The Combination of Body Mass Index and Age as a New Index for Identifying Osteoporosis in Thai Postmenopausal Women

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Objective: *The purpose of this study was to evaluate the application of the combination of bone mass index (BMI) and age as a new screening tool to identify osteoporosis in Thai postmenopausal women.*
Design: *Diagnostic study.*
Material and Method: *Bone mineral density (BMD) data of Thai postmenopausal women, age 40-80 years old who attended the outpatient clinic, Thammasat university Hospital, Thailand, between January 2004 and December 2008 were enrolled. The participants with history of metabolic bone disease or use of drugs associated with secondary osteoporosis and/or history of treatment for osteoporosis were excluded. Each had BMD records of lumbar spine, femoral neck and intertrochanter. The data were completely collected in all 372 women. A diagnosis of osteoporosis made according to WHO criteria.*
Results: *The prevalence of osteoporosis at lumbar spine, femoral neck and intertrochanter were 8.1%, 20.2% and 15.3% respectively. The combination of BMI and age as the index to detect osteoporosis had a sensitivity at 76.67%, 76% and 77.19%, respectively. The OSTA index at the standard cut-point of -1 had a sensitivity at 80%, 70.67% and 70.17%, respectively. Raising the cut-point to ≤ 0 would had a sensitivity at 90%, 85.33% and 78.95%, respectively.*
Conclusion: *The application of the combination of BMI and age as a screening tool is another option to identify osteoporosis in Thai postmenopausal women. Change the cut-point of ≤ 0 , OSTA index could improve the detection of osteoporosis at a very high level of the sensitivity.*

Keywords: *Osteoporosis, Clinical risk index, BMI, Age, Thai postmenopausal women, OSTA index*

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Osteoporosis is a common disease that is characterized by low bone mass with microarchitectural disruption and skeletal fragility, resulting in an increased risk of fracture, particularly at the spine, hip, wrist, humerus, and pelvis[1]. The number of osteoporotic fractures is certain to increase as a result of the growing aging population. This burden occurs in many region of the world, including Asia resulting the greatest morbidity and mortality. Disabilities from osteoporotic fractures give rise to the highest direct costs for health services[2].

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The gold standard of osteoporosis diagnosis is measurement of bone mineral density (BMD) by dual energy X-ray absorptiometry (DXA)[1]. The major disadvantages of DXA are that the machine is large, not portable and highly cost. Since the mid 1990s, a number of Clinical risk indexes (CRIs) are designed to assist clinicians in identifying women with low bone mass. Osteoporosis Self-assessment Tool for Asians (OSTA), one of CRIs which wildly accepted, is an index to predict low BMD simply on the basis of age and weight. It was firstly proposed by Koh LK[3], which had a sensitivity of 91% and specificity of 45% in identifying women of high risk when compared with final results of femoral neck BMD measurement in Asia women. However, the performance of this index in Thai postmenopausal women had lower sensitivity than original report, especially in prediction of lumbar spine

osteoporosis[4-6].

Low body mass index (BMI) is a well-documented risk factor for future fracture, largely independent of age and sex[7-11]. Meta-analysis study of 14 prospective population-based cohorts demonstrated that the age-adjusted risk for any type of fracture increased significantly with lower BMI. There was also strongly recommended the use of this risk factor in case-finding strategies. Therefore, the objective of this study is to evaluate the application of the combination of BMI and age as the new index to identify osteoporosis in Thai postmenopausal women.

Material and Method

The present study was a diagnostic analytical test with retrospective data collection. The data were collected from medical record forms. Sample population was Thai postmenopausal women, age 40-80 years old who attended gynecologic clinic and radiology clinic, Thammasat University hospital during January 2004-December 2008. All had complete records of bone DXA scan reported as bone mineral density at lumbar spine, femoral neck and intertrochanter. The exclusion criteria were the women who had a history or evidence of metabolic bone disorders, presence of cancer (s) with known metastasis to bone, menopause before the age of 40 years and also the participants who had a history of taking medications affecting calcium and bone metabolism, such as steroids, thyroid hormone, bisphosphonates, fluoride or calcitonin. The protocol was reviewed and approved by the ethics committee of Thammasat University Hospital and the Faculty of Medicine, Thammasat University prior to the commencement of the study.

The sensitivity of OSTA index as 91% from the study of Koh LK et al[3], was used for sample size calculation. Therefore, the number of women who have osteoporosis was at least 31.46. The estimation of total number of women was based on prevalence. Since the prevalence of osteoporosis at femoral neck in Thailand was 13.6%[12]. Thus, the minimum number of patients in the study is 362.

Bone mineral density (g/cm^2) at lumbar spine, femoral neck and intertrochanteric were measured by DXA using a Hologic Discovery densitometer (Hologic, USA). Women were classified as having osteoporosis of the lumbar spine , the femoral neck or intertrochanteric of femur if their BMD were equal to or less than -2.5 SD. The BMD reference values considered to be osteoporosis for lumbar spine, femoral neck and intertrochanter were 0.682, 0.569 and 0.769 g/cm^2, respectively[13].

Descriptive statistics was used to describe demographic characteristics as means, standard deviations (SD) and percent. Comparisons between women with and without osteoporosis of age, bodyweight, height and body mass index were made using Student's unpaired t-test. P-value less than 0.05 was considered statistically significant.

The OSTA index was calculated for each women using their age and weight as follows: 0.2 x (weight-age). A receiver operating characteristic (ROC) curve was generated to explore its relationships with osteoporosis at each site. The recommended cut-point of -1 was used to calculate the sensitivity and specificity.

Logistic regression model was performed to identify the relationship of characteristics; BMI and age, as women having osteoporosis were dependent variables. Then the regression coefficients for each variable were converted to the simplified formula as the new index.

A ROC curve was generated to explore its relationships with osteoporosis at each site, and the optimal cutoff points were selected base on sensitivity and specificity analysis. Area under the ROC curve (AUC) with 95% confidence intervals (CI) of the new index was calculated and compared with OSTA index.

Results

Data were obtained for 372 women as shown in Table 1. Mean age, height and average bodyweight were 59.99 years, 153.02 cm and 58.57 kg, respectively. In Table 2, compared with the non-osteoporosis group, women with at least one of three osteoporotic sites had significantly higher mean age, lower mean bodyweight and lower mean height (p-value for all comparisons < 0.001). They also had a significantly lower body mass index (p = 0.003).

The prevalence of osteoporosis at lumbar spine, femoral neck and intertrochanter were 8.1%, 20.2% and 15.3% respectively. The baseline characteristics; mean age, bodyweight height and body mass index, of postmenopausal women who having osteoporosis at each site (lumbar spine, femoral neck, intertrochanter) were similar as demonstrated in Table 3.

Comparison of ROC curves between the OSTA index and the new index for identifying women who had osteoporosis was demonstrated in Fig. 1. AUC with 95% confidence interval of all three osteoporotic sites, including osteoporosis at least one site were not

Table 1. Characteristics of the study women

	Mean	SD	Range
Age (years)	59.99	9.41	40-80
Bodyweight (kg)	58.51	9.93	31-98
Height (cm)	153.02	5.93	135-182
BMI (kg/m^2)	24.98	3.97	14.47-40.97
Menopause year (years)	47.53	5.90	41-62
BMD of lumbar spine (g/cm^2)	0.88	0.15	0.34-1.41
BMD of femoral neck (g/cm^2)	0.65	0.12	0.14-1.06
BMD of intertrochanter (g/cm^2)	0.91	0.16	0.80-1.32

BMI, body mass index; BMD, bone mineral density

Table 2. Comparison of characteristics between non-osteoporotic women and those women who having at least one of osteoporotic sites

	Non-osteoporosis (n = 271)	Osteoporosis* (n = 101)	p-value	Mean difference 95% CI
Age (years)	58.10 $\pm$ 8.75	65.11 $\pm$ 9.24	< 0.001	-7.01 (-9.05, -4.87)
Weight (kg)	60.13 $\pm$ 9.92	54.13 $\pm$ 8.60	< 0.001	6.00 (3.81, 8.20)
Height (cm)	154.03 $\pm$ 5.74	150.28 $\pm$ 5.59	< 0.001	3.75 (2.44, 5.06)
BMI (kg/m^2)	25.36 $\pm$ 4.06	23.96 $\pm$ 3.55	0.003	1.39 (0.54, 2.23)
Age of menopause (years)	47.24 $\pm$ 6.26	48.26 $\pm$ 4.82	0.151	-1.03 (-2.43, 0.38)

Data are mean $\pm$ SD, * based on at least one of osteoporotic sites

Table 3. Characteristics of osteoporotic cases

	Lumbar spine (n = 30)	Femoral neck (n = 75)	Intertrochanter (n = 57)
Prevalence of osteoporosis	8.1%	20.2%	15.3%
Age (years)	67.50 $\pm$ 8.36	65.61 $\pm$ 8.79	66.24 $\pm$ 9.23
Bodyweight (kg)	52.33 $\pm$ 9.46	52.99 $\pm$ 8.07	53.47 $\pm$ 8.77
Height (cm)	148.97 $\pm$ 5.18	149.78 $\pm$ 5.26	149.87 $\pm$ 5.94
BMI (kg/m^2)	25.57 $\pm$ 4.02	23.62 $\pm$ 3.38	23.79 $\pm$ 3.55
Bone mass density (g/cm^2)	0.59 $\pm$ .082	0.74 $\pm$ 0.13	0.74 $\pm$ .14
Age of menopause (years)	47.86 $\pm$ 3.64	48.93 $\pm$ 4.34	48.62 $\pm$ 4.62

Data are mean $\pm$ SD

different. In Table 4, the diagnostic performances of OSTA index and the new index for identifying osteoporosis in Thai menopausal women were compared. The OSTA index, cut-point at -1, had a higher sensitivity (80% vs. 76.67%) and specificity (65.70% vs. 66.57%) with AUC of 0.79 when compared with new index in detecting women with osteoporosis at lumbar spine. However, it had a lower sensitivity (70.67% vs. 76% ,70.17% vs. 77.19%) in detecting women with osteoporosis at femoral neck and intertrochanter,

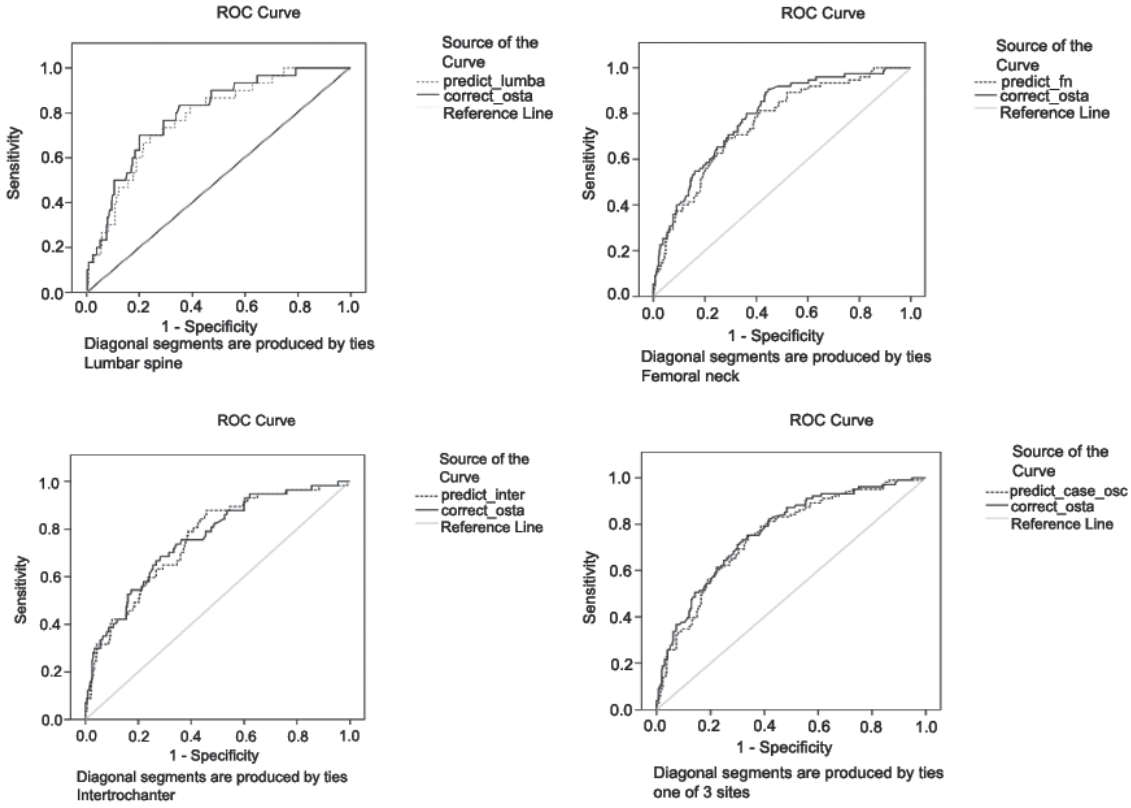

Fig. 1 Comparison of ROC curves between the OSTA index and the new index for identifying women who having osteoporosis

respectively. With raising the cut-point at 0, the OSTA index had a higher sensitivity at (90% vs. 76.67%, 85.33% vs. 76% and 78.95% vs. 77.19% at lumbar spine, femoral neck and intertrochanteric of femur, respectively compared with the new index.

Discussion

Although the treatment of osteoporosis is effective, screening for osteoporosis is essential because this silent disease is common and associated with high morbidity and mortality. Also, the healthcare cost of these burdens is great amount. Bone mineral density (BMD) measured by dual energy X-ray absorptiometry (DXA) is the most widely recognized as the standard predictor for fracture occurrence[1]. However examination DXA for in all postmenopausal women is not cost-effective benefit, because this instrument is not widely available in most developing countries including Thailand. Moreover, it was estimated that there have been only 50 DXA absorptiometer machines all over Thailand and most of them are limited to university or tertiary level hospitals[14].

It is very reasonable to use the clinical risk indices for identifying women with low BMD or high risk fracture individuals before sending them to test their BMD. OSTA index was formulated to predict BMD by using only age and bodyweight. Indeed, the two factors collectively account for 40 to 60 percent variance of BMD in the population[15-17]. In the present study, an another important clinical risk, BMI, was added into OSTA index to have the better diagnostic performances as the new index. Our findings revealed that using of the combination of age and BMI as the index for identifying osteoporosis in Thai postmenopausal women had high diagnostic performances as well as OSTA index. The original OSTA index, cut-point at -1, had a sensitivity of 91% and specificity of 45% with AUC of 0.79 in detecting women with osteoporosis at femoral neck. The new index, compared to OSTA index,

Table 4. Diagnostic performances of OSTA index and the new index for identifying osteoporosis in Thai menopausal women

	Lumbar spine	Femoral neck	Intertrochanter	At least one of osteoporotic sites
-OSTA at -1				
Sensitivity	80.00	70.67	70.17	66.33
Specificity	65.70	70.24	67.83	72.53
PPV	16.90	37.72	28.16	47.18
NPV	97.41	90.51	92.67	85.34
-OSTA at 0				
Sensitivity	90.00	85.33	78.95	79.20
Specificity	52.62	57.86	54.26	59.71
PPV	14.21	33.68	23.68	42.10
NPV	98.36	94.02	93.47	88.58
AUC	0.79(0.72-0.87)*	0.78(0.73-0.84)*	0.76(0.68-0.83)*	0.77(0.72-0.82)*
-New index				
Sensitivity	76.67	76.00	77.19	75.25
Specificity	66.57	61.20	61.52	63.37
PPV	16.67	32.94	26.50	43.18
NPV	97.03	91.04	93.75	87.37
AUC	0.78(0.69-0.85)*	0.76 (0.69-0.81)*	0.76(0.69-0.83)*	0.75(0.70-0.81)*

PPV; Positive predictive value, NPV; Negative predictive value, AUC; Area under curve, *(95% confidence interval)

had higher sensitivity at femoral neck (76% vs. 70.67%), intertrochanter (77.19% vs. 70.17%) but had lower sensitivity for lumbar spine (76.67% vs. 80%). Based on at least one of three osteoporotic sites, the new index has also higher sensitivity (75.25% vs. 66.33%). Therefore, the new index could be useful to screen osteoporosis when there are suspected of any osteoporotic sites.

Raising the cut-point to ≤ 0, OSTA index had a very high sensitivity and much more better diagnostic performances in all three osteoporotic sites; 90%, 85.33% and 78.95% at lumbar spine, femoral neck and intertrochanter, respectively. These could increase negative predictive value and also reduce the high false negative rate in prediction of osteoporosis. Similar to Geater S et al study[4] that the authors suggested the cut-point of ≤ 0 for the lumbar spine may be more appropriate. It could be explained that the baseline characteristic of population and the prevalence of disease were different. Most of participants in the OSTA original report were Chinese whose baseline BMD were lower than our sample Thai population. The present study use Thai BMD reference values from Limpaphayom K et al study[13] to diagnose osteoporosis, not T-score as the other studies because the most reference values in available DXA machines are Japanese or United states based data. Currently, the normogram of BMD has not been standardized and applied to general practice.

This study has several limitations. Firstly, the other clinical risks such as current smoking, alcoholism and/or history of recurrent falls should also included and analyzed. These should have more accuracy to represent the BMD. Secondly, the precision and reliability of height measurement are the issues to concern, particularly in older postmenopausal women. Because the loss of height is well-known consequence of aging and development of spinal osteoporosis. Thirdly, the accuracy error of DXA in BMD measurement have ranged from 2-4%. The precision depends on both machine, patient and operator-dependent factors. However, for well maintenance system, the machine error is small and long term precision is typical less than 1%. Lastly, this study is retrospective data collection, participants' data might be incomplete and have the information bias.

In conclusion this new index, compared to the OSTA at recommended cut-point -1, is superior in ability of predictive osteoporotic sites at femoral neck and intertrochanter but it is inferior at lumbar spine. Therefore, the application of the combination of BMI and age as a screening tool might be an another option

to identify osteoporosis in Thai postmenopausal women. Also, our data analysis strongly supported that changing the cut-point of ≤ 0, OSTA index could improve the detection of osteoporosis at very high level of the sensitivity.

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การใช้ดัชนีมวลกายร่วมกับอายุเป็นดัชนีใหม่ในการตรวจคัดกรองภาวะกระดูกพรุนในสตรีไทยวัยหมดระดู

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วัตถุประสงค์: *เพื่อประเมินคุณค่าของการใช้ดัชนีมวลกายร่วมกับอายุเป็นดัชนีใหม่ในการตรวจคัดกรองภาวะกระดูกพรุนในสตรีไทยวัยหมดระดู*

รูปแบบการวิจัย: *การวิจัยแบบ diagnostic study*

วัสดุและวิธีการ: *ได้รวบรวมข้อมูลการวัดค่ามวลกระดูกของสตรีไทยวัยหมดระดูอายุ 40-80 ปี ซึ่งไม่มีโรคทางเมตาโบลิคของกระดูก ไม่พบโรคหรือมีการแพร่ลามของมะเร็งที่กระดูก และไม่ได้ใช้ยาที่มีผลต่อแคลเซียมหรือมวลกระดูกโดยมีค่าผลการตรวจมวลกระดูกในช่วง 1 มกราคม พ.ศ. 2547 ถึง 31 ธันวาคม พ.ศ. 2551 และมีข้อมูลของค่ามวลกระดูกครบที่ 3 ตำแหน่งได้แก่ lumbar spine, femoral neck และ intertrochanter ได้ข้อมูล ครบถ้วนทั้งหมด 372 ราย การวินิจฉัยว่าเกิดภาวะกระดูกพรุนใช้ตามคำจำกัดความขององค์การอนามัยโลกนำข้อมูลที่ได้มาวิเคราะห์ผลทางสถิติ*

ผลการศึกษา: *พบความชุกของภาวะกระดูกพรุนที่ตำแหน่ง lumbar spine, femoral neck และ intertrochanter ร้อยละ 8.1, 20.2 และ 15.3 ตามลำดับ หากใช้ดัชนีใหม่ที่เกิดจากดัชนีมวลกายและอายุรวมกันจะมีความไว (sensitivity) ร้อยละ 76.67, 76 และ 77.19 ตามลำดับ เมื่อใช้ OSTA index โดยใช้ค่าจุดตัด ที่ -1 จะมีความไว ร้อยละ 80, 70.67 และ 70.17 ตามลำดับ แต่หากเปลี่ยนค่าจุดตัดเป็น 0 จะมีความไว ร้อยละ 90, 85.33 และ 78.95 ตามลำดับ*

สรุป: *การใช้ดัชนีใหม่ที่เกิดจากดัชนีมวลกายและอายุ อาจเป็นทางเลือกหนึ่งในการตรวจคัดกรองหาภาวะกระดูกพรุนในสตรีไทยวัยหมดระดู และการเปลี่ยนค่าจุดตัดของ OSTA เป็น 0 จะช่วยเพิ่มความไวของการตรวจคัดกรองได้สูงขึ้นอย่างชัดเจน*