intake (DCI) are important to optimize bone health. Therefore, this study was conducted to determine ethnic differences in bone health status (BHS) and to investigate the association between lifestyle factors and BHS among Malaysian older adults. A total of 120 older adults aged between 60 to 84 years old of three major ethnicities residing in Bangi and Kajang, Selangor, Malaysia were recruited in this cross-sectional study. They were asked to fill out food frequency questionnaire and the international physical activity questionnaires for the quantification of DCI and physical activity level (PAL) assessments. BMD was quantified using QUS-2 Calcaneal Ultrasonometer. The results showed that the Chinese participants had significantly lower body mass index (BMI) (p<0.001) than their counterparts. Malay participants had significantly higher DCI (p=0.027) compared to other groups. However, none of the participants met the recommended daily intake of calcium (1000 mg/day). The Indian participants had significantly higher (p=0.007) PAL compared to the Malay and Chinese groups. BMD analysis showed that the Chinese have significantly lower (p=0.001) T-scores (-0.54 ± 1.35) compared to Malay (0.78 ± 1.72) and Indian (0.61 ± 1.91), respectively. BMI and DCI were positively correlated with BMD (correlation coefficient, r= 0.320, p<0.001; r=0.383, p<0.001, respectively). In conclusion, the reduced BMI among the Chinese and DCI among all Malaysian older adults need to be concerned and addressed immediately. Future intervention programs should be focusing on optimizing DCI, not only among the older adults but should be emphasized and initiated at younger ages to prevent osteoporosis during old age.

Key words: Bone mineral density, calcium intake, physical activity level, Malaysian older adults

INTRODUCTION

Osteoporosis is a disease characterized by the reduction of the quality and density of the bone (Anam & Insogna, 2021). It is also known as a silent savagery because bone loss occurs gradually without symptoms and does not become apparent until after a fracture has occurred (Papadopoulou *et al*., 2021). Osteoporosis becomes more common with increasing age, due to progressive bone lost throughout adult life, following hormonal changes in the body particularly the decreased production of testosterone and oestrogen due to menopause (Rinonapoli *et al*., 2021; Vescini *et al*., 2021). In both genders, the osteoporosis prevalence is doubled when they are aged more than 70 years compared to other age groups (Tian *et al*., 2017; Choi *et al*., 2021). In Malaysia, a recent study reported that the prevalence of osteoporosis is 14% (Yeap *et al*., 2020). Many factors could lead to the occurrence of osteoporosis. Besides hereditary and endocrine disorders, lifestyle-related factors including body mass index (BMI), dietary intake and sedentary lifestyle are closely related to osteoporosis (Salari *et al*., 2021).

One of the suggested ways to prevent osteoporosis is by increasing the density of the bone, which potentially be modulated by optimizing daily calcium intake and performing regular physical activities (Papadopoulou *et al*., 2021). The Malaysian Recommended Nutrient Intake (RNI) suggests that men and women aged more than 60 years old should consume 1000 mg/day and 1200 mg/day, respectively

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and an additional 200 mg/day should be considered necessary for postmenopausal women (NCCFN, 2017). Despite the given recommendation, the inadequacy of dietary calcium intake is still a major problem among older adults in Malaysia. Suriah *et al*. (1996) reported that calcium intake of free-living older adults aged between 60 to 93 years old was 300.22 ± 165.90 mg/day and 265.18 ± 145.44 mg/day for men and women, respectively. However, after 20 years of the study has been performed, the calcium intake among Malaysian older adults is still unable to reach even half of the recommendation although recent studies did show an increase consumption of calcium. Zamzuri *et al*. (2019) reported that the older adults took 421.7 ± 344.3 mg/day of calcium whilst Ooi *et al*. (2022) showed an intake of 530.1 ± 254.28 mg/day. Moreover, there is not much known about calcium intake between 3 major ethnics of Malaysian older adults. Most studies reported as a total consumption or based on genders (Chee *et al*., 2002; Chee *et al*., 2010; Hawa *et al*., 2013).

Besides low calcium intake, Malaysian older adults were also reported as physically inactive. National Health and Morbidity Survey (NHMS) 2015 reported that the prevalence of inactivity was 48.8% (Chan *et al*., 2019). More recently, NHMS 2018 showed that 3 out of 10 Malaysian older adults above 60 years were inactive (Chan *et al*., 2020). Adult population, including older individuals are recommended to perform at least 150 min of moderate or vigorous physical activity per week in order to maintain their health (Ministry of Health Malaysia, 2017). Physical activity is critically important for them not just for the prevention of disease, but also for maintaining physical function, promoting independent living, reducing disability and improving the quality of life (Sun *et al*., 2013). The failure of Malaysian older adults to fulfil both calcium intake and physical activity recommendations has raised the question of the relationship between these factors with bone mineral density (BMD), as reported in many foreign studies (Specker, 1996; Nguyen *et al*., 2000; Dionyssiotis *et al*., 2010; Pinheiro *et al*., 2020; Yao *et al*., 2021). Contradictory, the relationship is yet to be reported among Malaysian older adults.

Additionally, data on the indicator of bone health status and BMD were also scarce among the Malaysian older adults. More importantly, the aforementioned measurements were also very least reported and compared among the multi-ethnic older adults, particularly in studies that measured these parameters together. This is crucial to observe whether bone health-related factors are related to ethnicity. Therefore, the current study determines BMI, calcium intake and PAL among multi-ethnic Malaysian older adults. Ultimately, the relationship between calcium intake, physical activity level (PAL) and BMD was also investigated in this study.

MATERIALS AND METHODS

Ethical statement and participants

The cross-sectional study was conducted in Bangi and Kajang, which are located 20 km southeast of Kuala Lumpur, the capital city of Malaysia. A total of 120 free-living male and female older adults comprised 40 Malays, 40 Chinese and 40 Indians (20 men & 20 women in each group, respectively) were recruited from communal areas such as mosques, temples, and older adults' social clubs and associations. Data collection was carried out from September to December 2017 following obtaining the ethical approval from the Secretariat for Medical Research and Innovation of Universiti Kebangsaan Malaysia (UKM) with the approval code of UKM PP1/111/8/JEP-2016-461. Prior to the start of the study, written informed consent was obtained from all participants. The inclusion criteria of this study were: participants must be of age more than 60 years old and, able to read and write. Participants were excluded if they had factors that were able to affect bone metabolism or modify BMD, including medications (ie. diuretics, thyroid hormone, calcium or vitamin D supplements) and chronic diseases (ie. liver cirrhosis, rheumatoid arthritis, hyperthyroidism). Prior to determining the study parameters, participants underwent interview sessions in which sociodemographic questionnaires were asked. Information including age, occupation and education levels were collected. All provided information was treated as confidential.

Body mass index and bone mineral density assessments

Height and weight were measured to the nearest 0.1 cm and 0.1 kg using a measuring tape body meter (SECA, Hamburg, Germany) and a portable mechanical digital lithium scale HD-312 (Tanita Corp., Tokyo, Japan). Assessments were performed with participants wearing light clothing and no shoes. BMI was calculated by dividing the weight (kg) by height squared (m^2) and categorized based on the World Health Organization (WHO) classification (WHO, 1995).

BMD was assessed on the left calcaneus using QUS-2 ultrasound densitometer (Quidel Corporation, California, USA) by the trained staff based on the standard protocol established by the device manufacturer. Measurements were expressed as T-scores and categorized based on the WHO classification in which normal, low bone mass (osteopenia) and osteoporosis were defined as T-scores of above -1.0, between -1.0 and -2.5, and -2.5 or less, respectively (Kanis *et al*., 2008).

Calcium intake assessment

The calcium intake was quantified using

a validated semi-quantitative food frequency questionnaire (FFQ) (Chee *et al*., 2002). A total of 92 types of foods from the group of milk and dairy products, carbohydrate-based foods, meat and derivatives, fish and seashell products, vegetables, fruits, oils and fats, desserts and, ready-to-eat foods were included in the questionnaire. Participants were asked to mark the type of foods and drinks, frequency of consumption, meal size and meals preparation that they have taken in the past month. Then, the frequency of calcium intake was converted to the amount of food intake in grams using the following formula (Norimah *et al*., 2008a): Amount of food (g) per day = frequency of intake (the conversion factor) × serving size × total number of servings × weight of food in one serving.

Physical activity assessment

The levels of physical activity per week were determined using International Physical Activity Questionnaire (IPAQ) (2005) (IPAQ, 2005). The assessment was expressed as metabolic equivalent of task (MET). The levels of physical activity were defined as less or equal to 600 MET-min/week for light activity, equal or more than 600 MET-min/week for moderate and equal or more than 3000 MET-min/week for heavy activities. Daily energy usage was determined using a 24-hour physical activity diary. Participants were asked to record and classify their daily activities into six categories: sleeping or lying down, sitting, standing and walking, personal, general and fitness activities. Then, the total amount for each category was calculated by multiplying the metabolic cost (kcal/mins) with the time (mins) used to perform the activity.

Data analysis

Data are expressed as mean ± standard deviation (SD) and analyzed using Statistical Package for Social Science (SPSS) version 22.0 (SPSS Incorporation, Chicago, IL, USA). The normality of data distribution was checked using the Kolmogorov-Smirnov test. Analysis of variance analysis was used to compare the means between races. Pearson correlation coefficient was used to determine the relationship between BMI, calcium intake, PAL and BMD. The statistical significance was set at p-values of <0.05 and <0.001.

RESULTS AND DISCUSSION

General characteristics of the participants

Table 1 shows the sociodemographic data of the study population. Participants were in the age range between 60 to 84 years with the mean aged of 64.9 ± 5.7 years. Most of the participants were non-ex-smokers (98.3%). Overall, the participants of this study had tertiary education levels (43.3%) compared to primary (30.8%) and secondary (25.8%) education levels. The majority of Malay participants (70%) had tertiary education whilst 60% of Chinese and 52.5% of Indian participants had secondary and primary education, respectively. The education levels of the participants in this study were significantly different ($p<0.05$) between ethnics compared to a study performed by Norimah *et al*. (2008b). The study showed that only 1% of the older adults had tertiary education whilst the majority of the population (54%) never attended school and 9% had secondary education (Norimah *et al*., 2008b). The authors also reported that majority of the older adults have poor nutrition knowledge and related it with their education status. Education plays an important role in nutrition. Studies showed that the levels of education associated with nutrition literacy (Pon *et al*., 2006; Liu *et al*., 2013). Therefore, it is expected that the increase of education levels of the older adults in the current study has improved nutritional knowledge and healthy lifestyle, particularly on the role of calcium and physical activities in health.

Malay older adults were reported to live with an average of 4 family members compared with Chinese and Indian older adults who lived with an average of 3 members. The low number of family members living together with the participants is possibly related to several factors, including late marriage, having a low number of children, or children and family members living in other cities due to work commitment (Rashid *et al*., 2016). A majority of the participants (92.5%) were retired as the minimum age of the participants in this study was 60 years old. This is in accordance with the Law of Minimum Retirement Age Act of Malaysia 2012, which was also set at 60 years. Nevertheless, 7.5% of participants were still working, possibly in the private sector or freelance workers.

Chinese older adults had significantly lower BMI ($p<0.001$) and BMD ($p=0.001$) compared to Malay and Indian older adults, although both findings were in the normal range. A low BMI has been reported as an important risk factor for low BMD (Salamat *et al*., 2013; Hoxha *et al*., 2014; Prabha & Meriton, 2015; Ma *et al*., 2021). Therefore, the low BMD in Chinese older adults is possibly related to the low BMI. A recent study suggested that the optimal BMI to reduce risk factor of osteoporosis is between 23.0 to 24.9 kg/m^2 (Lee *et al*., 2020). In agreement with our finding, the low BMD and BMI in Chinese participants compared to other populations had also been demonstrated in other studies (Nam *et al*., 2010; Yang *et al*., 2013; Zhang *et al*., 2014; Thu *et al*., 2019; Thambiah & Yeap, 2020; Ge *et al*., 2021). This has raised concern as low BMD could lead to the occurrence of osteoporosis and increased fracture risk if no preventive measures are taken. This situation is worrying and corrective measures, particularly increasing dietary calcium intake, need to be performed immediately as older adults are prone to suffer from osteoporosis.

Table 1. General characteristics of the participants according to races

Parameter	*n* (%) or Mean ± Standard deviations				
	Total (*n*=120)	Malay (*n*=40)	Chinese (*n*=40)	Indian (*n*=40)	*P* value
Age (years)	64.9 ± 5.7	63.8 ± 5.4	65.3 ± 5.5	65.6 ± 6.0	0.269
Ex-smoker					
• Yes	2 (1.7)	1 (2.5)	1 (2.5)	-	-
• No	118 (98.3)	39 (97.5)	39 (97.5)	40 (100)	-
Educational level					
• Primary school	37 (30.8)	8 (20.0)	8 (20.0)	21 (52.5)	
• Secondary school	31 (25.8)	4 (10.0)	24 (60.0)	3 (7.5)	-
• University / college	52 (43.3)	28 (70.0)	8 (20.0)	16 (40)	
Family members living together	3	4	3	3	-
Retired					
• Yes	111 (92.5)	35 (87.5)	37 (92.5)	39 (97.5)	-
• No	9 (7.5)	5 (12.5)	9 (7.5)	1 (2.5)	
BMI (kg/m^2)	23.0 ± 3.3	24.0 ± 3.2^a	21.3 ± 2.8^b	23.9 ± 3.4^a	<0.001**
BMD (T-score)	0.28 ± 1.77	0.78 ± 1.72^a	-0.54 ± 1.35^b	0.61 ± 1.91^a	0.001**

^{a,b} Different letters indicate statistically significant differences between groups at **p<0.01.

BMI=body mass index, BMD=bone mineral density

Assessment of calcium intake

Table 2 shows the calcium intake of older adults. Based on the type of food group, the highest contribution of calcium was obtained from milk and dairy products. However, no significant difference (p>0.05) was shown between the groups. The results showed that Malay had significantly higher calcium intake from meat and meat products (p<0.001), and fish and seashell products (p<0.001) compared to other groups. Conversely, the Chinese had significantly higher (p=0.006) calcium consumption from nuts and legumes, whilst Indians had significantly lower (p=0.032) calcium consumption from beverages. Overall, the order frequency of five types of calcium-containing foods that were commonly consumed by older adults were milk and dairy foods (150.52 ± 165.97), vegetables (46.12 ± 34.60), nuts and legumes (41.23 ± 47.23), meat and meat products (39.28 ± 21.16), carbohydrate-based foods (34.26 ± 18.01), and fish and seashell products (25.11 ± 25.25).

The comparison of total intake of calcium between the ethnics demonstrated that Malays had the highest consumption. However, all groups did not meet the Malaysian RNI for calcium, which is 1000 mg/day and 1200 mg/day for men and women, respectively, and an additional 200 mg/day for postmenopausal women (NCCFN, 2017). The low consumption of calcium among Malaysian older adults has been reported elsewhere (Nik Nur Izzati *et al*., 2016; Shahar *et al*., 2019; Zamzuri *et al*., 2019; Ooi *et al*., 2022). The barriers of optimising milk or dairy consumption among Malaysian older adults *per se* have not been reported. However, the cause of inadequacy intake of calcium among Malaysians or Asians is complex and related to many factors, including cultural, socioeconomic, lack of awareness and motivation, personal and environmental factors (ie. Family & peer influence, & availability) (Auld *et al*., 2002; Brázdová *et al*., 2014; Chan *et al*., 2018; Azhar & Jaafar, 2020).

Foods high in calcium, particularly dairy products are expensive in Malaysia as it generally needs to be imported from other countries such as Australia and New Zealand (Sim & Suntharalingam, 2015) because Malaysia is not a pastoralist country. As a result, dairy products are not a typical food among Malaysians, particularly older adults, therefore seldomly include them in their daily meals. A similar situation was also reported in other Asian countries, Taiwan and Japan (Zhang *et al*., 2007; Chang *et al*., 2022). Our results showed that the frequency of dairy products, skimmed milk was 59.39 compared to rice (91.23), white bread (71.64) and eggs (60.87). The frequencies of other milk and milk products (yogurt, yogurt drink, UHT milk, milkshake, ice-cream & yogurt ice-cream) were consumed at 35.21, 31.86, 25.69, 16.21, 15.69 and 15.09, respectively. Lack of consumption of dairy products, particularly after weaning period, could cause lactose intolerance, a health condition related to the occurrence of gastrointestinal symptoms following indigestion of lactose, a primary sugar that can be found in dairy products (Szilagyi & Ishayek, 2018). This condition could be another factor that prevents the intake of calcium.

In order to address these situations, perhaps it is time that we start to produce our own calcium-rich foods using local products that are affordable, palatable and up to the liking of the Malaysian

population, particularly the older adults. This step could potentially be one of the ways to increase calcium intake (Bhurosy & Jeewon, 2013) among Malaysians, particularly older adults. Alternatively, increase consumption of non-dairy based calcium products, such as fish and soy products (tofu & tempeh) would also help to achieve the purpose as implemented by the Japanese (Zhang *et al*., 2007).

Assessment of physical activity levels

Table 3 shows the PAL of older adults. IPAQ analysis showed that Indians had significantly higher (p=0.007) levels of physical activities compared with other groups. However, when categorised the average group score into PAL levels, Indian had heavy PAL levels whilst Malay and Chinese groups had moderate levels. There was also a large inter-individual variation of physical activities, particularly in the Malay group ranged from 337.8 ± 164.8 Met-min/week (light PAL category) to 11833.6 ± 9075.9 Met-min/week (heavy PAL category). However, this is inevitable as some older adults were physically inactive whilst others were still working and engaged in regular exercise. Out of 120 older adults, 41 older adults (34%) reported performing heavy physical activities (≥3000 MET-min/week), which contributed either from their works, regular exercise, doing household chores or being actively involved in social activities. In contrast, 21 Malay and 19 Chinese, but no Indian had a sedentary lifestyle with less than 600 MET-min/week physical activities. In agreement with our finding, Chan *et al*. (2019) and (2020) also reported the high prevalence of physical inactivity among older adults. Previous studies reported that the primary barriers to be actively involved in physical activity among them are insufficient time, tiredness, lack of skills and fear of injury (Ayiesah, 2007; Justine *et al*., 2013; Wen & Labao, 2019). These findings could be related with a perception that physical activity is a time-consuming activity and lack of motivation/awareness among them. Interventions that could elevate awareness, knowledge, skills, confidence and motivation related to optimise physical activities are required to promote higher level of participation and minimize barriers of physical activity among older adults.

Analysis of daily energy expenditure showed that Malay older adults were found to have significantly higher (p<0.001) sitting activity (995.81 ± 163.88 kcal/day) than Indians and significantly lower (p<0.001) fitness activity (61.70 ± 113.31 kcal/day) compared to the Chinese. On the other hand, the Chinese were found to have significant standing and walking activities (394.31 ± 324.79 kcal/day, p<0.001) and lying down and sleeping activities (335.92 ± 32.82 kcal/day, p<0.001) compared with other groups. Nevertheless, they were also reported to have significantly higher (p<0.001) fitness activity compared to Indians and Malay. This is probably because the Chinese older adults are usually involved in daily morning exercises such as yoga and tai-chi (Ayiesah, 2007). In accordance with the high PAL result, Indians were found to have significantly higher energy usage for standing and walking activities (p<0.001) compared to Malay and Chinese. and a significant lower inactive lifestyle, including lying down and sleeping (p<0.001), and sitting (p<0.001) activities compared to the Chinese.

Correlation between BMI, calcium intake, physical activity and BMD

This study showed that BMI had a significant moderate correlation with BMD (r=0.320, p<0.001). BMI has been suggested to regulate BMD by providing heavier mechanical loading on bones, which eventually leads to subsequent bone remodeling (Wu & Du, 2016; Fujii *et al*., 2021). However, high BMI is related to obesity and other metabolic syndrome diseases. Ma *et al*. (2021) suggested that a BMI of 26.0 kg/m^2 is the most beneficial BMI for protecting BMD, but at the same time reducing risk factors associated with obesity. Nevertheless, Lee *et al*. (2020) suggested to keep a BMI between 23.0 to 24.9 kg/m^2 as a higher

Table 2. Calcium intake of participants according to type of foods

Type of food (mg/day)	Mean ± Standard deviations (n=120)				
	Total	Malay (n=40)	Chinese (n=40)	Indian (n=40)	P value
Milk and dairy products	150.3 ± 166.0	188.5 ± 191.7	113.9 ± 108.1	154.3 ± 177.5	0.128
Carbohydrate-based foods	34.3 ± 18.0	33.8 ± 20.4	38.6 ± 11.2	32.4 ± 20.5	0.268
Meats and meat products	39.3 ± 21.2	51.4 ± 21.9[a]	30.0 ± 11.4[b]	36.8 ± 22.3[b]	<0.001**
Fish and seashell products	25.1 ± 25.3	43.3 ± 24.0[a]	20.1 ± 17.3[b]	13.4 ± 24.4[b]	<0.001**
Nuts and legumes	41.2 ± 47.2	36.0 ± 37.1[b]	61.8 ± 46.3[a]	31.1 ± 50.0[b]	0.006*
Oils and fats	0.5 ± 1.8	0.4 ±1.1	0.2 ± 0.9	0.9 ± 2.7	0.210
Ready-to-eat foods	4.0 ± 12.9	6.6 ± 12.8	1.1 ± 7.0	4.4 ± 16.6	0.161
Vegetables	46.1 ± 34.6	51.9 ± 43.0	41.6 ± 22.4	47.2 ± 35.9	0.418
Fruits	14.2 ± 15.5	14.4 ± 13.5	10.0 ± 8.1	18.4 ± 21.0	0.051
Desserts	0.1 ± 0.6	0.14 ± 0.41	0.01 ± 0.08	0.15 ± 0.90	0.450
Beverages	11.5 ± 24.2	14.6 ± 24.0[a]	15.8 ± 31.8[a]	3.1 ± 9.9[b]	0.032*
Total intake	366.5 ± 220.9	441.1 ± 288.4[a]	316.6 ± 125.4[b]	342.0 ± 202.8[b]	0.027*

[a,b] Different letters indicate statistically significant differences between groups at *p<0.05 and **p<0.001.

BMI could lead to an increase in type 2 diabetes risks. Additionally, this study also showed that calcium intake has a significant moderate correlation with BMD (r=0.383, p<0.001). As calcium is the main component for bone growth and development, therefore consumption of dietary calcium would potentially contribute to bone density (Tai *et al*., 2015). Indeed, the positive relationship between these factors has also been shown in many previous studies (Zhou *et al*., 2013; Kim *et al*., 2014; Tai *et al*., 2015; Vannucci *et al*., 2017; Yao *et al*., 2021). However, some studies reported no association between calcium intake and BMD (Skowronska-Jozwiak *et al*., 2014; Bristow *et al*., 2021). The inconsistencies between the findings were suggested due to the variety of ethnicity, population and geography of the study (Walker *et al*., 2008; Leslie, 2012; Chin *et al*., 2016; Zhou *et al*., 2019).

Our study also found no significant correlation between physical activity and BMD (r=0.293, p=0.793). This is surprising as the role of physical activities has been discussed in other populations (Muir *et al*., 2013; Rodriguez-Gomez *et al*., 2018; Hind *et al*., 2020; Kopiczko, 2020). This might be related to the large inter-variation PAL between individuals as discussed in the previous section. However, studies suggested that moderate-to-vigorous physical activities have the most significant effect on BMD than light and sedentary activities (Rodriguez-Gomez *et al*., 2018; Kim *et al*., 2019; Pinheiro *et al*., 2020; Ng *et al*., 2021). Therefore, strategic interventions including home-based to community-based programs need to be implemented immediately in order to reduce physical inactivity among Malaysian older adults.

CONCLUSION

Malaysian older adults had low daily calcium intake and physical activities compared to the recommendation. In comparison with other groups, Chinese had the lowest BMD, which possibly due to the low BMI. BMD was highly related to BMI and calcium intake, but not physical activities. The lack of significant effect of physical activities on BMD in this study possibly related to the high inter-variability of physical activities between the participants. The strength of this study is that it provides data on the relationship between BMD with physical activity and calcium intake among Malaysian older adults, which

Table 3. Physical activity levels according to races

	Mean ± Standard deviations (n)				
	Total	Malay (n=40)	Chinese (n=40)	Indian (n=40)	P value
Physical activity	3079.1 ± 3856.2	2074.9 ± 4767.7[b]	2558.0 ± 2961.5[b]	4604.5 ± 3189.5[a]	0.007*
(MET-min/week)					
- Light (≤ 600)	ND	337.8 ± 164.8 (21)	389.2 ± 131.8 (19)	Nil (0)	-
- Moderate (≥ 600)	ND	1195.4 ± 686.4 (14)	1851.1 ± 721.6 (7)	1920.7 ± 613.8 (18)	-
- Heavy (≤ 3000)	ND	11833.6 ± 9075.9 (5)	5937.4 ± 2491.2 (14)	6800.3 ± 2713.5 (22)	-
Energy usage (kcal/day)					
Sitting	ND	995.8 ± 163.9[a]	961.5 ± 194.1[a]	850.8 ± 138.0[b]	<0.001**
Fitness	ND	61.7 ± 113.3[b]	367.0 ± 371.5[a]	164.3 ± 246.3[b]	<0.001**
Lying down and sleeping	ND	272.3 ± 64.2[c]	335.9 ± 32.8[a]	293.9 ± 33.2[b]	<0.001**
Standing and walking	ND	577.2 ± 302.3[b]	394.3 ± 324.8[c]	941.3 ± 388.0[a]	<0.001**
Personal	ND	356.0 ± 152.5[a]	184.6 ± 69.0[b]	307.0 ± 171.9[a]	<0.001**
General	ND	140.7 ± 274.6	99.9 ± 199.6	55.8 ± 223.5	0.274

[a,b,c] Different letters indicate statistically significant differences between groups at *p<0.05 and **p<0.001 (n=120).

MET = Metabolic equivalent of task, ND = Not determined

Table 4. Correlation between body mass index, calcium intake, physical activity and bone mineral density

Parameters	R-value	p value
Body mass index*BMD	0.320**	<0.001
Calcium intake*BMD	0.383**	<0.001
Physical activity*BMD	0.293	0.793

Significant difference at **p<0.001 (n=120).

BMD = bone mineral density

were scarcely reported. Most of the previous studies investigated these parameters individually, without looking into the association. Additionally, comparison of the parameters between races were also performed in this study. Findings from this study would be helpful for the authorities to design intervention programs for Malaysian older adults. This study also has some limitations. The QUS-2 ultrasound densitometer used to measure BMD in this study is an alternative tool to dual-energy X-ray absorptiometry (DXA), a gold standard device in BMD studies. QUS-2 was chosen to use in this study because it is portable, inexpensive, radiation-free and easy to handle in a community study compared to DXA, a robust device but would be costly and immobile, thus make it inappropriate to be used in a community study. Moreover, QUS-2 fits the objective of this study, which is to determine the BMD and screen the bone health status, whilst DXA is primarily been used to diagnose osteoporosis. Secondly, as this study only been performed in 2 areas of Selangor and involved small sample population (n=120), therefore the result could not represent the whole population of Malaysian older adults. Therefore, future investigation should be expanded to other parts of Malaysia, particularly rural areas.

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ETHICAL STATEMENT

The study was approved by the Secretariat for Medical Research and Innovation of Universiti Kebangsaan Malaysia with the approval code of UKM PP1/111/8/JEP-2016-461. All participants signed a written informed consent form before entering the study.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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