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Research Article
A Population-based Study on Bone Mineral Density Using Dual-Energy X-Ray Absorptiometry (DEXA) in Postmenopausal Women in Jakarta, Indonesia

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Abstract

Background and Objective: Osteoporosis is established using a dual X-ray absorptiometry (DEXA). Patients were usually referred for DEXA from practice room. However, in most developing countries people have limited access to DEXA leading to underreport of osteoporosis prevalence. The aim of this study was to assess bone mineral density (BMD) in postmenopausal women using DEXA in a population-based study and to establish a correlation between BMD with some risk factors. **Materials and Methods:** Participants were postmenopausal women and referred from Posyandu. Anthropometric measurements were performed. DEXA was performed at the hip (total hip, femoral neck, trochanter and femoral shaft), distal radius and lumbar region (L1-L4). Participants were categorized according to body mass index (BMI) (normal if BMI <25 kg m^{-2}, overweight and obese if BMI $\geq$25kg m^{-2}) and to BMD (normal BMD if T-score$\geq$-1SD, low BMD if T-score<-1 SD). Pearson's or Spearman tests were applied to analyze correlation between variables. **Results:** A total of 60 postmenopausal women were participated. The results showed 17 (28.3%) had osteopenia and 33 (55%) had osteoporosis. Age, age at menopause and duration of menopause had the strongest negative correlation with the BMD of the distal radius ($r = -0.582, -0.414, -0.497$, respectively, $p<0.01$), whereas weight and BMI were positively correlated with the BMD of the trochanter ($r = 0.437$and 0.424, $p<0.01$). **Conclusion:** Population-based recruitment confirmed that osteoporosis was more prevalent in postmenopausal women. Further, the correlation and the strength of the correlation between BMD and associated risk factors is bone site specific.

Key words: Population-based, DEXA scan, bone mineral density, body mass index, postmenopausal women, risk factors

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Osteoporosis affects 200 million people worldwide[1] and the prevalence is increasing with the growing aging population. Data are not available on the prevalence of osteoporosis in Indonesia. In 2006, a study on bone mineral density (BMD) reported that the prevalence of osteoporosis in women aged 50-80 years was 23%[2]. In 2007, Perosi (Indonesia Osteoporosis Association) reported that 32.3% of women had evidence of osteoporosis[2], which is increased compared with the prevalence in Southeast Asia (15.3%)[3]. BMD examinations are typically performed in a clinical setting, either in a medical clinic or a hospital, on a physician referral-basis. Because these patients have been preselected, there is the potential for underreporting of the prevalence of osteoporosis in the population. To obtain accurate information regarding the prevalence of osteoporosis, BMD examinations should also be conducted in women with risk factors in a population-based study. However, access to dual X-ray absorptiometry (DEXA) examinations is limited in some developing countries, including Indonesia, because it is costly and available only in referral hospitals located in big cities. Sixty-five hospitals are estimated to be equipped with a DEXA machine in Indonesia. With a population of 250 million, the ratio of DEXA machines/population is less than 1 per 10 million[4].

Posyandu (Pos Pelayanan Terpadu-Integrated Health Center) is a community-based informal health service. Posyandu is organized by cadres (trained health volunteers) and is visited by a health professional once a month. The services target vulnerable groups, such as infants and the elderly and focus primarily on prevention and health promotion. Posyandu visitors are mostly from a middle to low socioeconomic population, which is one of the risk factors for osteoporosis[5,6]. Given that the activities in Posyandu mainly focus on prevention and health promotion, participants in the Posyandu program are considered in good health and generally have no complaints suggestive of osteoporosis. Therefore, the prevalence of osteoporosis among these women may reflect the prevalence in the general asymptomatic population of women in Indonesia.

Most previous studies have reported a correlation between bone mass and weight, BMI, 7-11 years of age[7,12,13], age at menopause and duration of menopause[14,15]. Low bone mass was usually found in subjects with a lower weight and body mass index (BMI), older age, earlier menopause and longer duration of menopause. However, these studies mostly investigated the correlations at one bone site. The correlation between these factors on BMD at different bone sites has not yet established. This study is an outreach effort to detect osteoporosis in the general population by means of DEXA examinations and . Furthermore, we aimed to determine the correlation between BMD and age, age at menopause, duration of menopause, weight and BMI in postmenopausal women visiting the Posyandu IHC in Jakarta.

MATERIALS AND METHODS

This study adopted a cross-sectional study design. The inclusion criteria was post-menopausal women aged 50-65 years visiting Posyandu who had been experiencing menopausal symptoms for at least 12 months. The exclusion criteria included treatment with steroids and hormones, tobacco and alcohol use, consumption of vitamin D and calcium supplements and drugs that affect bone mass and evidence of a chronic disease. Inclusion and exclusion criteria as well as demographic data were obtained through questionnaire-guided interviews.

Subjects were recruited from 3 Posyandu IHCs in Jakarta, in the cohort of the Faculty of Medicine, Universitas Katolik Indonesia Atma Jaya, Jakarta. The participants were from low to middle socioeconomic groups, housewives or small grocery vendors. Participants were selected during their initial visit.

Anthropometric measurements were performed on site at Posyandu. Body weight was measured using a portable digital scale (SECA, Robusta 813, Germany) with an accuracy of 0.1 kg with the subjects wearing minimal clothing. Height was measured in the Frankfort standing position without shoes using a wall mounted stadiometer with an accuracy of 0.5 cm. BMI was calculated by dividing the weight (in kg) with the square of height (in m). BMI was classified according to the World Health Organization (WHO) criteria for the Asian population (normal weight if BMI<25 kg m^{-2}, overweight and obese if BMI$\geq$25 kg m^{-2})[16].

DEXA scans were used to assess BMD in a hospital located in the Southern part of Jakarta. To prevent drop-out, participant transportation was arranged and provided by the researcher.

BMD was conducted using DEXA (Lunar Prodigy, GE Healthcare, USA). The DEXA machine was calibrated daily according to the instructions provided by manufacturer. Bone sites were selected as recommended by the International Society for Clinical Densitometry. DEXA scans were performed on the spine (L1-L4), left femur (femoral neck, trochanter, femoral shafts, total hip) and the distal radius[17]. T-scores were categorized according to WHO standards: Normal (T-score>-1), osteopenia (T-score between (-2.5 to -1.0) and osteoporosis (T-score<-2.5)[18]. For statistical analysis, the BMD scores were classified into two groups: Normal BMD (T-score$\geq$-0.1) and low BMD (T-score<-0.1).

Statistical analysis: Numerical data were presented as the mean and standard deviation and categorical data were presented as the number and percentage. An unpaired t-test was performed to compare the means of the risk factors and the BMD of all bone sites between the groups. A Pearson's or Spearman test was conducted to evaluate the correlation between the BMD of each bone site and age, age at menopause, duration of menopause, weight and BMI. Statistical significance was set at $p<0.05$. Statistical analysis was performed using SPSS version 17.0 for Windows (SPSS Inc., Chicago, Il., USA).

RESULTS

Data from the Jakarta provincial health department indicated that approximately 25 hospitals had DEXA machines. DEXA scans were conducted in a hospital in the Southern part of Jakarta because they were cooperative and had good standards of operation.

A total of 60 participants were eligible and willing to undergo DEXA scanning. Forty-two participants were from the Northern part of Jakarta. Twenty-two subjects were from Posyandu Luar Batang and 20 from Posyandu Tanah Merah. The other participants were from Posyandu Cengkareng in the Western part of Jakarta. DEXA scans for all participants were completed in 6 days.

The DEXA scan results revealed that only 10 (16.7%) of the participants had normal BMDs. In addition, 17 (28.3%) had osteopenia and 33 (55%) had osteoporosis. Of 24 participants with a normal BMI, only 3 (12.5%) had normal BMDs whereas 4 (16.7%) had osteopenia and 17 (70.8%) had osteoporosis. Of 36 obese/overweight participants, 7 (19.4%) had normal BMDs, 13 (36.1%) had osteopenia and 16 (44.4%) had osteoporosis. Independent t-test of normal and low BMD groups exhibited significant differences in age, age at menopause, duration of menopause and the T-score of BMD of the bone. No significant differences in body weight and BMI were noted (Table 1).

The results of the Pearson or Spearman correlations between BMD at each bone location and the risk factors are presented in Table 2. The BMD of the trochanter, femoral shaft, total hip and distal radius correlated with all identified risk factors, whereas the BMD of L1-L4 and femoral neck correlated with only 4 risk factors. Age, duration of menopause and weight were correlated with the BMD of all bone sites. Age at menopause did not correlate with the BMD of L1-L4 and BMI did not correlate with the BMD of the femoral neck. Age, age at menopause and duration of menopause correlated negatively with BMD, whereas weight and BMI were positively correlated with BMD. Most of the correlations were weak (0.250-0.399) or moderate (0.400-0.600). Most of moderate correlations were noted

Table 1: Comparison characteristics of the subjects according to the BMD

Characteristics	Total (n = 60)	Normal BMD (n = 10)	Low BMD (n = 50)	p-value
Age (year)	57.9 (5.3)	53.6 (5.2)	58.8 (4.9)	0.004
Age at menopause (year)	53.8 (2.7)	51.4 (3.0)	54.2 (2.4)	0.002
Duration of menopause (month)	49.5 (43.1)	26.4 (29.8)	54.2 (44.1)	0.025
Weight (kg)	57.4 (9.4)	62.3 (10.2)	56.4 (9.1)	0.073
BMI (kg m^{-2})	25.5 (3.8)	27.2 (4.2)	25.2 (3.7)	0.131
L1-L4 BMD (g cm^{-2})	0.912 (0.15)	1.129 (0.11)	0.872 (0.12)	0.001
Femoral neck BMD (g cm^{-2})	0.751 (0.15)	0.923 (0.08)	0.716 (0.13)	0.001
Trochanter BMD (g cm^{-2})	0.637 (0.12)	0.805 (0.10)	0.603 (0.09)	0.001
Femoral shaft BMD (g cm^{-2})	0.986 (0.18)	1.233 (0.148)	0.936 (0.15)	0.001
Total hip BMD (g cm^{-2})	0.815 (0.14)	1.013 (0.09)	0.775 (0.10)	0.001
Distal radius BMD (g cm^{-2})	0.341 (0.09)	0. 476 (0.05)	0.314 (0.07)	0.001
	Normal BMD	Osteopenia	Osteoporosis	
Normal weight (n = 24)	3 (12.5%)	4 (16.7%)	17 (70.8%)	
Overweight/obese (n = 36)	7 (19.4%)	13 (36.1%)	16 (44.4%)	

BMD: Bone mineral density, BMI: Body mass index, L: Lumbal

Table 2: A correlation between age, age at- and duration of menopause, anthropometric measurements and BMD

Variables	Age (year)	Age at menopause (year)	Duration of menopause (month)	Weight (kg)	BMI (kg m^{-2})
L1-L4 BMD (g cm^{-2})	-0.441**	-0.199	-0.482**	0.313*	0.325*
Femoral neck BMD (g cm^{-2})	-0.383**	-0.393**	-0.397**	0.257*	0.163
Trochanter BMD (g cm^{-2})	-0.411**	-0.266*	-0.439**	0.437**	0.424**
Femoral shaft BMD (g cm^{-2})	-0.368**	-0.312*	-0.270*	0.431**	0.412**
Total hip BMD (g cm^{-2})	-0.368**	-0.314*	-0.365**	0.398**	0.386**
Distal radius BMD (g cm^{-2})	-0.582**	-0.414**	-0.497**	0.410**	0.362**

*$p<0.05$ and **$p<0.01$, BMD: Bone mineral density, BMI: Body mass index, L: Lumbal

Table 3: Correlation and contribution of weight and BMI to BMD at skeletal sites

	Weight (kg)			BMI (kg m^{-2})		
Variables	R	R^2 (%)	β	R	R^2 (%)	β
L1-L4 BMD (g cm^{-2})	0.319	0.102	0.005*	0.333	0.111	0.013**
Femoral neck BMD (g cm^{-2})	0.235	0.055	0.004	0.142	0.020	0.005
Trochanter BMD (g cm^{-2})	0.415	0.172	0.005**	0.385	0.148	0.012**
Femoral shaft BMD (g cm^{-2})	0.426	0.182	0.008**	0.408	0.166	0.019**
Total hip BMD (g cm^{-2})	0.409	0.168	0.006**	0.375	0.141	0.013**
Distal radius BMD (g cm^{-2})	0.452	0.204	0.004***	0.420	0.176	0.010***

*p<0.05, **p<0.01, ***p<0.001, BMD: Bone mineral density, BMI: Body mass index, L: Lumbal

between the BMD of the trochanter and age, duration of menopause, weight and BMI. The strongest correlation was observed between age and the BMD of the distal radius (-0.510), whereas the weakest correlation was noted between the weight and the BMD of the femoral neck (0.257).

The age-adjusted linear regression between the BMD and body weight and BMI is presented in Table 3. Weight and BMI were positively associated with the BMD of most skeletal sites but not with the BMD of the femoral neck (p = 0.07 and p = 0.280). Body weight tended to have a stronger correlation with BMD than BMI for most skeletal sites except the lumbar region (trochanter: 0.415 vs. 0.385, the femoral shaft: 0.426 vs. 0.408, total hip: 0.409 vs. 0.375, distal radius: 0.452 vs. 0.420), (0.319 vs. 0.333). Body weight and BMI has the lowest R^2 for the BMD of the lumbar region (10.2 and 11.1%, $R^2 = 0.102$ and $R^2 = 0.111$, respectively) and the highest is for the BMD of the distal radius (20.4 and 17.6%, $R^2 = 0.204$ and $R^2 = 0.176$, respectively).

DISCUSSION

Osteoporosis might be underreporting as people in developing country have limited access to DEXA and patients were referred from clinical setting. These caused prevalence of osteoporosis was less than it should be. This study was the first attempt at identifying new cases of osteoporosis in postmenopausal women using DEXA by recruiting them from community setting (Posyandu). The results showed that 83.3% had low BMD (28.3% osteopenia and 55% osteoporosis).

Frequency of osteoporosis in this study was higher than that reported by other studies. From Indonesia, Perosi reported osteoporosis in postmenopausal women was 32.3% in 2007 whereas another study reported 23% in 2006[2]. Study by Bala *et al.*[19] also performed a community based study in rural and urban postmenopausal women aged 41-70 years. They reported osteoporosis in 51 and 35% of rural and urban postmenopausal women[19]. Diagnosis of osteoporosis in study by Bala *et al.*[19] was confirmed using a quantitative ultrasound at distal forearm site. The frequency of osteoporosis in this study was even higher than in type 2 diabetes mellitus patients in India (43.8%)[20]. It seemed that wide variations in the prevalence of osteoporosis between studies might be due to differences in diagnostic criteria, the methods to recruit patients, diagnostic device, underlying diseases and socioeconomic demography.

Consistent with studies by Montazerifar *et al.*[7] and Salamat *et al.*[9], this study found that the frequency of osteoporosis was increased in subjects with a normal body weight, whereas osteopenia was increased in overweight and obese subjects. This may in part be explained by the increased rate of bone loss in subjects with normal body weight. Bone mass reduction in individuals with normal weight progresses rapidly from normal to porotic bone such that the phase of osteopenia is of shorter duration. Bone mass reduction in overweight and obese subjects occurs slowly with a longer lasting phase of osteopenia. Thus, the prevalence of osteopenia diagnosed by bone scan in normal weight individuals would be lower than in overweight or obese subjects.

Similar with most previous studies, researchers observed a correlation between BMD, age[7,12,13] and weight[8-11,21]. Age and weight were the most highly correlated with the BMD of most skeletal sites suggesting that these factors strongly influence bone loss and osteoporosis. Age reflects the chronological time associated with decreasing estrogen levels, whereas weight is a reflection of the impact of mechanical load on bone formation. Bone formation predominates at a younger age and reaches its peak during the third decade. At menopause, bone resorption predominates, resulting in porotic bone and decreased bone mass[22,23].

In this study, BMD correlated with age, age at menopause and duration of menopause. Subjects who were older, with early menopause and a longer duration of menopause had a lower BMD. In addition, age and duration of menopause were strongly correlated with the BMD of almost all skeletal sites compared to other factors. These results were in agreement

with many previous studies in which age, age at menopause and duration of menopause were major risk factors associated with decreased BMD[7,12-15]. Age, age at menopause and duration of menopause were also associated with low estrogen levels.

Salamat *et al.*[9] observed a positive correlation between the BMD of most skeletal sites and weight and BMI in male subjects, suggesting that effect of weight on BMD does not differ between genders[24]. The lack of a significant association between weight and BMD in this present study suggested that body weight may not translated into bone mass at all skeletal sites[25]. Furthermore, compared with BMI, weight contributes more to BMD. The effect of weight on bone mass may be determined by absolute rather than relative body weight.

Interestingly, similar to Liu *et al.*[25], present study observed the highest R^2 of weight and BMI on the BMD of the distal radius. The beneficial effect of weight on non-weight bearing sites was not fully understood and may involve the effects of hormones produced by adipose tissue in overweight/obese individuals[26,27]. Nonetheless, the beneficial effect of obesity on BMD depends on fat mass[25].

There were some limitations of this study. First, the age range in this study was less wide. As the prevalence of osteoporosis increases with age, wider age range might yield a higher prevalence of osteoporosis in our population. Second, information about the dietary habit of the participants was not available as nutrition is an important factor that contribute to bone mass formation. Third, this study has a cross-sectional design that precludes making any conclusions about a causal relationship between the risk factors and BMD. Nonetheless, this is the first population-based study diagnosing BMD using DEXA in Indonesia. Researchers observed similar correlations between BMD and risk factors as reported in previous studies, however, population-based recruitment strategy likely uncovered more cases of osteoporosis than are typically identified.

CONCLUSION

Population-based recruitment strategy for bone scan using DEXA identifies more cases of osteoporosis in postmenopausal women than clinical-or hospital-based recruitment. This study also demonstrated that correlations between the risk factors and BMD are skeletal site specific.

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