Distal Radius Bone Mineral Density and Grip Strength in Peri/Postmenopausal Thai Women

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Abstract

To determine the relationship between distal radius bone mineral density (BMD) and grip strength (GS) in peri/post menopausal Thai women. 177 healthy volunteers, ≥40 years old, were included. Distal radius BMD of the non-dominant side was measured using dual energy X-ray absorptiometry. GS of both dominant and non-dominant sides was measured using a Jamar dynamometer. The association between BMD and GS was determined by correlation analysis. Other factors possibly affecting the BMD or GS including age, years since menopause (YSM), body weight (BW), height (Ht) and body mass index (BMI) were analyzed by the multiple regression method. It was found that BMD had statistically significant but weak positive correlation to GS ($r = 0.262$, $p < 0.001$ for the dominant side, $r = 0.193$, $p < 0.001$ for non-dominant side). Age and YSM had a negative correlation, whereas, BW and Ht had a positive correlation to either BMD or GS. After multiple regression analysis, the significant predictors of BMD were age and BW, of dominant GS were age and Ht, and of non-dominant GS was YSM. In conclusion, decrements in distal radius BMD and in GS were found in peri/postmenopausal women. Aging seems to be the most important factor for these features. Although the GS has statistically significant correlation to the corresponding BMD, the clinical significance might not be obvious. Furthermore, the stronger correlation of BMD to the contralateral dominant GS than to the ipsilateral non-dominant GS implies that the influence of muscular strength on BMD, if present, is not due to a direct effect in this age group.

Key word : Grip Strength, Bone Mineral Density, Peri/Postmenopause, Radius

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Aging in musculoskeletal system, characterized by progressive decline in muscular strength and in bone mineral content, is an important factor contributing to frailty and fracture risk in the elderly (1). The muscular strength reaches its peak by the 3rd decade of life and then steadily declines(2). The decline in muscular strength occurs earlier in women than in men; furthermore, a dramatic decline in specific force is observed around the time of the menopause(3,4). The female age-related profile of muscular strength is comparable to that of bone mineral density(5). These profiles are also observable in the Thai population(6,7).

Muscle and bone are contiguous organs that function in concert, therefore factors affecting one organ might affect the other. As stated in Woff's law, stress of mechanical loading applied to the bone *via* the muscle and tendons has a direct effect on bone formation and remodeling(8). Since the largest voluntary loads on bones come from muscles(9), the decline in muscular function would cause deterioration of the related bone strength. Interestingly there were 2 studies demonstrating moderate correlation between grip strength and BMD; therefore the authors suggested using grip strength testing as a screening test before BMD measurement(10,11). This would be beneficial since the cost of grip strength testing is far less than that of BMD measurement.

So far not many studies have investigated the relationship between muscular strength and bone density in postmenopausal women. They have demonstrated various degrees of positive relationship(10,12-16), though one study did not(17). The difference may be influenced by several factors including the research methodology (longitudinal *vs* cross-sectional, observational *vs* experimental), the study population (age, race, genetics, medication) and the outcome measured.

The objectives of the present study were to evaluate the relationship between grip strength and distal radius bone mineral density and to determine factors affecting these two variables in peri/postmenopausal Thai women.

MATERIAL AND METHOD

Subjects

All participants (n = 177) were peri/postmenopausal women aged 40-68 years old without obvious musculoskeletal or neurological diseases who could walk without aid. The participants were interviewed for their medical and menstrual histories. Postmenopause was considered when at least one year had elapsed since menopause (year since menopause or YSM $\geq$1 year). A physical examination was made including pulse, blood pressure, weight, height and forearm length.

Measurement of grip strength

Grip strength (GS) of both dominant and non-dominant hands was measured with a Jamar hand dynamometer (Jackson, MI 49203, USA). Three consecutive readings were obtained on each side. Subjects were allowed a 30-second recovery period between consecutive measurements. The maximum grip force was used for analysis. Tests were performed with the position of shoulder in slight anteflexion and adduction, arm in neutral and elbow supported on a table in 90° flexion. Wrist was slightly extended, the position of which enhanced the maximal grip strength. Handgrip spacing was set at 1.5 inches for all subjects.

Measurement of bone mineral density

Bone mineral density (BMD) of the non-dominant forearm was measured using dual energy X-ray absorptiometry (DXA-70, Panasonic, Matsushita Industrial Equipment, Co., Ltd, Japan). The distal radius bone mineral content was automatically calculated by software installed from the manufacturer.

Statistical analysis

Data were presented in mean $\pm$ SD or percentage. Paired *t*-test was used to compare the GS of dominant to non-dominant sides. Pearson's correlation was used to evaluate the association between the GS of dominant and non-dominant sides, between the BMD and other variables including age, year since menopause (YSM), body weight (BW), height (Ht), body mass index (BMI), dominant GS and non-dominant GS, and between the GS and other variables. Multiple regression analysis for linear relationship was used to determine the significant predictors for the BMD or the GS. Since the data of some variables were missing, the number (n) of each variable was different. The Pearson correlation and multiple regression analysis for linear relationship of the analyzing variables were performed after excluding the participants with missing data. All statistical analysis was performed using SPSS 10 for Windows software.

RESULTS

Demographic data of all 177 participants are given in Table 1. Only 139 participants could give information about their menopausal status; while the rest were still having menstruation or could not remember the YSM.

Table 2 shows the Pearson correlation between demographic data and BMD, dominant GS, or non-dominant GS. As expected, dominant GS and non-dominant GS were strongly correlated to each other ($r = 0.740$, $p < 0.001$). It was found that BMD had a statistically significant linear relationship to age, YSM, Ht, BW, dominant GS and non-dominant GS. A similar relationship was found in dominant GS or non-dominant GS, except that dominant GS had no relationship to BW. The non-dominant distal radius BMD has stronger correlation to the contralateral dominant GS ($r = 0.262$, $p < 0.001$) than to the ipsilateral non-dominant GS ($r = 0.193$, $p < 0.001$).

Multiple regression analysis was performed in 139 postmenopausal women who had complete data. It was found that significant predictors for BMD were age and body weight, for dominant GS were age and height and for non-dominant GS was YSM.

DISCUSSION

As expected, the authors found that both GS and distal radius BMD declined with age in peri/postmenopausal women. Although most of the factors studied had significant correlation to both GS and BMD, after multiple linear regression analysis, the most important independent predictor for both GS and distal radius BMD in postmenopausal women was age (negative correlation to both variables). Another independent predictor for BMD was BW (positive correlation), for dominant GS was Ht (positive correlation) and for non-dominant GS was YSM (negative correlation). The present findings were similar

Table 1. Demographic data of 177 participants.

	N	X ± SD	Range
Age (yr)	177	54.72 ± 6.28	42 - 77
YSM (yr)	139	7.63 ± 5.76	1 - 32
Weight (kg)	177	59.65 ± 8.52	38 - 83
Height (cm)	177	153.82 ± 5.23	137 - 170
BMI (kg/m^2)	177	25.23 ± 3.52	17.5 - 34.1
Grip Strength (kg)[a]			
Dominant	177	26.31 ± 5.75	8 - 40
Non-dominant	177	24.25 ± 5.66	6 - 36
BMD (g/cm2)	177	0.501 ± 0.053	0.362 - 0.629

Note : YSM = years since menopause, BMI = body mass index,
BMD = bone mineral density of non-dominant forearm
a = Dominant grip strength is stronger than non-dominant grip strength (p<0.01)

Table 2. Pearson correlation of BMD, DGS and NDGS.

Variables	BMD			DGS			NDGS		
	n	r	p	n	r	p	n	r	p
Age	177	-0.482	<0.001[a]	177	-0.361	<0.001[a]	177	-0.261	<0.001
YSM	139	-0.379	<0.001	139	-0.280	<0.001	139	-0.238	0.003[a]
Ht	177	0.221	0.003	177	0.328	<0.001[a]	177	0.241	0.001
BW	177	0.187	0.013[a]	177	0.131	0.081	177	0.170	0.024
BMD	-	-	-	177	0.262	<0.001	177	0.193	<0.001
DGS	177	0.262	<0.001	-	-	-	177	0.740	<0.001
NDGS	177	0.193	<0.001	177	0.740	<0.001	-	-	-

Note : DGS = dominant grip strength, NDGS = non-dominant grip strength,
a = significant predictors after multiple regression analysis of post menopausal participants (139 cases)

to others(18,19). It is noteworthy that none of these independent predictors, except for body weight, were modifiable.

Considering musculoskeletal system aging as an important factor contributing to frailty in the elderly, preserving its function should be beneficial. Since most of the independent predictors are not modifiable, other measures should be applied to maintain the healthiness of the musculoskeletal system. Two promising measures are hormonal replacement therapy (HRT) and exercise. It is well established that HRT can prevent bone loss in the early postmenopausal period(3). However, the effect of estrogen on muscular strength is controversial(20), varying from null(21-24) to positive effect(4,25,26). HRT may offer protection against muscle weakness, although there is no evidence in the early postmenopausal period(27). As exercise has a positive effect on both muscle and bone(1,14,16,26), appropriate physical training should be recommended to all menopausal women.

Theoretically, strong muscle has a positive impact on bone(8). This has been proven by many studies demonstrating positive correlation between muscular strength and regional BMD in postmenopausal women with the degree of correlation varying from 0.34 to 0.66(10-14). Moreover, two recent studies demonstrated that GS was a strong independent predictor for BMD in postmenopausal women (10,11). Although the present study confirmed the positive correlation between GS and BMD, the degree of correlation was much less ($r = 0.193$-0.262). Furthermore, after multiple linear regression analysis, GS was not an important predictor for distal radius BMD.

Interestingly, the authors found that the non-dominant distal radius BMD was correlated more strongly to the contralateral dominant GS than to the ipsilateral non-dominant GS. This finding, which has never been reported in other studies, implied that the influence of GS on distal radius BMD, if present, might not be due to a direct effect in this age group. Moreover, GS is not an ideal indicator for forearm muscular strength. Extrinsic muscles of the hand, the force of which has a direct impact on the distal radius, are not major force generators for GS. This could explain why the correlation between GS and hand BMD in Ozgocmen's study was much stronger than that between GS and distal radius BMD in the present study.

Muscular grip strength testing was suggested as a screening test before BMD measurement in some studies(10,11). Since the correlation between these two tests in the present study was weak, the authors do not encourage this application. Nevertheless, the measurement of GS and distal radius BMD can offer information about the healthiness of the musculoskeletal system in postmenopausal women who do not have obvious musculoskeletal or neurological deficit. The information from this easy-to-measure site may reflect information of other sites(11,13,28). The positive correlation between muscular strength and BMD suggests that muscular strengthening in postmenopausal women would be beneficial for their bones.

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ความหนาแน่นของกระดูกเรเดียสส่วนปลายและกำลังกล้ามเนื้อมือในสตรีไทยวัยก่อนและหลังหมดระดู

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ได้ศึกษาความสัมพันธ์ระหว่างความหนาแน่นของกระดูกเรเดียสส่วนปลายและกำลังกล้ามเนื้อมือในอาสาสมัครสตรีไทยวัยก่อนและหลังหมดระดูที่มีอายุตั้งแต่ 40 ปีขึ้นไป โดยตรวจความหนาแน่นของกระดูกเรเดียสส่วนปลายของแขนข้างที่ไม่ถนัดด้วย dual energy X-ray absorptiometry และตรวจกำลังกล้ามเนื้อมือทั้งสองข้างด้วย Jamar dymamometer แล้ววิเคราะห์หาความสัมพันธ์ด้วย correlation analysis ตลอดจนหาปัจจัยที่มีผลต่อความหนาแน่นกระดูกหรือต่อกำลังกล้ามเนื้อด้วย multiple regression analysis พบว่าความหนาแน่นกระดูกเรเดียสของแขนข้างที่ไม่ถนัดและกำลังกล้ามเนื้อมือทั้งสองข้างมีความสัมพันธ์ต่อกันแบบเส้นตรงไปในทิศทางเดียวกัน อย่างมีนัยสำคัญทางสถิติ ($r = 0.262$, $p < 0.001$ ในมือข้างที่ถนัด, และ $r = 0.193$, $p < 0.001$ ในมือข้างที่ไม่ถนัด) ปัจจัยที่มีอิทธิพลต่อความหนาแน่นกระดูกหรือกำลังกล้ามเนื้อในเชิงลบ คือ อายุ และระยะเวลาที่หมดระดู ปัจัยที่มีอิทธิพลในเชิงบวก คือ น้ำหนักและส่วนสูง ภายหลังจากการวิเคราะห์ด้วย multiple regression analysis พบว่าปัจจัยที่ยังคงมีความสำคัญต่อความหนาแน่นกระดูกคืออายุและน้ำหนัก ต่อกำลังมือข้างที่ถนัดคืออายุและส่วนสูง และต่อกำลังมือข้างที่ไม่ถนัดคือระยะเวลาที่หมดระดู โดยสรุปเมื่อสตรีมีอายุมากขึ้นความหนาแน่นกระดูกและกำลังกล้ามเนื้อจะลดลง แม้ว่าความหนาแน่นกระดูกและกำลังกล้ามเนื้อจะมีความสัมพันธ์กันอย่างมีนัยสำคัญทางสถิติแต่เนื่องจากค่าสัมประสิทธิของความสัมพันธ์มีค่าน้อย ความสัมพันธ์นี้จึงไม่น่าจะมีนัยสำคัญมากนักในทางคลินิก นอกจากนี้การที่ความหนาแน่นของกระดูกเรเดียสของแขนข้างที่ไม่ถนัดมีความสัมพันธ์กับกำลังมือข้างเดียวกันน้อยกว่าความสัมพันธ์กับกำลังมือข้างที่ถนัดอาจจะบ่งชี้ว่าในสตรีวัยนี้กำลังกล้ามเนื้อไม่ได้ส่งผลโดยตรงต่อความหนาแน่นกระดูก

คำสำคัญ : กำลังกล้ามเนื้อมือ, ความหนาแน่นกระดูก, สตรีวัยก่อนและหลังหมดระดู, กระดูกเรเดียส

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